



# The Importance of a Country's Welding Industry, Its National Welding Capability (NWC) and Their Significance to the UN Sustainable Development Goals (SDGs)



**Long Report – Volume 1:  
NWC and SDGs Interconnected and  
Interdependent in the Welding Industry**

Edited by *Chris Smallbone*

## The Importance of a Country's Welding Industry, Its National Welding Capability (NWC) and Their Significance to the UN Sustainable Development Goals (SDGs)

<https://iiwelding.org/iiw-jointothefuture/iiw-and-sustainable-development/>

Short Report

Long Report Volume 1: NWC and SDGs Interconnected and Interdependent in the Welding Industry

Long Report Volume 2: Potential National Welding Capability Welding Industry Projects and Resources

© International Institute of Welding 2024

This work is copyright. Apart from any use permitted under the Copyright Act, no part may be reproduced by any process without prior written permission from the International Institute of Welding (IIW).

*Requests and enquiries concerning reproduction and rights and further information should be addressed to:*  
**International Institute of Welding**

Secretariat

Chief Executive Officer

E-mail: [iiw@iiwelding.org](mailto:iiw@iiwelding.org)

Web: [www.iiwelding.org](http://www.iiwelding.org)

Phone: +39 010 8341 476

Mail: Lungobisagno Istria 15A, 16141 Genoa, Italy

First published 2024

Layout and design: A for Art Pty Ltd. email: [chris@aforart.com.au](mailto:chris@aforart.com.au)

While every effort has been made and all reasonable care taken to ensure the accuracy of the material contained herein, the authors, editors and publishers of this publication shall not be held to be liable or responsible in any way whatsoever and expressly disclaim any liability or responsibility for any injury or loss of life, any loss or damage costs or expenses, howsoever incurred by any person whether the reader of this work or otherwise including but without in any way limiting any loss or damage costs or expenses incurred as a result of or in connection with the reliance whether whole or partial by any person as aforesaid upon any part of the contents of this publication. Should expert assistance be required, the services of a competent professional person should be sought.



International Institute of Welding

Lungobisagno Istria 15A, 16141 Genoa (Italy) – [iiw@iiwelding.net](mailto:iiw@iiwelding.net) – [www.iiwelding.org](http://www.iiwelding.org)

<v1>

## Foreword



*Thomas Böllinghaus*  
IIW President 2023-2026



*Chris Smallbone*  
Editor, IIW President 2005-2008



*Luca Costa*  
IIW Chief Executive Officer

The International Institute of Welding (IIW) was founded in 1948 by the Welding institutes or societies of 13 countries that considered it crucial to make more rapid scientific and technical progress in welding possible on a global basis [1]. Its membership today comprises welding organisations from 51 countries worldwide.

IIW provides a unique cooperative and collaborative platform for experts, practitioners and policy makers in the welding and related industries to share not only technical information and innovation, but knowhow in all areas affecting a country's ability to achieve sustainable development in a sustainable environment and fulfil their responsibilities in a cooperative and converging global community.

As the world population continues to grow, the pressures on manufacturing, infrastructure and power generation, not to mention basic needs such as food, water, shelter and education, have become enormous common challenges. The welding industry is a significant global industry and, together with welding as an enabling technology, it plays a critical role in the world's ability to cope with these pressures and changes and drive significant progress.

The IIW community is dedicated to the concept of helping all countries build their own sustainable welding capabilities to meet these challenges and improve the quality of life for their people and all mankind. The IIW Project "Establishing a National Welding Capability (NWC) in a Country" is a means of achieving this [4].

This report, which is split into a Short Report and a Long Report, is an outcome of the IIW National Welding Capability (NWC) Project. It provides guidance, including practical ideas and recommendations, on how a country's welding industry can improve its national welding capability and simultaneously progress targeted UN Sustainable Development Goals (SDGs) as well as complement other initiatives being taken by governments, aid agencies, industry and like-minded organisations.

It is hoped that the guidance, ideas and recommendations in the report will lead to enhanced cooperation and collaboration between countries, governments, industries, aid agencies and organisations in mutually beneficial projects to enhance the NWCs and SDGs.

Besides improving the quality of life for so many, the rewards for involvement by individuals and companies will be immense.

## Task Group Members



Mr Chris Smallbone (Chair),  
IIW President 2005-2008, Chair IIW  
Working Group Regional Activities  
and Liaison with Developing Countries  
(WG-RA) (1993-2005), (2008-2017)



Prof Luiz Paes,  
Center for Research and Development  
of Welding Processes (LAPROSOLDA) at  
the Uberlandia Federal University (UFU),  
Brazil



Mr Deepak Acharya, President IIW-India  
(2021-2024), Chief Executive Officer,  
INOXCVA, India



Mr Rosario Russo,  
Administrative and Communication  
Specialist, IIW Secretariat



Prof Dorin Dehelean, Executive Director,  
Romanian Welding Society (ASR),  
President European Welding Federation,  
(2011-2013)



Ms Dorothee Schmid (Chair),  
IIW Working Group Regional Activities  
(2020-2023), Business Development  
Partner Manager, Global, Autodesk, Inc



Dr Michail Karpenko, General Manager,  
Welding Centre, Heavy Engineering  
Research Association (HERA),  
New Zealand. IIW Director and Board  
Member (2015-2018)



Mr John Tarboton,  
Executive Director, Southern African  
Institute of Welding (SAIW)

## Acknowledgements

Besides members of the Task Group, various people and organisations have contributed information in the report for common use and others have contributed as reviewers to various aspects of the report. All their efforts are acknowledged and appreciated.

Reviewers.

- Mr Rituraj Bose, Honorary Secretary General, The Indian Institute of Welding
- Dr Troy Coyle, CEO, HERA
- Dr Emmanuel Afrane Gyasi, President and CEO, Ghanaian Institute of Welding (GIW)
- Mr Douglas Luciani, President and CEO, CWB Group
- Mr R Srinivasan, Chairman, IIW-India Foundation

*“With the four attributes of **ENTHUSIASM, PERSISTENCE, COOPERATION & COLLABORATION** we can all work together in an excellent team effort to improve the quality of life globally.”*

Chris Smallbone, IIW President 2005-2008, IIW Fellow



# Long Report – Volume 1: NWC and SDGs Interconnected and Interdependent in the Welding Industry

## Executive Summary

This report highlights the crucial role that a country's national welding capability (NWC) can play through its welding industry in progressing the 17 UN Sustainable Development Goals (SDGs) and 2030 Agenda in the country.

It will serve as a reference point and catalyst for governments and organisations in industry, research and development, education and training, qualification and certification, technology transfer as well as standards-making and regulatory bodies to cooperate and collaborate in progressing both the NWC and SDGs in a country.

The 51 member country International Institute of Welding (IIW) and present regional organisations have potential roles in addressing the existing specific regional disparities through establishing global partnerships and enthusiastic collaboration to progress the SDGs.

The period set by the UN to achieve the targets for the SDGs by 2030 has now passed 50% with the global targets currently achieved falling well short for many reasons.

This report gives a number of specific recommendations on how the welding industry in a country, and globally, can improve on this particularly by prioritising the strategies and projects to be implemented particularly in relation to the resources available in the country so that the resources and efforts are devoted to do the most good.

In this regard, examples of possible welding industry projects for each SDG are shown in Section 1 of Volume 2 of the Long Report which will result in mutually beneficial outcomes being realised for all parties in improving the National Welding Capability, progressing the Sustainable Development Goals and improving the quality of life for all.

**Note:** All numbered references in the text are listed in Section 2 of Volume 2 of the Long Report.



## IIW Vision, Mission and Core Values

### Vision

The leading global welding community linking industry, research and education

### Mission

Advance welding and joining through a worldwide network

### Core Values

IIW is committed to the advancement of welding and joining for a safer and sustainable world

IIW operates based on mutual respect for diversity, culture and languages



# Table of Contents

<b>Volume 1</b>		Page
1.	Introduction to United Nations Sustainable Development Goals (SDGs) . . . . .	5
2.	The Importance of a Country's National Welding Capability (NWC) and Its Significance to the UN Sustainable Development Goals . . . . .	8
3.	Some Beneficial Outcomes of a Flagship Programme on the NWC and SDGs. . . . .	10
4.	Challenges and Potential Welding Industry Initiatives and Innovations for Each UN Sustainable Development Goal.. . . .	12
4.1	SDG 1 End Poverty in All Its Forms Everywhere . . . . .	13
4.2	SDG 2 End Hunger, Achieve Food Security and Improved Nutrition, and Promote Sustainable Agriculture 17	17
4.3	SDG 3 Ensure Healthy Lives and Promote Well-Being for All at All Ages... . . . .	20
4.4	SDG 4 Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities For All.. . . .	13
4.5	SDG 5 Achieve Gender Equality and Empower All Women and Girls . . . . .	28
4.6	SDG 6 Ensure Availability and Sustainable Management of Water and Sanitation For All.. . . .	32
4.7	SDG 7 Ensure Access to Affordable, Reliable, Sustainable and Modern Energy For All... . . . .	35
4.8	SDG 8 Promote Sustained, Inclusive and Sustainable Economic Growth, Employment and Decent Work For All... . . . .	38
4.9	SDG 9 Build Resilient Infrastructure, Promote Inclusive and Sustainable Industrialisation and Foster Innovation.. . . .	42
4.10	SDG 10 Reduce Inequality Within and Among Countries... . . . .	45
4.11	SDG 11 Make Cities and Human Settlements Inclusive, Safe, Resilient, and Sustainable . . . . .	47
4.12	SDG 12 Ensure Sustainable Consumption and Production Patterns . . . . .	50
4.13	SDG 13 Take Urgent Action to Combat Climate Change and Its Impacts by Regulating Emissions and Promoting Developments in Renewable Energy... . . . .	53
4.14	SDG 14 Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development . . . . .	56
4.15	SDG 15 Protect, Restore and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification, and Halt and Reverse Land Degradation and Halt Biodiversity Loss . . . . .	58
4.16	SDG 16 Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable and Inclusive Institutions at All Levels. . . . .	61
4.17	SDG 17 Strengthen the Means of Implementation and Revitalise the Global Partnership for Sustainable Development . . . . .	64



	Page
5. Challenges and Opportunities for Improvements in the Regions..	67
5.1 Global Challenges and Opportunities.	67
5.2 African Countries ..	68
5.3 South Asian Countries ..	71
5.4 South East European Countries...	72
5.5 Asian Countries ..	74
5.6 European Countries..	76
5.7 Latin American and the Caribbean Countries ..	78
5.8 Oceanian Countries ..	80
5.9 North American Countries...	82
5.10 Middle Eastern Countries ..	84
6. General Recommendations Including Possible Future Actions..	85
6.1 Introduction...	85
6.2 IIW's Potential Role...	86
6.3 Typical Organisations Which Could Be Involved in the NWC and SDG Flagship Programme...	88
6.4 Typical Personnel Who Could Be Involved in the NWC and SDG Flagship Programme ..	89
6.5 Industry Sectors Which Could Be Involved in the NWC and SDG Flagship Programme ..	89
6.6 Key Challenges in Establishing and Sustaining the Resources of the NWC and SDG Flagship Programme ..	90
6.7 Some Ideas for Obtaining Flagship Programme Resources Including Examples of Previous Funding Resources ..	91
6.8 Specific Recommendations .	93

# 1. Introduction to United Nations Sustainable Development Goals (SDGs)

The United Nations (UN), has 193 countries as members and with the challenges of improving the quality of life in countries, in 2015, world leaders agreed for the UN to implement 17 Sustainable Development Goals (SDGs) aimed particularly at low and middle income countries.

Each UN country is supposed to measure its progress on an annual basis against the targets and indicators set against each SDG. The title of each SDG and its description together with the number of targets and indicators for each SDG are shown at [https://en.wikipedia.org/wiki/Sustainable\\_Development\\_Goals](https://en.wikipedia.org/wiki/Sustainable_Development_Goals) [6].

The 17 UN SDGs are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those of poverty, inequality, climate change, environmental degradation, peace and justice. The 17 Goals are all interconnected, and in order to leave no one behind, it is important that we achieve them all by 2030.

Each SDG has a clear Goal with targets to be achieved by 2030 and indicators for measuring, monitoring and evaluating progress against the Goal. It is not just countries which are being asked to implement the SDGs but also companies, organisations of all types and even individuals. Since the Goals are interconnected, contributions into one Goal can have a positive effect on other Goals. The full Sustainable Development Report 2023 giving the Global SDG Index and country reports is on [Sustainable Development Report 2023 \(sdgindex.org\)](https://sdgindex.org) [5].

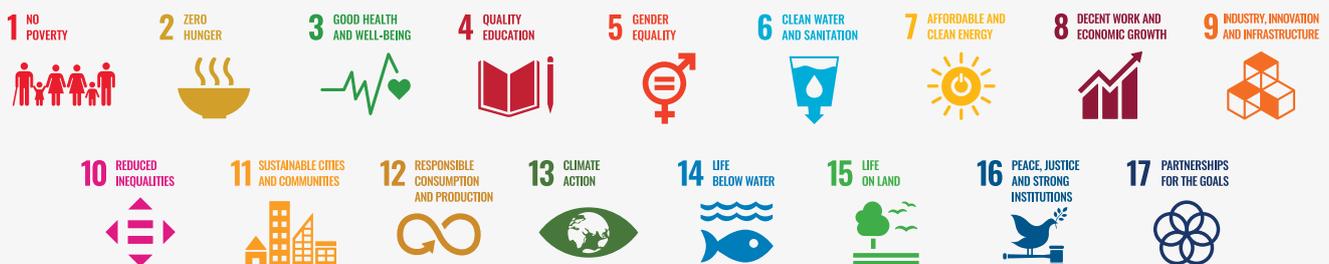
There are well documented criticisms and challenges regarding the targets for the UN SDGs not being achieved by 2030. Although some of these may be true, it does not

prevent countries attempting to progress the SDGs and give benefits to their populations which might not have arisen without having the focussed SDG approach in place.

There are many examples of how IIW Members have previously cooperated and collaborated with developing countries to assist in improving their national welding capabilities [8]. Such examples include amongst others: Germany has assisted China, Vietnam, Ethiopia, South Korea and Indonesia; France has assisted Thailand, Morocco and Kazakhstan; UK has assisted Malaysia; USA has assisted Trinidad and Tobago; Japan has assisted Vietnam and Egypt; Austria has assisted Indonesia; South Africa has assisted Africa (IAEA); South Africa has assisted Nigeria; Holland and Canada have assisted South Africa; Portugal has assisted Brazil, Angola and Mexico; Spain has assisted Peru and Mexico. The main emphasis in all of the examples mentioned was on education and training and transfer of appropriate technologies.

Even though these examples happened over the past three decades, the experiences and results achieved can be used to introduce new projects today. For example, the UN has had a range of programmes which countries benefitted from. Reference [9] gives examples in a number of countries of UNIDO's programme of direct support to industry under trust fund arrangements, Reference [10] shows how UNIDO visited Vietnam to study the status of welding in Vietnam and the requirements for improvements and welding training development and Reference [11] shows many of the programmes which have been available within UNIDO to help developing countries.

## SUSTAINABLE DEVELOPMENT GOALS



## 2. The Importance of a Country's National Welding Capability (NWC) and its Significance to the UN Sustainable Development Goals (SDGs)

The original concept of the IIW NWC Project was to assist developing countries to create an optimal NWC in their countries and hence improve the quality of life in the country.

Imagine, if you will, a person sitting at a desk in such a developing country with a blank piece of paper and being given the challenge to create a plan to implement and grow the NWC of the country. This would be a herculean task but with the assistance of people around the world with the experience and knowledge on implementing the NWC building blocks, such a person, with the right team, culture, drive and enthusiasm, could build the NWC Project up at a much faster rate than on their own. This will also involve coming up with a national plan.

In line with fundamental humanitarian principles, any national plan must have as a main objective, the improvement of the quality of life of people in the country and its biodiversity. Most people simply want a job, personal security and health for their family, a decent roof over their heads, education for their children, food in their stomachs and a sustainable positive environment around them benefitting biodiversity.

The IIW NWC project therefore aims to assist a country's industry, government or IIW Members to achieve the following objectives:

- to identify the welding related needs in the country and provide solutions to ensure the country's future sustainability in relation to these needs;
- to implement its own National Welding Capability (NWC) Project as a Flagship Program;
- to identify the country's existing capability and consolidate the existing welding related 'building blocks' in the country to create the basis for an NWC;
- to analyse, and identify the improvements required in the existing welding related 'building blocks' as well as what additional 'building blocks' are required in the country; and
- to create the mechanisms and processes, to establish and maintain the country's sustainable NWC including the possible establishment or improvement of a national organisation(s) responsible for leading the promotion of welding and related disciplines.

The welding industry is taken as those organisations and people:

- involved with the total life cycle of welded products/ structures including design, manufacture, fabrication, construction, conformity assessment, inspection and testing, operation, maintenance, repair and decommissioning including recycling, repurposing and other environmental conditions
- engaged in, or employing, any of the organisations or people involved above;
- supplying welding equipment or consumables or materials to be welded; and /or
- involved with education, training, qualification, certification, research and development, work, health and safety (WHS), standards and industrial relations aspects of welding.

Key areas identified in a country to assist in achieving the SDGs in conjunction with the welding industry improving its national welding capability include, amongst others, establishing or improving:

- the support infrastructure provided by the welding industry
- research and development
- technology transfer
- national and international networks
- education, training, skills and careers
- qualification and certification of both individuals and companies
- appropriate cultures
- communications and marketing
- resourcing the strategies and actions required

In the IIW NWC Project, Guidance Notes (GNs) are presently being produced to cover each NWC Building Block, each containing a Plan-on-a-Page with a Goal, five Objectives and 30 Strategies, and the start of an Operational Plan for each Strategy.

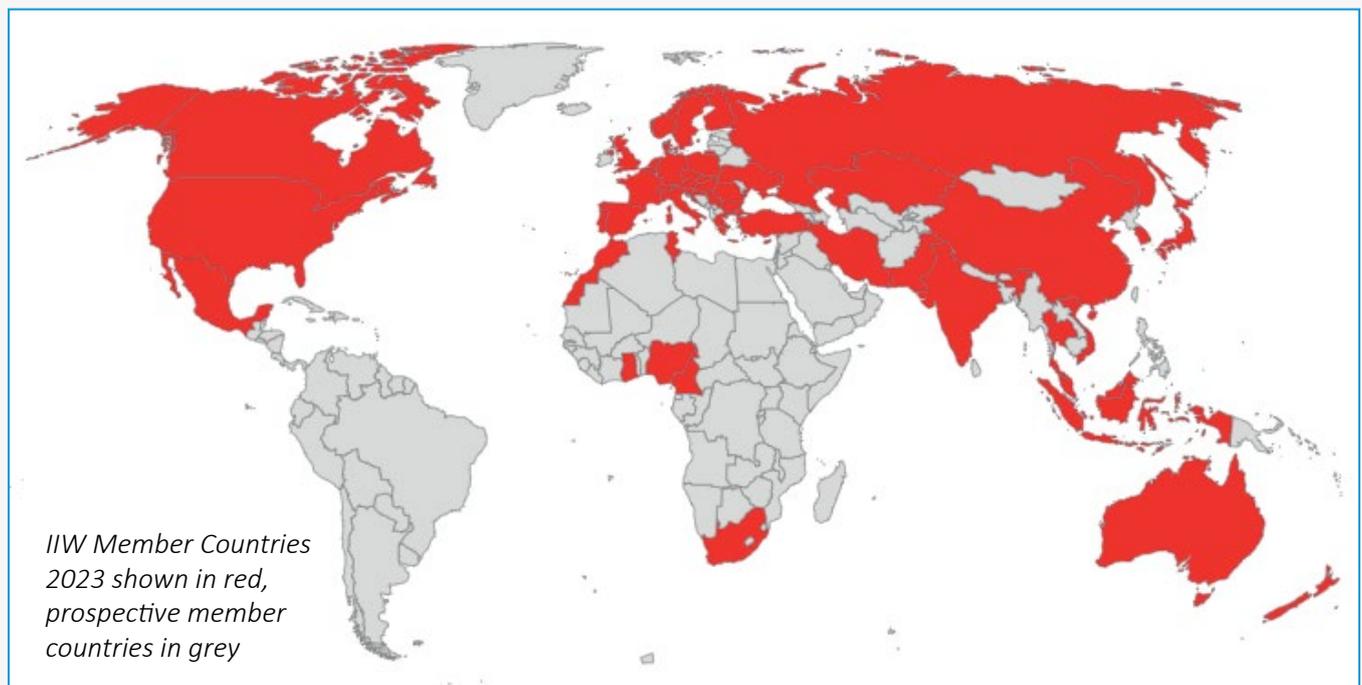
The concept of each Guidance Note is that the user can link through each strategy to an IIW NWC Resource Centre with information pertinent to that particular strategy. The information obtained through the links, documents, references, reports etc in the IIW NWC Resource Centre will have been gathered from the experiences of organisations and individuals who are prepared to share their successes and lessons, including challenges and failures, with the global community.

The user of the Guidance Notes will then decide which strategies (those shown in the GNs or amended or new ones) and information to use to meet the outcomes required in their own country's National Welding Capability Project business plan. Such a plan helps:

- to continually clarify the thoughts and intentions of all NWC Project participants as a roadmap in the efforts to create a successful NWC.
- to assist a non-NWC person to understand why the NWC Project exists, what is expected from it, how it will achieve its expectations and the potential role for such a person in the NWC Project.
- Such people could include, amongst others:
  - Government and Aid Agency representatives;
  - a new NWC Project staff member;
  - any person interested in any aspect of the NWC Project work.
  - A new, or potential, participant in the NWC Project
  - A new, or potential, member organisation.
- to improve the image of both the welding industry and the NWC by showing people that the NWC is a progressive, modern, pro-active, enthusiastic project worthy of support and involvement.
- to determine required NWC Project resources including staff, facilities, NWC Project membership, funding, mentoring amongst others.
- to continually show the value of, and return on, the efforts by all parties for the country.

Today, improving a country's national welding capability will have a significant effect on improving its UN Sustainable Development Goals to varying degrees:

- with the assistance of people around the world with the experience and knowledge on implementing the NWC Project building blocks, a person, with the right team, culture, drive and enthusiasm, could build the optimal NWC for the country and help improve targeted SDGs in that country.
- the role of engineering in achieving each of the 17 SDGs is also highlighted in the UNESCO Engineering Report titled "Engineering for Sustainable Development: Delivering on the Sustainable Development Goals" published on 4 March, 2021 [7].
- when one considers the networks which the IIW, its 51 Member countries, universities, colleges, research organisations and companies involved in welding have, bringing all the available welding resources plus other capabilities required for development together to assist in achieving SDGs, can have a remarkable positive effect globally on all countries.
- the Covid-19 Pandemic has brought major challenges to all countries in particular the poorer developing countries. To achieve the optimal NWC in each country as well as contribute to the SDGs, it is becoming even more important on how to assist countries with both concrete ideas and practical support.



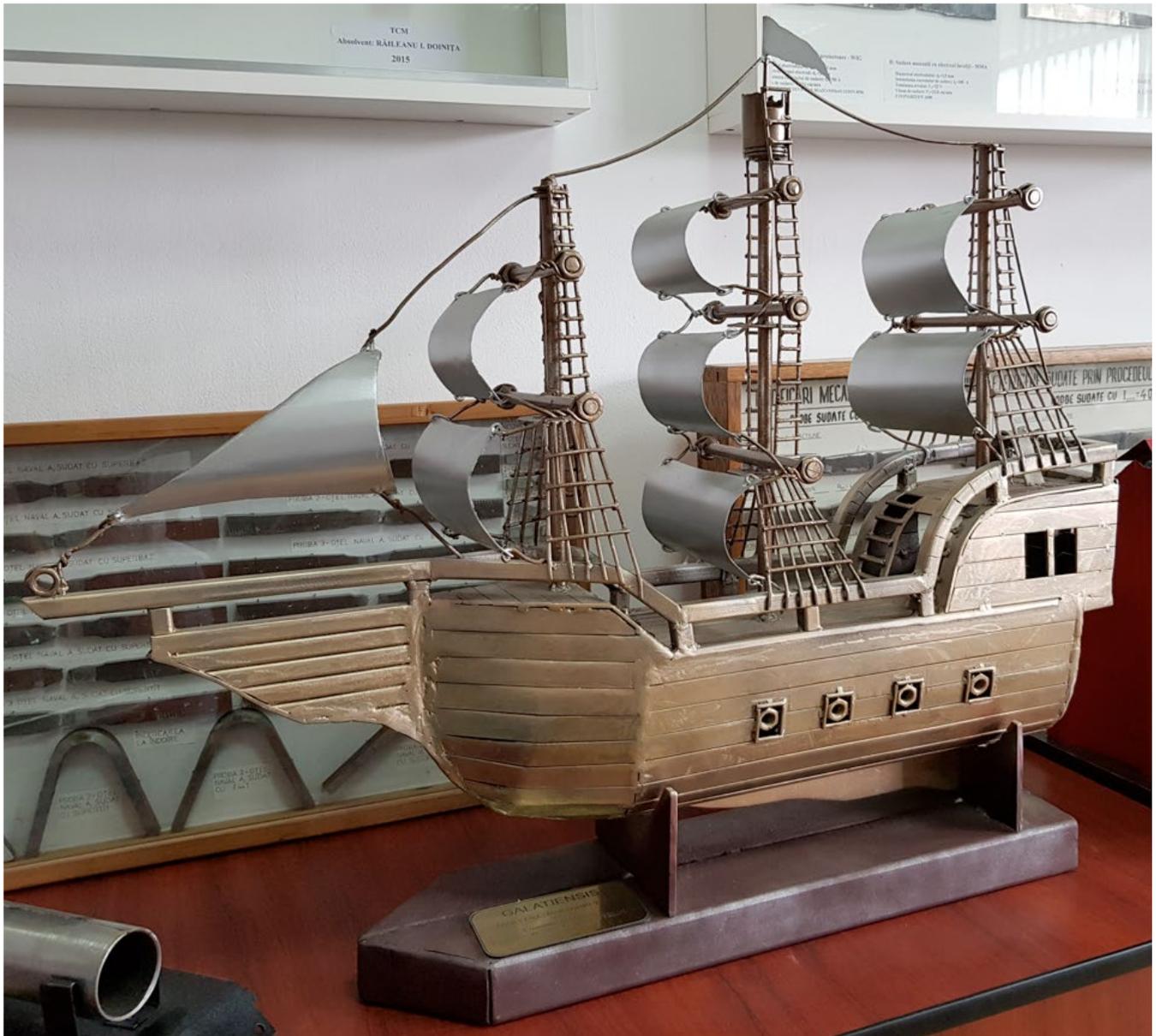
### 3. Some Beneficial Outcomes of a Flagship Programme on the NWC and SDGs

To link the NWC and the SDG could involve strategies being introduced by a country including implementing a Flagship Programme with a single global focus “To Assist the Country to Establish, Sustain and Improve Its National Welding Capability and Progress its UN Sustainable Development Goals”. Such a Programme may have many initiatives and projects associated with it but all related to the single global focus.

Having such a Flagship Programme and harnessing an improving NWC, the welding industry's contribution to the UN SDGs can be immense and helps to:

- develop short, medium and long term strategies to meet the needs of a country including agreed prioritised SDG targets;
- ensure that the needs and solutions are appropriate and relevant and help minimise waste of money and effort;
- assist in identifying and securing both local and international funding for the required activities, ensure its proper use and control of the finances and maximise the value of the return on the investment by all parties;
- determine where the most progress can be made, in the most efficient manner, for the most beneficial return;
- assist in being able to see how different government funding and innovation programmes work in other countries and hence learn from these experiences when seeking new programmes and funding in one's own country;
- bring forward how different and/or comparable countries are achieving their optimum NWCs and their SDGs;
- implement appropriate solutions to ensure that the required numbers of personnel of all types and categories are available to achieve the optimal NWC and agreed SDG targets;
- create the appropriate links, culture and teamwork necessary to achieve the challenges in the NWC Project;
- improve the cooperation and collaboration between all NWC Project groups;
- in a relatively short time period, grow the number of people involved in a national association of welding related personnel to appropriate levels;
- make it easier for the exchange of people, ideas, facilities and equipment between organisations;
- ensure that the competent personnel are available at all levels to identify the problems, find the solutions, deliver these to industry and assist in the receiving, adopting, adapting and implementing of the solutions to increase company and industry performance and hence a successful NWC and hence SDGs;
- continually improve the credibility of the NWC Project groups and SDG initiatives to governments, industry, sponsors, investors etc;
- create a culture for governments and industry to recognise the benefits of investing in welding related activities which normally do not have the same star appeal as say biomedical, information technology and other activities;
- maximise the promotion, marketing and communication of all NWC and SDG Project activities both nationally and internationally;
- act as the catalyst for bringing individuals and organisations as experts to the country to assist in the various NWC Project activities appropriate to their expertise;
- provide opportunities to 'showcase' success as well as give recognition to individuals and organisations at all levels who have contributed to building up a successful NWC.

Shown below under each SDG are a few examples for each of the 17 SDGs on how welding can make positive contributions both in a country and globally.



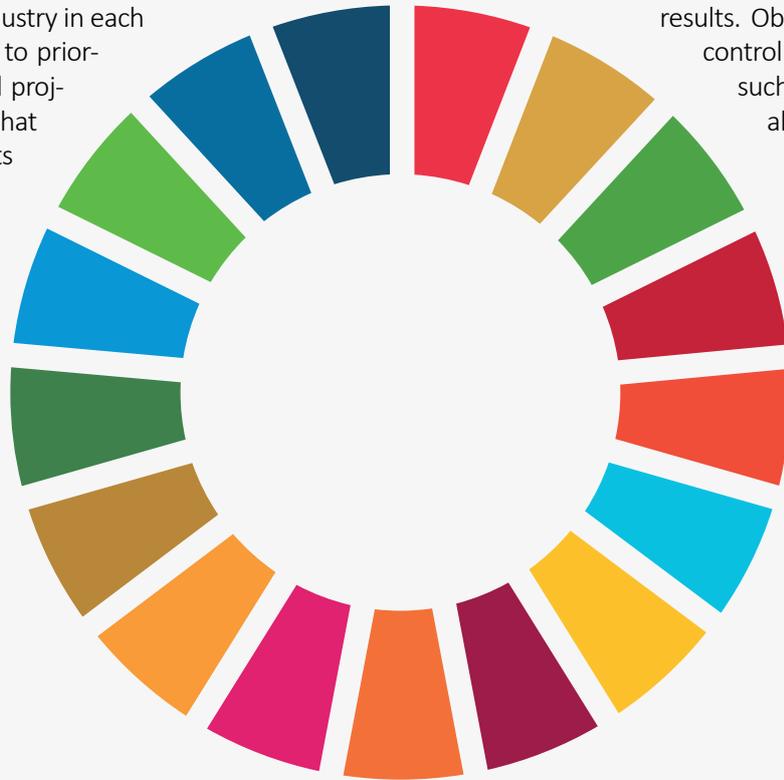
*Galatiensis*  
Ivan Baraghin, Romania. IIW 2023 Digital Collection  
Reference [113]

## 4. Challenges and Potential Welding Industry Initiatives and Innovations for Each UN Sustainable Development Goal

The title of each UN SDG has been used, and together with the number of targets and indicators for each UN SDG, more detailed information on each UN SDG can be found at [https://en.wikipedia.org/wiki/Sustainable\\_Development\\_Goals](https://en.wikipedia.org/wiki/Sustainable_Development_Goals) [6]. The volume of information and activities related to welding which can have a positive effect upon the SDGs is immense so only a few examples are shown under each SDG below. The welding industry in each country will also need to prioritise the strategies and projects it implements so that its resources and efforts

are devoted to do the most good and beneficial outcomes will be realised.

In some SDGs, an Industry Sectoral Project (ISP) approach has been recommended since this approach harnesses all relevant groups from industry, government departments, research and academia, education and training at all levels, amongst others, giving optimal ownership, effectiveness, efficiencies and results. Obviously, factors outside the control of the welding industry such as pandemics and global financial crises can have major negative effects on the best laid plans.



## 4.1 End Poverty in All Its Forms Everywhere



### Overview of SDG 1

*Achieving SDG 1 would end extreme poverty globally by 2030. One of its indicators is the proportion of population living below the poverty line. The data gets analysed by sex, age, employment status, and geographical location (urban/rural).*

*It is hoped that the mobilisation of resources and the establishment of poverty eradication policy frameworks at all levels can be implemented to help achieve the end of poverty. The eradication of extreme poverty, reduction of all poverty by half, implementation of social protection systems, ensuring equal rights to ownership, basic services, technology and economic resources, and the building of resilience to environmental, economic and social disasters are key to this [6].*

### Introduction

The challenges facing many developing countries including from geo-political and socioeconomic viewpoints can be immense. As an example, even though Nigeria is now the largest economy in Africa, with a GDP of USD397 billion and accounting for 17% of the continent's GDP, 40.1% of Nigerians (83 million people) live in poverty and growth per capita has been negative [12]. Reducing hunger and improving education lead to increased wealth and resilience.

The poor health and education services for those who cannot afford to pay is also a driver of poverty. Key to a country's efforts at addressing poverty is to recognise the centrality of women in producing healthy children if they can do so when they choose, contributing to productive households if they have access to essential services, such as water and sanitation, and agricultural support [12].

A key challenge will always be to be able to combine environmental conservation with job and income generation and economic growth. Mobilising the resources of the global welding industry can be a means to creating numerous employment opportunities and the achievement of reducing poverty.

Mohandas Karamchand Gandhi is widely recognized as one of the twentieth century's greatest leaders and led many campaigns against inequality and poverty. Due to his stature, he is now referred to as Mahatma, meaning "great soul." He was also famous for his quotes related to poverty including "There's enough on this planet for

everyone's need but not for everyone's greed", "Poverty is the worst form of violence", "To a man with an empty stomach food is God".

### Some factors to be considered by the Welding Industry

Welding technology is an enabling technology used across almost all industries and a wide range of materials and applications, from micro-joining of medical devices, electronics and photonics, to larger scale applications such as bridges, buildings, ships, rail, road transport, pressure equipment and pipelines.

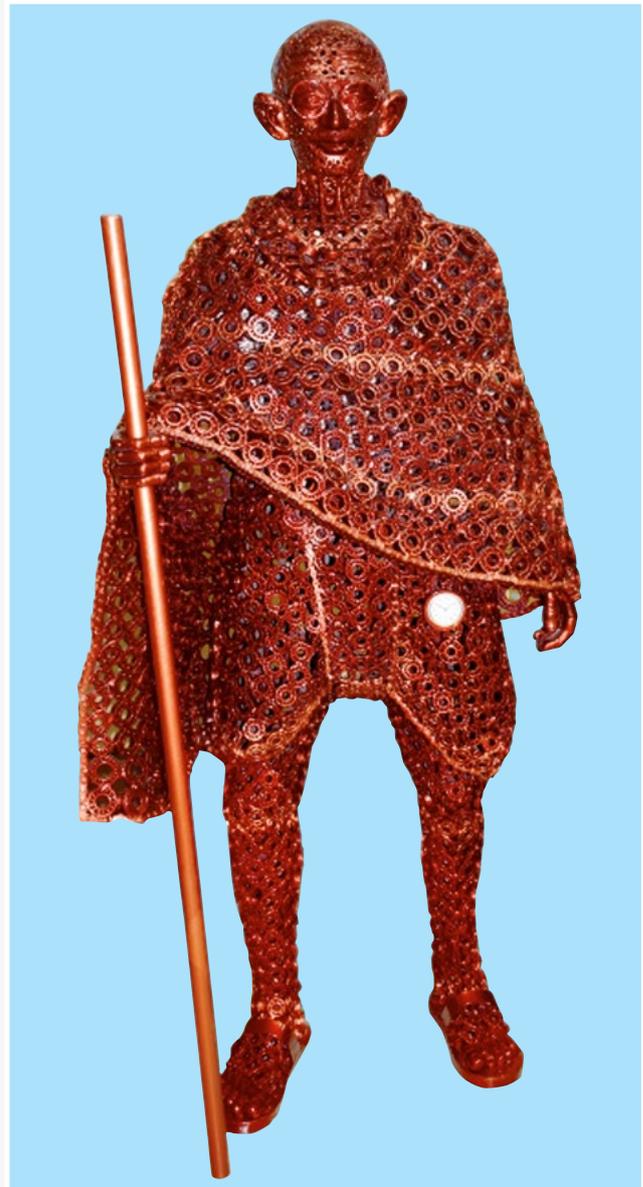
- It encompasses the total life cycle of welded products/structures including design, manufacture, conformity assessment, inspection and testing, operation, maintenance, repair and decommissioning including recycling, repurposing and other environmental conditions. It is critical to the infrastructure of any country;
- History shows many examples of the importance of welding to the world. The formation of the International Institute of Welding (IIW) itself illustrates this. After the devastation created through the Second World War, Europe in particular, was in a terrible mess but countries got together in 1947 and formed ISO and IIW amongst other organisations to somehow build up the quality of life again. 13 countries formed IIW (11 European, USA and South Africa). This number has

grown to 51 illustrating the importance countries give to welding [1];

- Examples of the value of welding to economies of countries and its contribution to improving quality of life have been shown over many decades [13], [14], [15], [16], [17], [214];
- Federal, State and Local Government and industry initiatives in different countries, results of these initiatives and success stories from local and overseas sources can all be used to show the importance of welding to a country and its effect on alleviating poverty;
- One comprehensive study in the USA (2002) surveyed the manufacturing, construction and mining industries in which welding was a critical enabling technology [13];
- It found their combined revenue totaled some USD3.1 trillion, or about one-third of that country's gross domestic product. Direct welding costs were USD34.1 billion, 70% of which was labour costs. The labour costs for welding activities was in fact about 4% of the total labour costs for those industries. The true value added by welding technology in this example is probably at least ten times the direct welding costs due to the added value to the economy after the implementation and use of the technology;
- The German Welding Society (DVS), has regularly arranged for the economic significance of various joining technologies to be investigated and quantified in scientific expert reports (in 2001, 2005, 2009, 2013, 2017). These originally applied to the value added and employment connected with the production and application of welding in Germany and were then progressively expanded for other joining technologies and for various other countries in Europe and the EU [14].
- Such information has been used by the European Union (EU) to establish a Joining Sub-Platform within the Technology Platform "Manufuture". The Manufuture Technology Platform was implemented to create a strategy regarding research and innovation in manufacturing. Part of the justification for the Joining Sub-Platform is that joining is a core element of innovative and sustainable manufacturing and will have its own strategic research agenda funded by the EU [17].
- Welding contributes positively to all human endeavour and the quality of life of all. It does this in numerous ways, whether through creating power for lighting and cooking, potable water and safe sanitation, national infrastructure, efficient, safe and effective transportation, accommodation both for living and working, a multitude of machines for different industrial applications, medical, health and safety devices and by many other ways. All of these are also linked to job creation.
- Without welding, people around the world could not switch on a light, turn a tap to access water, travel by train, road, sea or air, or use a computer or a multitude of other applications which improve the quality of life.
- In short, welding contributes to improving the national and global quality of life including the mental health and physical wellbeing of current and future populations and makes a major contribution to alleviating poverty.
- As the governments of many countries have identified, ending poverty in all its forms is a multidimensional challenge involving many of the SDGs. Besides increasing the monetary income of the poorest, it is necessary to overcome all the other deprivations derived from poverty. Improving productive capacity through better access for the poor to transportation, infrastructure, energy, basic sanitation, improved housing conditions, better education as well as less vulnerability to disasters and diseases amongst others is acknowledged as a key challenge to eliminating poverty [18].
- The welding industry and their networks could assist in finding solutions to meet some of these challenges through the implementation of welding and related appropriate technologies, creating more job opportunities, reaching out to far greater numbers of people than in their current networks, creating greater educational opportunities and career paths [220].
- As mentioned previously, the vast majority of people in a country simply want a decent job, food, education, health, safety and security and a roof over their heads for their family as well as a decent environment to bring up their children. Welding industry initiatives will help progress such aspirations.
- As mentioned above, over the years, the welding industry has been able to show the value and benefits of its work and outcomes of that work to a country. Many of the examples and initiatives developed by it over the years contribute to ending poverty and improving the quality of life.
- Industrialisation through manufacturing and construction can lead to economic growth – and most importantly – with the creation of quality jobs with a high labour absorption rate. In metals manufacturing and construction, welding is the enabling technology that allows these activities to take place. Welding, as a career choice, is able to absorb unskilled, poorly educated people and give them in-demand, well-paid, high quality jobs as well as through further education and training, give them career paths to even better opportunities in the welding industry [19].
- Good welders will continue to be in demand. Globally, the welding industry has grown to make up approxi-

mately 2% of the world's GDP and it employs around 3 million people around the world. Despite the pandemic, this sector exhibited a modest growth and is projected to globally grow from USD20.99 billion in 2021, to USD28.66 billion in 2028 [81]. These latter growth figures only include the sales of welding equipment and filler materials and none of the value added by the manufacturing, fabrication, construction, repair and maintenance industry sectors.

- Assessments of the importance of the metals industry's effects on social, human, natural and physical/financial living standards have concluded that the metals industry contributes strongly to the economic performance and well-being of countries [20]. In 2021, Business and Economic Research Limited (BERL) conducted an assessment of the potential economic impact of Industry 4.0 technologies in Construction on New Zealand and concluded an increase of 0.5 to 1.0% in GDP could result over the next five year period [21].
- Although there are still problems with the adoption and impact of Industry 4.0 in many countries, the welding industry is also now focusing on the introduction of Industry 4.0 which if successful is anticipated to give unprecedented transformation to a country's industry. The introduction of new and appropriate technologies besides saving time, will boost productivity, reduce waste, expand business models and be more responsive to fast changing environmental and consumer demands which will all contribute to the improvement of the quality of life [235].
- One of the best examples of a national welding institute being able to show the value of its work particularly related to technology transfer is that of TWI in the UK. Together with industry funding and its own funds, TWI had received significant funding from the UK government for a project "The Joining Forces Programme" aimed in particular at technology transfer to small and medium sized enterprises (SMEs). The 15m pound programme ran for five years from 1994 to 1999, and an evaluation on the success of the project was carried out in 2000 by the UK Government Department of Trade and Industry (DTI).
- Reference [15] shows the excellent results from many aspects. In particular, the results of the value for money evaluation were so good that the Welding Technology Institute of Australia (WTIA) built upon the principles of the evaluation to show Australian Federal and State Governments and industry the value of the projects which it successfully undertook from 1998 to 2011.
- Furthermore, based on this previous work by both TWI and WTIA, HERA in New Zealand, a country with a small population, prepared its own successful approach to



*Mahatma Gandhi*

*Bichitra Kumar Padhiary, India. IIW 2023 Digital Collection*

*Reference [113]*

measuring and showing the value of its products and services to the New Zealand economy [22], [214].

- In many developed countries, the shortage of skilled welding personnel is significant due to a variety of reasons and creating major problems in manufacturing and infrastructure creation. In developing countries, if the SDGs are to be met, an immense number of employment opportunities in the welding field will need to be filled. Innovative solutions are being sought.
- The CWB Group publishes an employment and salary report on the Canadian Welding Industry which contains an immense amount of useful information for both individuals and companies [182].

- Such a report could be used as a model for implementation in other countries. In particular, such reports can be used to identify the industry skills needs and help people at various levels and situations obtain the skills required for the potential employment opportunities to help them avoid poverty.
  - Consider a region of subsistence farming, collective farming or individual large farms, access to skilled people and equipment is essential in order to make components and perform repair and maintenance using welding.
  - A key objective should be to train as many people as possible in the area in the appropriate welding skills and knowledge for any eventuality which may arise. Such people can also use the skills and knowledge for non-agricultural purposes as well and develop other businesses in the rural areas as well as increase the opportunities for employment in various industries. In particular, a true entrepreneurial culture could be developed at the micro-enterprise level.
  - It is also important that people understand the career opportunities and job opportunities that are available.
- Recruitment Bridges [190] and Employment Fairs [191] are examples of tools which can be made available for this in India.
  - In India, Pradhan Mantri Kaushal Vikas Yojana (PMKVY) is the flagship scheme of the Ministry of Skill Development and Entrepreneurship (MSDE) implemented by the National Skill Development Corporation (NSDC). The objective of this Skill Certification scheme is to enable Indian youth to take up industry relevant skill training that will help them in securing a better livelihood [224].
  - It is also important that both local people and immigrants into a country are able to receive proper recognition and accreditation for existing skills and knowledge so that they are not inhibited from entering the correct training courses and then employment market [74], [191], [192].
  - The CWB Group, Focus Humanitarian Assistance (FOCUS) and Karabuk University in Turkiye, have combined in an excellent team effort to train, certify and find employment in Canada for 200 Afghan refugees presently living in Turkiye [192], [223].



*IIW Commission XII: Involved with advanced manufacturing systems*



*IIW Commission XVIII: Involved with the quality of welding operations and systems in manufacturing*

## 4.2 End Hunger, Achieve Food Security and Improved Nutrition, and Promote Sustainable Agriculture



### Overview of SDG 2

*A key 2030 target with SDG 2 is to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality [6].*

### Introduction

The Food and Agriculture Organization (FAO) is a specialized agency of the United Nations that leads international efforts to defeat hunger. According to the FAO, in a definition established at the World Food Summit (WFS) in Rome in 1996, food security is achieved when everyone has physical, social and economic access at all times to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Unfortunately in many developing countries, food security is declining dramatically.

Governments in various developing countries have created sets of public policies focused on combating hunger and food insecurity, ranging from social protection policies, especially income transfer programmes, to specific policies to foment agricultural production, through credit provision and public programmes for procuring the production of family farming [23].

In 2019, 144 million children under the age of 5 were stunted and 47 million were affected by wasting. It is critical for a country to stimulate healthy nutritional habits since astoundingly cheap investments made today in better nutrition for children can lead to better education and more productive adult lives. Research in Ghana and Malawi has shown that with this approach, it can cost as little as USD5 per mother and yet save lives and transform live-long prospects so that each dollar spent delivers USD36 of social returns [24].

Poverty in many countries has markedly rural traits. The reduced access to land and income by small farmers is historically associated to the land concentration prevalent in the country, to very low rates of labour formal-

isation and to the scarcity of public services in rural areas. Enhancing agricultural productivity, sustainable food production systems and resilient agricultural practices would be worthwhile achievements for the welding industry particularly through an Industry Sectoral Project (ISP) approach.

To achieve food security, end hunger and promote sustainable agriculture while at the same time protecting flora and fauna, is a major challenge. In order to feed all the growing populations, it is vital not to allow environmental degradation and biodiversity loss. It is now a significant problem in many countries, both developed and developing, where the changes being made related to food production are now taking a heavy toll on the natural world around us.

### Some factors to be considered by the Welding Industry

- Agriculture plays an immense role in shaping the economy of developing countries. The agricultural sector is also a crucial aspect of first world countries. This is because this domain provides the main source of food, income and employment to their rural populations. Currently, it has been established that the global share of the agricultural population in the total populace is 67%, that agriculture accounts for 39.4% of the GDP and that 43% of all exports consist of agricultural goods [25].
- Unfortunately, many developing agricultural producing countries depend on agricultural imports and food certainty and many emerging countries will not refine



*Unity with Nature – Conservation of Fauna and Flora*

*Ivan Iliyanov Georgiev & Marijan Magdalenov Panayotov, Bulgaria. IIW 2023 Digital Collection, Reference [113]*

without a significant increase in local production. Farming throughout history has had good times and lean times and even with periods of healthy animals and crops, the risk of flooding, pestilence and war, are always present.

- Food production throughout the world is seeing new methods implemented through the introduction of technologies such as AI, IoT, Automation, Urban agriculture with Smart design and vertical farms, use of drones, amongst others.
- On the other hand however, some predictions on major issues affecting food production in 2020 included:

- climate change;
- the ongoing trade war between the United States and China;
- rapidly depleting reserves of freshwater around the world;
- the *looming food crisis*;
- economic insecurity in the United States;
- ongoing closures of food processing facilities and local businesses due to the COVID-19 pandemic;
- depletion of natural resources due to widespread industrial agricultural practices;

- ▶ high rates of food waste, which threaten to intensify food insecurity around the globe;
- ▶ disruptions in trade networks and fluctuations in global demand for agricultural products;
- ▶ economic strife and crippling debt for individual farmers;
- ▶ wars and ongoing conflicts.
- Although there are many factors which can produce hunger in the population in a country, if one considers some of the elements required to assist a country to be able to grow, harvest, store, process and distribute food, the welding industry can assist at each stage in ensuring success and add value to a country's food production needs and hence reduce the probability of hunger.
- At the planting, growing, irrigating and harvesting stages, there will always be a need to assemble, install and repair equipment such as tractors, tilling equipment, planters, balers, combines, ploughs, mowers, harvesters, grain and feed handling, dams, sprayers and irrigation equipment. Similarly, with storage and distribution, storage and drying equipment, boiler and boiler components, scrubbers, fans, pumps, conveyors, gearboxes and turbines as well as forklift trucks, pallets, lorries.
- As mentioned previously, even if one is in a region of subsistence farming, collective farming or individual large farms, access to skilled people and equipment is essential both to make components and perform repair and maintenance using welding.
- In developed countries, many farmers call on companies to perform such work which could add considerable costs to food production, or the farmer or employee attend training courses at colleges to obtain the required skills to perform such work. A key objective should be to train as many people as possible in the area in the appropriate welding skills for any eventuality which may arise. Such people can also use the skills for non-agricultural purposes as well and develop other businesses.
- Some innovative ideas over the past four decades in countries such as Australia, Canada and the US have involved mobile welder training centres which can be driven to all areas accessible by road.
- The availability of welding supply companies to offer technical advice and welding supplies to such farmers is also critical. Timing is very important since the farmer cannot wait in the middle of planting or harvesting to fix machinery. Transfer of appropriate technology to farmers is much easier today due to the more acceptable forms of communication such as the latest welding news, blogs, podcasts, virtual conferences, online courses, and digital tools designed to help people grow and succeed.
- With respect to food processing the hygienic requirements of for example the food and beverage industry, place high demands on the welds that hold tanks, pipes and vessels together.
- The requirements specified in codes and standards for a high-quality weld and weld surface finish are paramount in the dairy and other food and beverage industries, as the consequences of poor surface and weld quality can be costly and dangerous.
- Contamination scares in the dairy sector provide some examples of the consequences of not getting things right. In effect, every metre of weld inside a storage or process tank or vessel represents a risk to be managed. Fabricators must make significant efforts to ensure that both the weld integrity is adequate and that the surface finish meets the specified requirement for hygiene.
- Collaborating with organisations such as steel, aluminium and stainless steel associations in their networks can also help the welding industry ensure a competent industry is available using appropriate technologies to be able to build, repair and maintain the relevant plant, facilities, infrastructure and equipment for fertiliser production, food processing, storage and food transportation as well as agricultural equipment and facilities [71], [199], [200], [201].
- Agricultural based economies thus face some significant challenges which the welding industry can contribute solutions to. Production of agricultural goods and point-of-use is often a big problem because of poor infrastructure and road connectivity and efforts are necessary to improve the logistics by way of improving the road, rail and waterways networks where they exist.
- For grain storage, sufficient storage space and appropriate environmental conditions are often not available leading to wastage of food grain. Efforts are being made to store the food grain in large stainless steel silos with proper nitrogen purging and humidity control [28].
- Metro rail links could be planned from rural to larger cities and coaches reserved for perishable goods such as fruits, vegetables etc. Refrigerated vans/containers could be provided for exotic vegetables, dairy products and sea food [28].

## 4.3 Ensure Healthy Lives and Promote Well-Being for All at All Ages



### Overview of SDG 3

*There are many factors negatively affecting the well-being of people globally. SDG 3 sets out to improve all the different aspects impacting peoples' well-being. One aspect is mental health which is associated with a number of factors such as diet, exercise, stress, drug abuse, social connections and interactions, poverty, security amongst others. All of these are intimately associated with most of the SDGs. Depression and anxiety are probably the most common mental disorders [6].*

### Introduction

Ensuring healthy lives and promoting well-being is important to building prosperous societies.

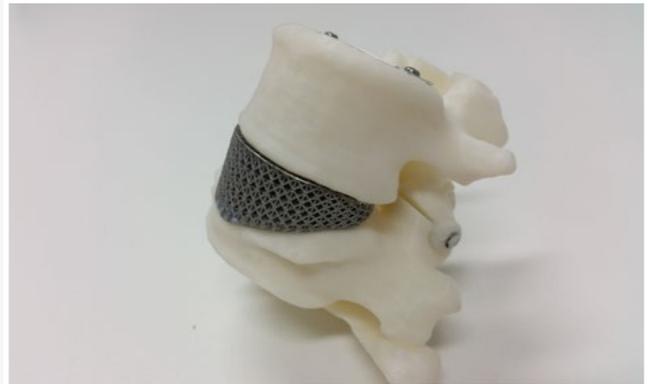
Healthcare is variable throughout many developing countries. Urban centres may be well served in many cases and where most hospitals, clinics and pharmacies in the country can be found. Rural areas often have no modern healthcare services and patients in these areas either rely on traditional medicine or travel long distances for care. The Covid-19 pandemic has exposed large gaps in the health sector in many countries, including the need to build more district-level hospitals [12]. Most countries, especially poor countries, have insufficient health facilities, medical supplies and health care workers as shown in the recent surges in demand.

Many countries have very limited local production of pharmaceuticals and even less manufacturing of medical equipment and devices and rely on imports for a very high percentage of their total healthcare consumption although this can lead to increased opportunities for local manufacturing particularly through an Industry Sectoral Project (ISP) approach.

### Some factors to be considered by the Welding Industry

- Technological improvements can lead to cheaper and more efficient components, better recovery, reduced surgery times and greater access to the wider population. The integrity and reliability of the plant and equipment to produce pharmaceuticals, medical gases and medical radioisotopes relies on the availability of competent welding personnel and companies as well as appropriate welding related technologies. Medical radioisotopes are classified as essential products and in many countries the government both manufactures them and imports them. Unfortunately, many countries do not have such facilities but over the past four decades, the International Atomic Energy Agency (IAEA) has made significant inroads in various regions of the world to provide competent personnel and facilities to rectify this situation [29].
- To accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world, one of the main functions of the IAEA – in accordance with its Statute (Article II) – is to assist member states with capacity building, sharing knowledge and expertise and assisting with the procurement of equipment. The IAEA works with its member states to foster the role of nuclear science and technology applications in support of sustainable human development.
- A number of welding industry companies produce medical gases and are involved in installing them into the national networks of hospitals and medical facilities. The criticality of this industry was shown by the reported massive needs for oxygen during the Covid-19 crisis.
- The importance of building good infrastructure such as for roads, rail and plant also helps reduce road injuries and deaths as well as reduces illnesses and deaths from hazardous chemicals and pollution.

- The welding industry also plays a key role in ensuring that people involved in welding are protected from a health and safety viewpoint. Involvement with many other organisations from industry, government, standards organisations, regulators and IIW among others, has enabled the appropriate standards, guidance notes and educational materials to be available for use throughout any country to continuously improve the well-being of people.
- For example, IIW Commission VIII, 'Health, Safety and Environment,' studies occurrences during the welding process that can potentially affect health, safety and the environment, and additionally looks at the development of technical guidance for correct management of the fabrication process in industry. Commission VIII acts as the global interdisciplinary forum for exchange of knowledge in the industry, supported by the expertise of its members who represent different scientific disciplines including medicine, chemistry, occupational hygiene and welding engineering.
- One of the most effective ways to improve work health and safety is through the effective application of the laws and regulations which exist in many countries. Unfortunately, where such enforcements do not take place, many accidents and health problems related to welding activities do occur. There are many examples of people particularly in the informal economy in developing countries ignoring even the basic requirements of maintaining work health and safety standards [89]. For example, ignoring the simple requirement to use correct welding masks to protect injuries to the eyes has led to quite a number of such significant injuries in Ghana [225].
- The key to development and continuous improvement in a WHS culture is to change attitudes and behaviours at all levels. IIW and its members have been very active in creating awareness through education, training and technology diffusion throughout the world but it is probably at the stage where both national and international collaborative projects could be implemented to improve this culture on a global basis.
- With respect to linking welding to assisting people to have healthy lives and well-being, probable good examples are those related to equipment and medical devices. Such equipment could include examples such as medical gas distribution and piping systems which are critical for use in hospital operations and patient care to the more exotic examples involving a wider range of materials and process challenges as well as operating conditions. Some developed and implemented in IIW member countries, for example, related



*First 3D printed titanium spinal disc in Australia that was implanted into a patient in 2016.*

*Supplied by Distinguished Professor Milan Brandt, RMIT Centre for Additive Manufacturing.*

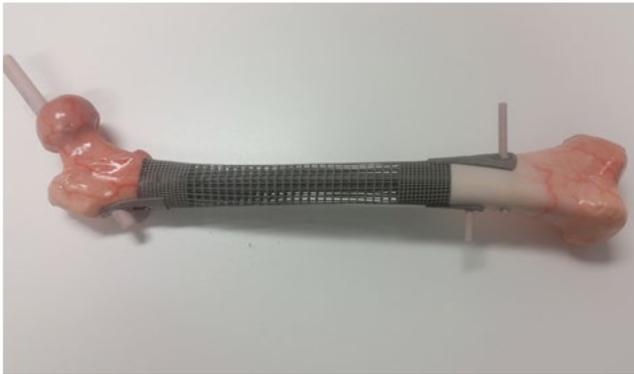
to medical devices, implants, prosthetics illustrate this [30], [31], [32], [229], [230].

To ensure the continuous well-being of people in a country and continued accessibility to health systems to increase life expectancy, welding and joining technology transfers are needed and contribute to meeting various medical objectives including past and present examples such as the following:

- design, materials selection, joining of exotic materials, surface coatings;
- replacement or augmentation of body parts (e.g. hip implants);
- malfunction assist devices (e.g. heart pacemaker, hearing implant);
- control over regeneration (e.g. stents);
- transient devices (e.g. pins or screws in broken bones);
- methods during assembly fundamentally influencing design, performance and cost.

In the past, specific challenges have included:

- medical devices involving welding and allied processes have been increasingly in demand. Not only does interconnection and packaging technology dictate the electrical, optical, mechanical, reliability and service life performance of a medical device, but it often accounts for over 65% of its added value;
- micro-joining technology, involving welding and allied processes, is fundamental to the cost effective assembly of sensors and medical device based products;
- joining issues could at one time be traced to over 80% of failures in devices;
- design, FEA, simulation, animated modeling for virtual visualisation of products;
- size reduction to minimize intrusive surgical procedures;



*3D printed implant Titanium for patients with bone cancers.*

*Supplied by Distinguished Professor Milan Brandt, RMIT Centre for Additive Manufacturing.*

- materials with long-term stress corrosion cracking resistance;
- surface engineering for in-vitro and in-vivo acceptance;
- new materials such as shape-memory alloys capable of surviving hostile environments;
- bio-compatibility;
- hermetic and environmentally sealed assemblies.

Different countries, depending on their needs and existing expertise, may need general outcomes including technology transfer related to:

- fine laser welding and cutting;
- laser welding of plastics;
- laser micromachining e.g. fine hole drilling, sieve and fine filter manufacture;
- laser soldering;
- laser surface modification for implants;
- electronic bonding of ceramic composites;
- titanium performance in medical applications evaluation;
- improved knowledge of materials selection and application;
- improved knowledge of design principles for manufacturing;
- creating facilities for local production of radioisotopes for medical purposes;
- increased use of modelling techniques to improve efficiency, reduce costs and increase profitability;
- improved surface coatings via novel coating and spraying techniques;
- improved awareness of adhesive bonding technology and capabilities;



*Laser welded blood bag*



*Cardiac pacemaker laser welded case*



*Orthopaedic hip joint*

*IIW White Paper*

<https://cld.bz/users/user-36910767433/IIW-White-Paper#/1>

- industry awareness of global issues (Pb-free solder and removal of toxic fluxes);
- industry awareness and uptake of state of art technology such as lasers;
- availability of improved tools for surgery and non-invasive procedures;
- increased incidence of bone and joint replacements;
- increased incidence of implanted devices;
- increased availability of artificial parts used in maxillo-facial and craniofacial treatments;
- increased use of titanium alloys in external prostheses and implanted devices;
- improved surgical instruments made from titanium alloys;
- improved life for implantable devices.

In terms of improving this SDG, results from the above might include assisting countries by:

- enabling technologies made available to innovative manufacturers seeking to push the boundaries of existing medical device technology;
- specialist training courses for engineers and technicians involved in medical device manufacture;
- medical specifications for bio-medical materials, e.g. titanium alloys;
- improved life for implantable devices;
- reduction in premature failures;
- improved quality of life for post-operative patients,
- ensuring high reliability in all types of medical gas distribution and use;
- increasing local production of radioisotopes for medical purposes;
- increasing local production of utility vehicles such as trikes for special needs mobility impaired people [236].

## 4.4 Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities For All



### Overview of SDG 4

*Results of Federal, State and Local Government education and training (E&T) initiatives in different countries, as well as success stories from local and overseas sources, can all be used to show the importance of education, training, skills and careers paths to a country.*

*For this to happen however, the outcome orientated targets for SDG 4 must all be achieved. Free primary and secondary education, equal access to quality pre-primary education, affordable technical, vocational and higher education, increased number of people with relevant skills for financial success, elimination of all discrimination in education, universal literacy and numeracy and education for sustainable development and global citizenship are essential to achieve all the SDGs [6].*

### Introduction

The role of education in ensuring sustainable development is not limited to developing regions but the whole world at large and is a force for nation building and peace. A major objective is to provide an inclusive and high-quality education that will improve the learner's standard of living and the community's future. Children and young people who gain certain skills such as reading, writing or counting, are more likely to have a better future than their peers who lack these skills.

Developed countries can play a key role in assisting developing countries implement projects which could easily lead to improving lifelong learning. These include efficient and economical education and training via upgrading of schools and educational facilities, modern training course resources, remote training, education and examination methods, inexpensive virtual reality training, the Metaverse, grants, scholarships and career opportunities for a diverse range of people.

Care must be taken however since particularly since the Covid Pandemic, there are reports that student discontent with the quality of teaching has risen [50] and online courses which were supposed to bring higher education within the reach of everyone, have dropout rates that typically exceed 90% [51]. Some concerns are that increased profits for individuals and teaching organisations is a key driver.

An OECD study on academic performance at schools found "countries that have invested less in introducing computers in school have improved faster, on average, than countries that have invested more" and that the sole advantage of computers is that they are cheaper than teachers [51].

To be successful, winning nations must also have a number of cultures. These include a skills respect culture, a quality culture, innovation culture and a productivity culture [33]. Linking these will lead to improving this SDG in a country.

Even though national education and training systems are multi-disciplinary, major achievements can be made with this SDG through also adopting an **Industry Sectoral Project (ISP)** approach for the welding industry.

### Some factors to be considered by the Welding Industry

- With respect to educational, training, skills and careers activities, organisational structures in a country are often determined by the rules and requirements of national or international bodies involved in education and training. For example, over 46 countries have established IIW Authorised Nominated Bodies (ANBs) in line with the IIW International Authorisation Board (IAB)'s rules and guidelines [34] and similarly if one

wishes to comply with a country's national system, then one must comply with its rules, guidelines etc.

- Each country will also have its own national education and training requirements for organisations to comply with for recognition in that country. Again whichever structure is to be established, the most important thing is to have all the relevant organisations involved. These organisations must feel that by contributing to the work involved in meeting the education and training needs, the benefits will arise for their industry sectors in terms of better trained, qualified and competent personnel who can be employed in their industry sectors.
- Linked to this also, technology innovation is a necessity for a country to be globally competitive. Innovation can be defined as 'To bring in something new, make changes (ideas, methods etc.) whether in simple or complex forms'. It includes applying inventions and the adoption of research and development (R&D) outcomes.
- Whether a country's economy is considered developed, developing or an economy in transition, innovation is constantly required to meet the growing needs of its population. Innovation includes new products and processes, significant changes to existing products and processes and significant changes to management and organisational structures.
- Understanding the need for innovation, the availability of technology receptors in companies, effective technology transfer mechanisms and appropriate research and development (R&D) are all dependent, to a large extent, on the education, training and related skills of the people in the industry, and hence lifelong learning opportunities.
- None of the above can occur if the correct human resources are not available. Many countries are in the position of having a dearth of well-qualified and experienced personnel in the welding-related fields. Education and training therefore underpins so many other factors influencing an industry's performance and competitiveness and hence the SDGs [217].
- It is incumbent upon both government and industry in a country to investigate, recommend and implement measures that will ensure that the optimum E&T is performed to produce outcomes to meet the needs of the different welding-related industry sectors in the country including skills levels and career paths and routes for people [34], [35], [36], [37], [38], [39], [40], [41]. This will help ensure lifelong learning opportunities.
- Assessments of workforce trends and challenges have been performed and could be used as models to estimate potential workforce needs in a country [36], [81], [151], [182], [197].
- Highly skilled employees, who generally feel more valued, are more flexible and better able to adapt to changes in processes and product design than their lower skilled counterparts and can respond more rapidly to changes in market demand.
- High level skills will become more important to a country's industry as its economy moves towards a reliance on greater skills intensity and knowledge-based industries.
- Economies with lower skills levels might well be at a disadvantage in a global knowledge-based economy where rewards for firms and individuals will flow increasingly to the technologically skilled and innovative, that is with broadly based skills and abilities.
- There must also be sufficient competent researchers in the country to be able to perform the R&D to deliver optimum outcomes in the optimum time so that the technology can be delivered (by technology deliverers) to people to receive it (technology receptors), assimilate it, develop it further if necessary, and apply it.
- A project could be implemented to determine the training requirements for researchers and, working with research organisations, implement the necessary training on an ongoing basis
- Implementing processes for exchange of research personnel between local research organisations as well as internationally could be introduced.
- Processes such as study missions both in and out of the country, technology diffusion mechanisms etc. whereby researchers and young professionals will be continually updated on latest technologies could be introduced. Between 2000 and 2008, WTIA conducted a whole range of industry and research study missions across Europe, Japan and the USA with the support of IIW Members [42], [140].
- There are excellent examples of networks successfully established to bring industry and all levels of government together to supply the education and training for the skills and career paths to create viable industry sectors and overcome constraints as well as fostering partnerships between Small, Medium Enterprises (SMEs), larger firms and training providers [39], [40], [41].
- The development of the International Institute of Welding (IIW) E,T,Q and C programmes and their implementation in 47 countries worldwide illustrates the importance and need for world class personnel to be available in the welding industry in a country [34].
- The vast majority of developed economies also have well established sustainable programmes for the recruitment, training and qualifying of practical welding personnel of all types and levels to meet industry's needs. Similar programmes need to be implemented

in medium to low income countries with the assistance of the developed countries and examples of this do exist.

Consider the different types of personnel who may need E&T to acquire the necessary skills and knowledge to perform their work competently.

These could include:

- Research and Development – researchers [41];
- Technology Diffusion – technology deliverers, technology receptors [34], [38];
- Education and Training – lecturers, teachers, instructors [38], [43], [44], [45];
- Qualification and Certification – examiners, auditors [34];
- Industry Personnel – designers, specifiers, engineering personnel, welding engineers, technologists, specialists, practitioners, welders, artisans and apprentices using welding, inspectors, hobbyists and handy men, maintenance and repair personnel, and stores personnel amongst others;
- Personnel using specific techniques such as additive manufacturing [34], adhesive bonding, rail welding, thermal spraying and Thermit welding.

All these personnel will require career paths and career routes available to them to achieve success [34], [35], [38]. Many developed countries are in the position of being able to assist less developed countries improve their SDGs. Such assistance could include:

- Upgrading competency levels of welding instructors at training centres and companies to world's best practice to improve efficiencies as well as ensuring the latest and best training resources and facilities are available to them [43], [44], [45].
- Implementing programmes to assist secondary schools to develop and support educational programming, capital equipment, consumables and protective equipment that create and upgrade quality learning environments in school technology programs [46], [47].
- Giving people opportunities to earn qualifications and certification, offering better opportunities for employment at all levels including upper level management, research and technology innovation.
- Promoting education and training which results in credible personnel qualifications and certifications, which should also be portable both within a country and overseas, as well as being recognised on an international basis, is important to help retain work in the country [37], [76].
- Assisting Industry to create new employment opportunities by making the best of a country's and international employment practices thus improving industry

performance and give people incentives and career opportunities to develop and master new fields.

- Promoting policies with Governments which enable the re-training of job leavers and older workers for re-employment for sustained employment and supporting industry in its ability to attract and bring in expert overseas personnel where required.
- Linking in with the Government initiatives to provide secondary students with improved career paths from school to work; such initiatives could include part-time apprenticeships and traineeships; training of school teachers to teach welding, provision of training resources [43], [44], [45], [46], [47].
- Helping establish closer partnerships between higher education institutions and industry and the development of an effective, affordable research and research training system to contribute to national economic development, international competitiveness and the attainment of social goals [41].
- Notwithstanding the above, in many developing countries, regional disparities can be significant in terms of children being able to read and write. Much of this is attributed to poor attendance levels at school and leads on to the meagre participation of youth and adults in formal and non-formal education and training [12].
- A major challenge is to improve participation in education at all levels substantially. Many of the countries need to increase the resources to provide quality education. This also becomes prevalent for the successful introduction of Industry 4.0.
- To engage youth from elementary and secondary ages across the country, countries are working on introducing a new inexpensive welding simulator program which will use virtual and augmented reality to allow students to try welding in a safe, controlled environment while learning about career opportunities in welding and related skilled trades. This may also be included in Train-the-Trainer programmes. Research studies show the benefits of such training [176], [177].
- To attract young people, the welding industry has also implemented many projects on a voluntary basis including improving the image of welding. Through the holding or supporting of welding skill competitions, welded art exhibitions and competitions, the industry is encouraging as many people as possible to take up the art, trade or profession of welding.
- Various national welding institutes conduct national welding competitions to encourage young people in their welding careers as well as participating in international skill competitions and the IIW Welded Art Photographic Exhibition [48], [49].



*Young Professionals enjoying networking at the IIW Annual Assembly, Helsinki 2015*

- There are also opportunities at the micro-enterprise level to develop true entrepreneurial cultures and significantly increase the number of micro-entrepreneurs in a country. Such opportunities can be linked to government programmes such as in Ghana's Youth Inclusive Entrepreneurial Development Initiative for Employment (YIEDIE) [23].
- IIW, Cameroon, France, Germany, Hungary, India, Romania and Thailand have held events and activities aimed at supporting young professionals (YP) in the welding field. YP events have been held at the IIW Annual Assemblies in 2015 to 2019, and again in Tokyo in 2022 and Singapore in 2023. Some examples are shown below and in Appendix 3.7 of Volume 2 of the Long Report.
- The Hungarian Welding Society established the Youth Forum in 2012, which unites university welding groups and provides national and international professional events, Conference of Young Welding Professionals, Welding Summer University, organized professional visits, and team building which are boosting and encouraging an active professional life and career building. In 2014, Hungary launched the IIW-recognized Young Professionals International Conference (YPIC) event series and other countries such as France and Germany followed suit with their own YPIC events.
- The Cameroon Welding Association (CWA) created the Cameroonian branch of the IIW Young Professionals (YPs) and the 237welders group in 2017 [52]. CWA is also extending its assistance with YPs to the Economic and Monetary Community of Central Africa (CEMAC) which includes Gabon, Cameroon, Central African Republic (CAR), Chad, Republic of Congo and Equatorial Guinea.
- The Indian Institute of Welding (IIW-India) started the young professionals activity in 2017, with the objective to bring more and more young people to take up welding as their professional career. The campaign started in the Engineering colleges where Mechanical and Metallurgical streams are in force. IIW-India has succeeded in establishing 22 such colleges as Students' Chapters resulting in over 700 young professionals actively taking welding as a career.
- The Romanian Welding Society (ASR) "YOUTH CREATES" competition aims to stimulate young people's interest in the field of welding and related processes. The competition is addressed to young people up to 35 years old, ASR members or supporters of the Association, as well as to those who have concerns or work in the field of welding and related processes, single or collective authors, students and / or young engineers who, within scientific events, present the latest results in the field, obtained in universities, institutes and/or industry, based on the principle "FROM CONCEPTION TO USE".



*Spring of Knowledge*

*Ricard Mira. IIW 2023 Digital Collection, Reference [113]*

## 4.5 Achieve Gender Equality and Empower All Women and Girls



### Overview of SDG 5

*The achievement of SDG 5 would grant women and girls equal rights, opportunities to live free from discrimination including workplace discrimination or any violence. Education is a key to fostering equal rights to economic resources, property ownership and financial services for women, promoting empowerment of women through technology and adopting, strengthening policies and enforcing legislation for gender equality, hence the importance of enabling young girls to access as many educational opportunities as possible [6].*

### Introduction

During the Second World War, in some countries, due to sheer necessity, women and girls were employed in a wide range of employment situations normally fulfilled by men [53].

Similarly, in many developed countries today, women and girls showing that they are competent to fulfil careers and employment roles are employed on an equal basis to men. In many developed and developing countries, there is a recognition that in terms of the country's Constitution and embrace of human rights, that it is imperative that there is gender equality.

Unfortunately, there may be countries where due to a variety of reasons, this does not apply. There may therefore be a need to change a number of cultures in a country to achieve equality and empowerment.

For example, in some countries, there are still complex issues concerning male dominance and patriarchy that need to be addressed in order to step up efforts towards achieving sustainable development [18]. Governments however can commit to a range of national policies which are either gender focussed or contain gender equality considerations and can lead to promoting women's economic empowerment and enhance women's participation in the labour market [23].

In terms of assisting girls to achieve their potential, due to the very negative impact that Covid-19 had on girls' education, the G7 group of countries produced and agreed a significant policy paper during 2021 titled "Declaration on girls' education: recovering from COVID-19 and unlocking

agenda 2030" [54]. Such initiatives should be supported and promoted where appropriate.

In another example, seventy per cent of women working in the nuclear sector in Latin America and the Caribbean have reported gender-related institutional barriers in the pursuit of their careers, according to the findings of a survey featured in a new gender perspective publication by the Women in Nuclear ARCAL Chapter [55]. The publication was launched at the annual meeting of representatives to the Regional Cooperation agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) which took place on the margins of the 66th IAEA General Conference. Representatives from 20 States, parties to the Agreement, convened to review regional progress and priorities, and to reinforce their commitment to the peaceful uses of nuclear science and technology for sustainable development.

The new publication is a guide to show the obstacles that women face so that something can be done about practices that contribute to the reduced presence of women in the nuclear sector, to propose solutions and overcome these stumbling blocks.

### Some factors to be considered by the Welding Industry

To counter negative perceptions of women in the welding industry, qualification and certification of women can go a long way to prove their competence and rightful place in the work environment

At the same time, if one can also change the culture which might be creating such negative perceptions then it would achieve positive results.

This becomes easier to achieve when a country has a Constitution embracing human rights and gender equality and also has developed and implemented a number of cultures including a skills respect culture.

A skills respect culture [56] is a national way of life which is characterised by:

- support of, and value placed on, a willingness to learn;
- respect for people who acquire skills; and,
- tangible rewards for individuals who acquire skills

This means that people at all levels irrespective of gender and in all disciplines within organisations will have a willingness to adapt or learn new skills. They will also be seen to deliver excellent work results. Organisations will be seen to promote skills development and will be highly productive and competitive.

All of the above will lead to a thriving national economy since a culture of skills development is encouraged nationally [56].

There has been excellent work carried out by the National Productivity Institute (NPI) and Skills SA Foundation in South Africa to show how a country could identify the key issues detracting from having a national skills respect culture and ideas on how such a culture could be implemented [56].

Ideas on infrastructure and conditions to be created to facilitate the development of a national skills culture include:

- ▶ reshaping the role of schools;
- ▶ refocusing training systems;
- ▶ improving the image and competence of trainers;
- ▶ improving the image and competence of employers and,
- ▶ designing attractive training incentives for organisations.

Ideas on refocusing the skills development processes to establish a national skills culture include:

- ▶ developing the 'whole employee'; and
- ▶ developing a national sense of work pride.
- ▶ In addition, equal pay, having in place diversity, inclusion and anti-discrimination policies including gender equality and women and girls' empowerment,
- development programs to ensure that unconscious biases are addressed, ensuring that there are support programs in place for women entering the workforce, reviewing procedures to remove physical requirements that may disadvantage women, having materials to support change within the industry and programs that can identify the role that men play as

advocates for gender parity, all play a role in gender equality and empowering women and girls.

- Learning from other countries is very important. For example, a review of the 'Winning Nations' report by Lindeque and Verster of Eskom in South Africa in 1992 revealed after a group visited such nations that these nations use various tools for creating a skills respect and work pride/work ethic culture as a means of developing skilled workers/professionals who can deliver excellent goods and services.
- Various countries, for example Australia, Canada, Germany, Singapore and the USA, have used activities to improve the image of welding as a strategy to create a skills respect culture in their countries [57].
- The welding industry in all countries must therefore become involved in supporting programmes promoting such cultures and enabling women and girls to enter the welding related fields at various levels and areas such as education, training, research, development and technology transfer accompanied by the appropriate career paths.
- The implementation of scholarships and support for Science, Technology, Engineering and Mathematics (STEM) initiatives, are examples of how the industry can work towards gender equality and greater diversity to progress this SDG.
- The German Welding Society was a forerunner in implementing programmes for young professionals and with its support, IIW introduced a programme which also encourages young women to increase participation [57].
- An example of a successful programme in Canada is the CWB Group programme "Women of Steel" which aims to encourage women to explore careers in welding, building awareness and clarifying perceptions for improved understanding of potential opportunities and rewards of this career [58].
- The American Welding Society (AWS) holds its "Women in Welding" Conferences as a means of promoting women in the welding field [59].
- Many countries have projects which they have implemented and the experiences and lessons learnt including successes and failures are invaluable. The Australian Federal and State Governments as examples, have been quite proactive in promoting skills on both a national and regional basis [60], [61].
- Today, digital technologies such as artificial intelligence, robotics and automation are transforming the world of work. Developing the appropriate digital skills in the workforce is an important component in industry's effort to compete in this rapidly emerging global digital economy. Reference [62], a research report on



*Women across Canada love CWB's Women of Steel™ programs*

skilling the Australian workforce for the digital economy is excellent with a significant number of further references from across the world for additional information. The challenges of training the general workforce in digital technology will grow significantly as the welding industry embraces more of Industry 4.0.

- Unfortunately in many developing countries, basic finance is a major impediment to women progressing. A good example of overcoming this however is that of the Indian government which has enabled new avenues of credit, insurance and Direct Benefit Transfers to the poor, including to over 200 million women, thereby accelerating their economic empowerment which can lead to pursuing opportunities in welding related fields [63].
- The Indian Government has also introduced programmes of reserving specific jobs for women both in private and government organisations and is continually requesting industries to recruit more women and girls.
- In many rural areas in India, young girls often struggle to attend school since there are no school buses available to take them the long distances to the nearest schools. In West Bengal, a programme to give bicycles to 4 million young girls in rural areas was introduced with great results in 2015. This is a great initiative with lots of benefits which the welding industry could contribute significantly to [64].
- With respect to the bicycles, if this concept spread to all other states in India, the number of welded frames required would be immense. Maybe India could set up a bicycle industry to rival Taiwan as the “Bicycle Kingdom”.
- In some cultures, girls may be subjected to early marriage before completing their education. In West Bengal, India, the Kanyashree Prakalpa Yojana Scheme of assisting with payment for a girl's education is both simple and tremendous. It was designed by the Department of Women Development and Social Welfare. It uses a social safety net mechanism that has shown a high degree of success in transforming the lives of children and adolescents in several countries in the world through a Conditional Cash Transfer Scheme. Its main objective is to assist girls from socio-economically disadvantaged families or girls with special needs to avoid marriage until they have completed their education at a minimum of 18 years of age [65].
- The programme has had much recognition including awards. For example, it was honoured by the UN with the UNPSA Award 2017. It has received national and international recognition for its design and features of good governance. The welding industry could link in to such programmes particularly by creating career opportunities for such girls.
- A very good example of such an initiative in India is shown by INOXCVA [66]. ‘SPARK’ is a corporate social responsibility initiative promoted by INOXCVA, a leader in delivering Cryogenic storage, distribution and transportation solutions worldwide. The Cryogenic industry has a huge demand for welding professionals. As a part of woman empowerment and gender equality initiatives, INOXCVA has collaborated with ITM (SLS) Baroda University (ITMBU), Jarod, Vadodara to implement an on-campus Skilled Development and Welding Excellence Centre.



*Sabooj Sathi wheels of change*

- The company identifies girls to learn welding and related soft skills and carries all expenses of training and hostel facilities at the Centre and also pays a stipend to the girl welders to help them in alleviating the poverty and overcoming the economic constraints. At the end of training, all female welders are absorbed by INOX India in employment. This initiative also motivates local industries to adopt such initiatives which are also encouraged and supported by the Government of Gujarat.
- In South Africa, over the past 20 years, Cell C Take a Girl Child to Work Day® has made a meaningful contribution towards shaping the career choices and future aspirations of thousands of girls by exposing them to real life workplace experiences in preparation for a brighter future. The theme, #MoreThanADay, focuses on innovative ways in which gender equality and the empowerment of women and all girls can be advanced [67].
- Welding industry leaders, companies, organisations and entrepreneurs can help create unprecedented opportunities and exposure for young women and girls to play an active role in the building of a more inclusive society using such approaches.

## 4.6 Ensure Availability and Sustainable Management of Water and Sanitation For All



### Overview of SDG 6

*SDG 6 aims to help to expand water and sanitation support to developing countries, and to support local engagement in water and sanitation management. This will include safe and affordable drinking water, end open defecation and provide access to sanitation and hygiene, improve water quality, wastewater treatment and safe reuse, increase water use efficiency and ensure freshwater supplies, implement Industrial Waste Management Evaluation, protect and restore water-related ecosystems [6].*

### Introduction

Life without water could simply not exist.

“In one drop of water are found all the secrets of all the oceans, in one aspect of You are found all the aspects of existence”. Kahlil Gibran [68].

In many regions of the world, collecting water is primarily the responsibility of women whose lives are further impacted by lack of water and sanitation because they are responsible for the care of children, who are affected by diarrheal diseases. Furthermore, in some nations, 50% of girls drop out of school due to lack of toilets. In Bangladesh, it was shown that the provision of microcredit loans to women increased the presence of latrines in their households from 9% to 26% [69].

Clean Water Management is a key issue in any Government's strategic policy. A sustainable water environment is critical to all stakeholders in a country and hence its national interest. Major restructuring is normally required and strategic challenges could include drinking water quality, access to improved sanitation, water wastage e.g., leaking pipes, environmental issues related to effluent discharge and irrigation issues and for industry to meet these challenges in a productive and competitive manner.

In many developing countries, the available renewable water resources are insufficient to meet the ever-increasing demand with population growth, unequal distribution and access to clean water, the quality and state of water infrastructure, industrial pollution and even untreated sewage flowing into streets, rivers and groundwater. The end of open defecation and access to sanitation and hygiene are critical in many countries.

Due to the effects of El Nino and La Nina as well as climate change, highly variable rainfall patterns are occurring in many countries resulting in extremes from floods to drought-ridden areas in the country giving quite complex challenges.

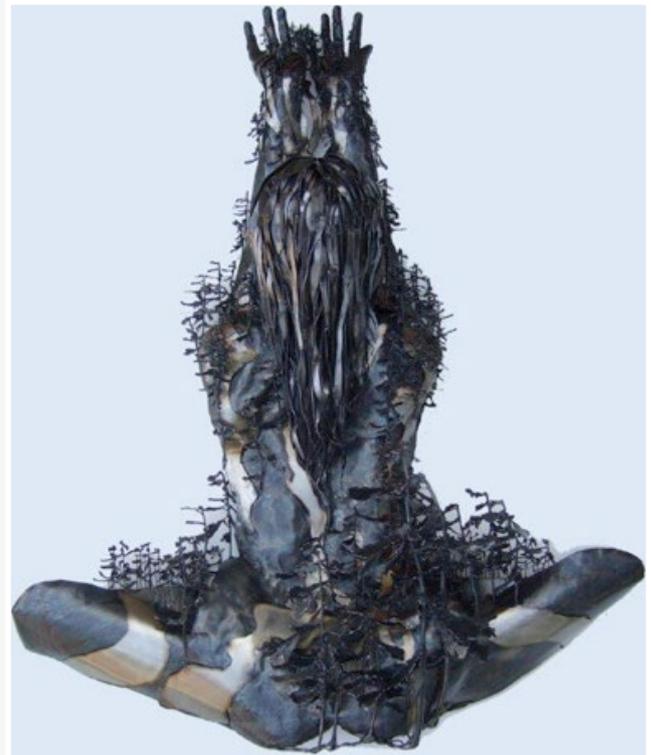
Major achievements can be made with this SDG through an Industry Sectoral Project (ISP) approach [227].

### Some factors to be considered by the Welding Industry

- Integrated Water Resources Management (IWRM) is a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems
- Implementing IWRM thereby helps to protect the world's environment, foster economic growth and sustainable agricultural development, promote democratic participation in governance, and improve human health.
- The welding industry could become involved with the relevant parties in a country responsible for the IWRM and cooperate and collaborate with them. Industry Sectoral Projects, cooperating and collaborating with governments, aid agencies and other appropriate industry sectors, could be implemented in a country.
- Networks within IIW members have developed and implemented over the years examples of technologies in applications which have led to cleaner, better qual-

ity drinking water, more efficient irrigation, less water wastage, more efficient waste water treatment, less pollution, better water capture and increased water resources and better sanitation systems.

- The use and benefit of improved welding fabrication and construction technologies have shown, by numerous examples, of plant required for climate-resilient water sources to help combat water scarcity. These are those on which climate variability, such as variations in rainfall, temperature and drought, has little or no influence with two of the most significant being desalination and water recycling plants.
- Inter-relationships between poverty and the environment are also evident where access to basic sanitation, sewage treatment and solid waste management, are not adequate leading to environmental degradation as well as having an adverse impact on the health of the population.
- Population pressures on fragile natural resource bases in many countries aggravate factors leading to problems such as desertification which lead to vicious circles of cause and effect with impacts on many aspects including agricultural production which consequently leads to increased poverty.
- In desert areas and cities near the sea, desalination plants might be installed and water made available to people. Water treatment plants can be installed in all cities to ensure a good quality of potable water is available through pipelines.
- As more and more “smart cities” are being built, sweet water lakes could be connected by welded pipelines to ensure water is available in all lakes and is stored during high rainfall periods and distributed to households. Emphasis on efficient drainage and water harvesting would be given during construction of smart cities [28].
- Besides financial and environmental sustainability, a key element in any water or sanitation project is technical sustainability. This has been an ongoing problem in developing countries and can be illustrated by examples of pumps or other pieces of equipment breaking and cannot be repaired. This problem can occur along all the scale of services from a pump at a borehole to a pump in a modern water or wastewater treatment plant [69].
- Sustainable infrastructure is very important with, for example, upgrading water distribution systems being costly and difficult to implement. Even in developed countries such as the USA, 20-30% of production water is lost, and older systems, with many pipes nearing the end of their planned lifetimes, may lose as much as 50% of their water. Such examples could also lead to reduced quality from increased exposures to pathogens from distribution system contamination



**Born of the Rain**

Hilary Clark Cole. *IIW 2023 Digital Collection, Reference [113]*

meaning more home chlorination treatment of the water in countries [69].

- The International Stainless Steel Forum (ISSF) has shown projects where stainless steel has been used to replace water systems in cities such as Tokyo with a reduction of water losses from 17% per year to 2% and other benefits including improved quality of water [70]. The Indian Stainless Steel Development Association (ISSDA) has also shown examples for water service pipelines, treatment and storage [71].
- The Australian Stainless Steel Development Association (ASSDA) received an ISSF Award for a project which showcased the successful use of stainless steel in delivering effective infrastructure to achieve water savings and secure a sustainable environment and future for irrigation communities in Australia [201].

The welding industry can truly assist across the whole range of water challenges.

Welding and joining technology transfers could contribute to meeting a country's national objectives in the following ways:

- urgent need for a country to upgrade its water catchment, storage, treatment and distribution and waste water infrastructure in both urban and rural applications;
- minimisation of resource wastage and the risks of serious health and supply breakdown due to failing pipes/distribution;
- maintenance of aging infrastructure;



*Aerial view of the Lake Eildon hydroelectric infrastructure dam and surrounds.*

- construction, operation and maintenance of sanitation infrastructure including sewerage systems and sewage treatment.

Examples of specific applications and welding technology solutions that could be analysed, prioritised, developed, demonstrated and disseminated with relevant stakeholders to help meet the management of water and sanitation in the country include:

- manufacture and construction of mainstream pipelines;
- manufacture of pipework and structures in water and waste water treatment facilities;
- manufacture and construction of desalination plant involving materials such as titanium alloys;
- the growing use of different materials such as stainless steels, titanium alloys, PVC, polyethylene, polypropylene and polybutylene, ABS and Glass Reinforced Plastic (GRP), as against existing materials such as concrete, grey cast iron and carbon steel;
- Installation and maintenance of water storage liners and floating covers;
- repair and maintenance of aging infrastructure.

Developed countries can assist with these by providing expertise in areas such as:

- joining and NDT testing techniques for liners and covers;
- avoidance of failures due to poor structural integrity through better design and inspection technology;
- new methods of repair and maintenance including the use of composites;
- in-line inspection of butt fusion welded plastic pipe;
- mechanised welding of external and internal joints on mainstream pipelines;

- high-pressure water-jet cutting of damaged concrete support structures for low cost maintenance of in-service pipelines.

General outcomes leading to increased quality of life and the SDG could include:

- joints in pipes/pipelines of a range of different materials having high integrity and reliability;
- high integrity joints in liners and covers;
- more economical longer pipelines for transferring water over long distances;
- more efficient water distribution;
- more efficient tankage and filtration systems;
- efficient operating desalination plants;
- life extension for aging infrastructure;
- reduced overall project costs;
- reduced maintenance, repair and inspection costs;
- less failures and lower environmental damage;
- longer working life of plant.

These can all help with improving the water and sanitation management issues in this SDG by having:

- cleaner better quality drinking water;
- more efficient irrigation;
- less water wastage;
- more efficient waste water treatment;
- better sewerage systems including sewage treatment;
- less pollution, environmental damage and health risks;
- increased water resources.

The continual transfer of such existing and new technologies into countries, as well as training the people to apply them, is paramount for achieving this SDG. There also needs to be investment in building human capacity in-country in order to be able to construct, operate, manage and maintain water and sanitation services [69], [218].

## 4.7 Ensure Access to Affordable, Reliable, Sustainable and Modern Energy For All



### Overview of SDG 7

SDG 7 aims to improve the percentage of a population with access to electricity as well as the renewable energy share and energy efficiency.

This includes universal access to modern, affordable and reliable energy, increasing global percentage of renewable energy, doubling the improvement in energy efficiency as well as promoting access to research, technology and investments in clean energy infrastructure, and expanding and upgrading energy services for developing countries [6].

### Introduction

A well-established energy system is essential to support all sectors in a country as well as progress all the SDGs positively.

Investment in energy infrastructure is also seen as one of the key factors for poverty eradication since the provision of energy in abundance at low cost has always been considered a major factor of human well-being and development.

Access to electrical power is therefore a key requirement to meet the challenges of sustainable economic growth and development in countries as well as progress many of the UN SDGs. Even in countries endowed with energy resources, the limitations in the power sector often constrain growth.

Unfortunately, a country's power sector may experience many broad challenges related to electricity policy enforcement, regulatory uncertainty, gas supply, transmission system constraints and major power sector planning shortfalls that keep the sector from reaching commercial viability. The welding industry may not be able to influence many of these but it can have a significant impact on various present and future aspects.

For example, excessive costs and environmental concerns are being raised in some areas. The European Court of Auditors warns that the EU has grossly underestimated the environmental damage that offshore wind farms pose for the environment and that much more needs to be done to make offshore renewable energy socio-economically and environmentally sustainable [232].

Again, major achievements can be made with this SDG through an Industry Sectoral Project (ISP) approach.

### Some factors to be considered by the Welding Industry

- For a country to develop affordable, efficient, reliable, sustainable and clean modern energy for its people, this often means developing industries competent to manufacture and maintain the appropriate equipment. Although one tends to think of “clean energy” as renewable energies such as solar, wind, hydro etc, these and other types of energy sources, both present and future, require high quality design, manufacture, maintenance etc, to ensure their reliability and financing to ensure their implementation.
- In the foreseeable future up to 2030, even with a determined effort to move to cleaner energy sources, energy sources such as coal, gas, nuclear will still be in existence and will require the same attention to reliability in service as provided by the technologies, personnel and companies existing in the welding industry.
- IIW Members and the welding industry in Europe support the EU 2021-2030 Integrated National Energy and Climate Plan and where possible will work to achieve the outcomes required in the five prime dimensions: energy safety, decarbonisation, energy efficiency, the energy internal market, and research, innovation and competitiveness.
- The European Commission (EU) recently put in place a so-called taxonomy, “a classification system,

establishing a list of environmentally sustainable economic activities". This taxonomy could be described as the EU's green investment rulebook, intended to serve the goal of allowing the continent to become climate neutral by 2050.

- In July, 2022, the European Commission, the EU's executive arm, decided to give nuclear energy and natural gas a green label under this taxonomy.
- Developments are taking place to create nuclear energy facilities and fuels which will be accepted for use by many countries as part of their reduction in emissions strategies [95]. In such cases, the 'complex' welding associated with building such facilities will be a challenge in terms of reducing delays in construction and cost over-runs.
- Globally, there are many examples of the welding industry's networks being involved in aspects of helping the development of affordable, reliable, sustainable and clean modern energy for a country, including developing industries competent to manufacture and maintain the appropriate equipment.
- In the past, the welding industry and its networks have worked very closely to ensure that there were companies both local and overseas competent to manufacture and maintain the appropriate equipment. The Koeberg Nuclear Power Station in South Africa is a good example of this.
- The repurposing and conversion of some existing energy facilities will be required in the future and greater cooperation between developing countries and those countries with the appropriate expertise will be necessary.
- For example, with the latest developments in the use of pipelines for hydrogen, ammonia and carbon dioxide transport and distribution in the energy transition, new design and build, testing of existing systems, plus repurposing of existing hydrocarbon pipelines and piping systems will be required.
- Actively developing repurposing strategies, processes and methods to address safe conversion including defining overall risk-based repurposing approaches, threat evaluation and material performance testing requirements will require such expertise [72], [189].
- Such strategies could also encompass having to find solutions for accommodating the workforces and broader communities affected when decommissioning such facilities.
- There are many types of energy related equipment applications covering areas such as structural, rotating, corrosion resistance, pressure equipment etc all requiring optimal reliability.
- For example, the types of pressure equipment employed in energy sources could cover items such as boilers, pressure vessels, pressure piping, pipelines, gas cylinders and tanks. Such equipment is used in power stations, petro/chemical, process plants, hospitals, general industry, energy, food, cryogenics, LPG, mineral processing and for public gas cylinders etc as well as being linked to numerous structural related equipment.
- The number of pressure equipment items installed/used in a country is immense with an enormous asset value matched by the number of people directly involved in industry using pressure equipment.
- The fabrication, construction and maintenance sector is vital for any country's power and energy supply and the strategic challenge is to improve performance and avoid failures. Fortunately in many countries, codes, standards and regulations exist and compliance rigorously enforced.

The specific aspects of the energy industry where welding and joining technology transfers are needed and contribute to meeting the national objectives may include the following in a developing country:

- local manufacturing and repair companies being able to meet local demand as well as developing unique areas of competitive advantage in the energy equipment industry on a global level;
- optimisation of strategies and practices to handle aging plant and equipment.

Examples of specific applications and welding technology solutions that could be analysed, prioritised, developed, demonstrated and disseminated with relevant stakeholders to help meet the energy challenges in the developing country could include:

- manufacture of boilers, pressure vessels, pressure piping, pipelines, air receivers, gas cylinders, wind turbines, solar panels etc;
- maintenance, repair and rehabilitation of the above equipment;
- maintenance of good quality, reliability and safety, yet reduction of costs by better technology – hard and soft technologies;
- improvement of fabricators/welding technology skills (competency at all levels including top management). This will be achieved through solutions, amongst others such as:
  - extend the use of advanced technologies in design, joining and testing;
  - provide guides to industry such as diffusion of latest best equipment and practices which also helps governments, regulators and insurance companies;



*Interest in nuclear power capacity has increased significantly in recent times with over 60 reactors currently under construction in 15 countries*

- help a country with conformity assessment aspects such as risk based inspection, design verification, fabrication verification, In-service inspection verification;
- development of a national mark to identify pressure equipment conforming to standards and comparable with EU = “CE”, USA = “U” Stamp);
- risk assessment and management guide to manufacturers and users;
- commentaries on codes, on design, on training, welding procedures (ASME, EU and ISO) and documentation simplification;
- harness industry capabilities regarding technology, facilities, equipment by having a full record of national capabilities and creating networks and alliances to maximise use of the capabilities.
- rationalise critical equipment e.g., heavy roll, heavy presses and spinning for heads, forging facilities and large heat treatment furnaces;
- laser welding for large numbers – water heaters and gas cylinders;
- greater use of plastics for pressure piping.

One could expect general outcomes leading to more affordable energy to include:

- reduced manufacturing costs;
- reduced inspection costs;
- less failures and rolling blackouts;
- greater use of ISO and other national or regional Standards

- improved weld quality in energy equipment manufacture;
- extended service life of equipment;
- reduced maintenance costs;
- less unplanned shutdowns;
- extended duration between shutdowns.

Thus helping improve this SDG with:

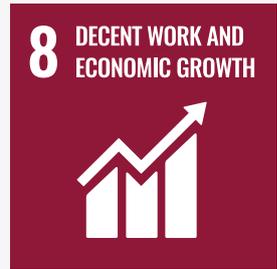
- increased turnover for SMEs;
- safer operating environments;
- prevention of catastrophic failures and major losses to the economy;
- less environmental damage;
- import replacement and increased exports

As the implementation of newer energy sources grows, welding industry support for the transfer of such technologies to the appropriate implementers must also grow.

The continual transfer of such existing and new technologies into countries, as well as training the people to apply them, is paramount for achieving this SDG. There also needs to be investment in building human capacity in-country in order to be able to construct, operate, manage and maintain existing and future services [219].

Appropriate **Industry Sectoral Projects**, cooperating and collaborating with governments, aid agencies and other appropriate industry sectors, could be implemented in a country. These could cover existing and future energy sources.

## 4.8 Promote Sustained, Inclusive and Sustainable Economic Growth, Employment and Decent Work For All



### Overview of SDG 8

*SDG 8 has a range of targets; sustainable economic growth, diversify, innovate and upgrade for economic productivity, promote policies to support job creation and growing enterprises, improve resource efficiency in consumption and production, full employment and decent work with equal pay, promote youth employment, education and training, end modern slavery, trafficking, and child labour, protect labour rights and promote safe working environments, promote beneficial and sustainable tourism, universal access to banking, insurance and financial services [6].*

### Introduction

Many developing countries would like to be seen as growing emerging economies with a young population and burgeoning innovation and business ecosystem. To achieve this, they would need to pursue an inclusive and sustainable growth trajectory by stimulating manufacturing, building infrastructure, spurring investments, fostering technological innovation and boosting entrepreneurship.

Linked to this would be the implementation of a circular economy which aims to maximise the use of resources through the reuse, repair, repurposing and recycling of products and materials to extend their lifecycle. Eliminating waste and pollution and keeping products and materials in use and regenerating natural systems are key principles in such an economy.

The International Organization for Standardization (ISO) is developing standards covering frameworks and principles, guidelines on business models and measuring circularity. Individual countries can focus on their priority areas to introduce such standards to help introduce the circular economy

In many developing countries, the informal economy might constitute the highest percentage of both present and new jobs with the country showing very high rates of unemployment and underemployment particularly amongst the youth. This means that young people in particular are not gaining the skills to enter the labour market or to become self-employed.

A key objective of this SDG related to the welding industry would be to increase local manufacturing, fabri-

cation, construction, repair and maintenance using local companies and personnel.

### Some factors to be considered by the Welding Industry

- Priority areas in a country's transition to a circular economy could include amongst others, identifying opportunities and challenges with a focus on waste management, improved product design, and the building of more efficient manufacturing, fabrication, construction, repair and maintenance processes in the welding industry.
- It is critical that building the required skills into young people to enable them to move into secure and less precarious forms of employment is essential to reduce poverty as well as diversify and grow the economy beyond dependence on a few key sectors.
- Governments in various countries have introduced programmes to help alleviate such problems. The Generation Unlimited intervention which targets employment for 20 million youth in Nigeria is a good example. There are also efforts to provide greater access to finance to leverage greater private sector-led growth aimed at Micro, Small and Medium Enterprises (MSMEs) [73].
- Many Governments are also keen to place more emphasis on vocational skills and entrepreneurial training specifically also towards the needs of older persons in the informal sector.

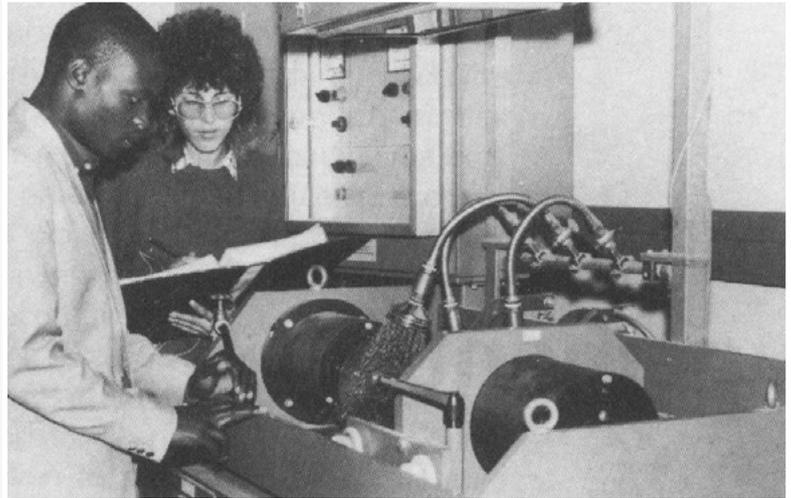
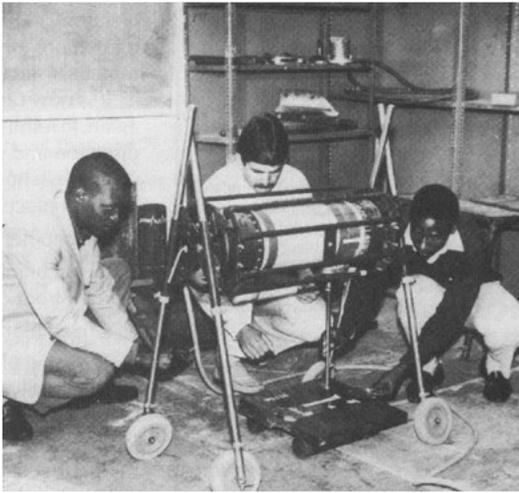
- There are many factors which can have a positive effect on the growth of a country's economy. Some of these involve creating the correct cultures within the country. For example, ethics, skills respect, productivity, quality, work, health and safety, environmental, innovation and service excellence amongst others .
- People in the welding industry can have a positive effect on economic growth. Innovation and the need to have competent people to play their part in innovation also places emphasis on the importance of education, training, qualification and certification of people as well as certification of companies in the country to improve this SDG.
- As a simple example, according to an American Welding Society (AWS) report, by employing a qualified welding supervisor, a company can save up to USD17,044 per welder per year as follows: reduced weld metal volume USD3,319; reduced arc time per weldment USD4,281; reduced rework, scrap and rejects USD3,244; reduced work effort, motion and delay time, USD6,200 [75].
- Qualification can be defined as: Evidence of education, training, and knowledge gained. A qualification is valid for life and cannot be withdrawn if earned correctly e.g. a degree or IIW Diploma or some certificates.
- Society changes and technologies improve, so the need to keep pace with change requires the need for ongoing education to remain valid and have some currency.
- Certification can be defined as: The procedure by which a certification body gives written assurance that a person is competent for a specified class of work. The document issued is a Certificate of Competency. Continued ongoing certification is valid for a set period of time, and proof of continued ongoing competence is required for regular re-certification and continued registration. Certification can be withdrawn if it has been proven that the person has dropped below the competency level required.
- Competency can be defined as having the training, qualification and skill to apply knowledge and experience to satisfactorily perform the required level of work required.
- Certification has the benefit of giving both the person and the industry in which they work increased confidence that the person can carry out their work professionally and competently, in line with current regulations, standards and requirements, and that they continue to enhance their knowledge and skills.
- The inclusion of mandatory qualifications and certifications for different types of welding personnel in national and international standards as well as customer specifications shows the importance of personnel education, training and skills levels to the quality and reliability of welded products/structures.
- Appropriate Qualification and Certification (Q&C) arrangements in the welding industry are essential if companies are to achieve and maintain international competitiveness in a global economy. To enable the use of local personnel in the country instead of imported personnel, such Q&C arrangements are essential.
- There is a growing trend that companies in industry see the value of putting in systems in compliance with standards such as ISO 9000 and ISO 3834, and bodies qualifying and certifying personnel complying with ISO 17024 and ISO 9712. For example, more than 40 countries have established a Personnel Certification Body (PCB) to comply with the requirements of ISO 9712:2012 Non-destructive testing-Qualification and certification of NDT personnel.
- Other examples include bodies certifying products, processes and services complying with ISO/IEC 17065:2012 – Requirements for bodies certifying products, processes and services as well as WHS and environmental standards such as ISO 45011:2018 *Occupational health, safety management systems* and ISO 14001:2015 *Environmental Management Systems Standard*
- There is also greater emphasis on ensuring that the relevant organisations comply with ISO/IEC 17021:2011 – Conformity assessment-Requirements for bodies providing audits and certification of management systems.
- The qualification and certification of welding related personnel has not just given greater assurance to users of such personnel with respect to their competence but has increased the work pride, and quality culture of the individuals in achieving such status and professional recognition.
- In developing countries however, there are probably large numbers of personnel who have not been exposed to such processes or cultures and strategies need to be implemented to assist such people achieve their optimum performance and a quality culture.
- There is a need to show developing countries the value and benefits of introducing a quality culture through improved productivity and greater prosperity in the country. There have been good examples of Expert Technology Tools available to assist companies implement ISO 3834 and ISO 14731 [76]. These can be easily updated.
- The ongoing development and implementation of ISO 3834 Quality requirements for welding-Fusion welding of metallic materials and ISO 14731 Welding coordination-Tasks and responsibilities throughout the world, is



*IIW Member SAIW hosted an NDT training course for a group of students from across Africa, supported by the International Atomic Energy Agency (IAEA)*

leading to an improved quality culture in many countries and companies including greater recognition of the image and importance of competent welding related personnel.

- In all the above, investment in skills is a key way in which industry can adjust to the changing market environment. Increased skills levels in firms and meeting the required standards above are likely to lead to improved international competitiveness and an improved market share in domestic and international markets for low and middle income countries.
- Marketing in the country should promote the benefits of education, training, qualification, certification, R&D, technology and innovation at the same time. Federal, State and Provincial governments in developed nations have helped build up world class vocational education and training systems with an extensive network of colleges across each country offering vocational education and training in welding, fabrication, non-destructive testing, pressure equipment inspection and other welding industry related disciplines.
- They also have networks of both government and industry organisations responsible for the accreditation, qualification and certification of both organisations and personnel across the range of industry requirements including those mentioned above.
- These countries also promote the use of standards to both improve their national welding capabilities and progress the SDGs. Such standards cover all the appropriate areas including products and services giving users the necessary confidence related to integrity and reliability.
- A key challenge is to implement the above into developing countries.
- The development of the International Institute of Welding (IIW) Education, Training, Qualification and Certification programmes and their implementation including the IIW Manufacturers Certification Scheme according to ISO 3834 (IIW MCS ISO 3834) in 47 countries worldwide illustrates the importance and need for world class personnel and companies to be available in the welding industry in a country [34].
- Developing countries could emulate such approaches. Benefits of this can be shown by the number of Indian companies specializing in manufacturing various critical pharmaceutical equipment which meet the high standards of the US Food and Drug Administration (FDA) and the Indian FDA high standards, the number of South African companies meeting the requirements of the steel producing, power generation and refinery industries as well as New Zealand companies meeting the very strict requirements for building in earthquake zone areas. These companies employ a very high quality level of welding and IIW members and the welding industry have pioneered the techniques to meet these exacting requirements.
- A key objective in a developing country is to provide jobs for local people and improve their quality of life. Having the various welding related personnel and companies acknowledged as meeting International and National Standards is a means of achieving this, hence the importance of recognised portable qualifications and certifications.



*IIW WG-RA/COM Success Story No 1. Lecturer Ben Beetge and Examiner Amanda van der Westhuizen, with students at SAIW [78]*

- Ideally, all companies no matter how small, can institute 'on-the-job' training to equip human resources with greater knowledge and skill and in turn, develop a learning culture. This philosophy will add value to the individual, the company and to national prosperity.
- The encouragement of young people is also very important and this can be illustrated by the competition, "Sustainable Development Goals -Through the Eyes of Young Bulgarian Welders" hosted by the Bulgarian Welding Society (BWS) in conjunction with the Bulgarian Ministry of Education and Sciences from 24-25 March, 2023 in Sofia, Bulgaria [158].
- Persuading governments and industry to support the upliftment of disadvantaged people through improved skills and knowledge of welding and NDT can also be a positive approach to be adopted in a project promoting the national welding capability in a developing country.
- For example, IIW WG-RA/COM, Success Story No 1 illustrates how the Canadian, Dutch and South African Governments were persuaded to provide the funding to train and qualify 65 disadvantaged people in Non-Destructive Testing (NDT). As the Success Story states "This wonderful team effort, between three national governments, industry bodies, national welding institutes and South African industry resulted in an outstanding outcome in improving the quality of life and ongoing opportunities for young people"[78].
- Such a success story can lead to further support. For example, the Australian Federal Government later supported SAIW in the training of disadvantaged people in South Africa as welders and through the South African Fabrication and Construction Training Trust Fund (SAFCTF) hundreds of disadvantaged people were also trained at SAIW as welding inspectors, welding supervisors and NDT personnel.
- A very good example of African collaboration is shown by the support of the International Atomic Energy Agency (IAEA) in the development of non-destructive techniques for industrial quality control in Africa. In 1994, IAEA started funding a pan-African NDT training, qualification and certification programme conducted at the SAIW. For over 25 years, this has been very successfully implemented through the excellent cooperation and collaboration of the IAEA and many individuals and countries in Africa. South Africa (SAIW) and Tunisia (CETIME) became the two Regional Designated Centres (RDCs) for Non-Destructive Testing (International Atomic Energy Agency – AFRA) with the emphasis on training and certification of NDT personnel throughout Africa [129].

## 4.9 Build Resilient Infrastructure, Promote Inclusive and Sustainable Industrialisation and Foster Innovation



### Overview of SDG 9

*SDG 9 has an admirable target to facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and Small Island Developing States. A key objective should be to avoid the negative destructive effects which can so easily occur [6].*

### Introduction

The growth of new industries means improvement in the standard of living for many. If industries pursue sustainability, this approach will also have a positive effect on the environment. Decent infrastructure such as roads, ports, information and communication technologies, sanitation, electrical power and water remain a challenge for many developing countries. Failure to improve infrastructure and promote technological innovation could translate into poor health care, inadequate sanitation and limited access to education [18].

At the G7 summit hosted by the UK in 2021, the Build Back Better World (B3W) partnership was launched which aims to meet the infrastructure needs of low and middle income countries. Other existing programmes include China's Belt and Road Initiative and groups such as the G20 have focused on mobilising private investment to fill the infrastructure investment gap. There are a number of pitfalls with respect to the financing of infrastructure projects [79].

For successful industrialisation, a country needs a skilled workforce and one that includes welding and related qualified and certified personnel to ensure sustainable industrialisation and provide the ongoing innovation.

Similarly, leaders in a country and its welding industry must enthusiastically promote the concept of a creative nation. Many developing countries have been exporters of raw materials rather than having a mind-set of designing, making and building things, hence being creators.

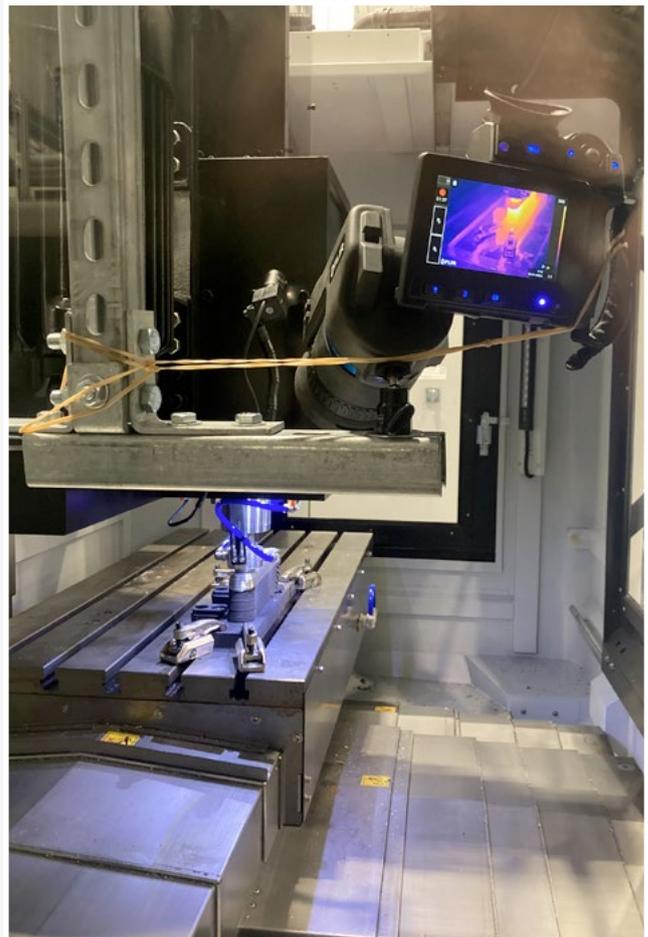
### Some factors to be considered by the Welding Industry

- Ever since the formation of IIW, its members and networks, have been involved in the building up of a vast array of resilient infrastructure to world class standards. They have inspired an innovation culture both in themselves and in their countries.
- As mentioned, an innovation culture is where everybody and every effort contributes to bringing in something new, to making changes (ideas, methods etc.) whether in simple or complex forms and includes applying inventions and the adoption of R&D outcomes.
- Innovation is now much more of an incremental process, in which research, entrepreneurship, creativity, customer demand and customer service all play their part and greater innovation spurs higher productivity helping the industry and economy to prosper.
- Implementation of innovative ideas and processes especially for smaller firms requires an effective link between the firms themselves and sources of technology. Research and development must therefore link in well with what technology diffusion provides but there must be market awareness of the R&D outcomes if technology diffusion mechanisms are to be effective and increase innovation.
- Companies themselves must recognise the importance of new technology to their business, and hence importance of R&D, so that the market demand for new technologies continually improves and the level of technology uptake at the individual company level increases.

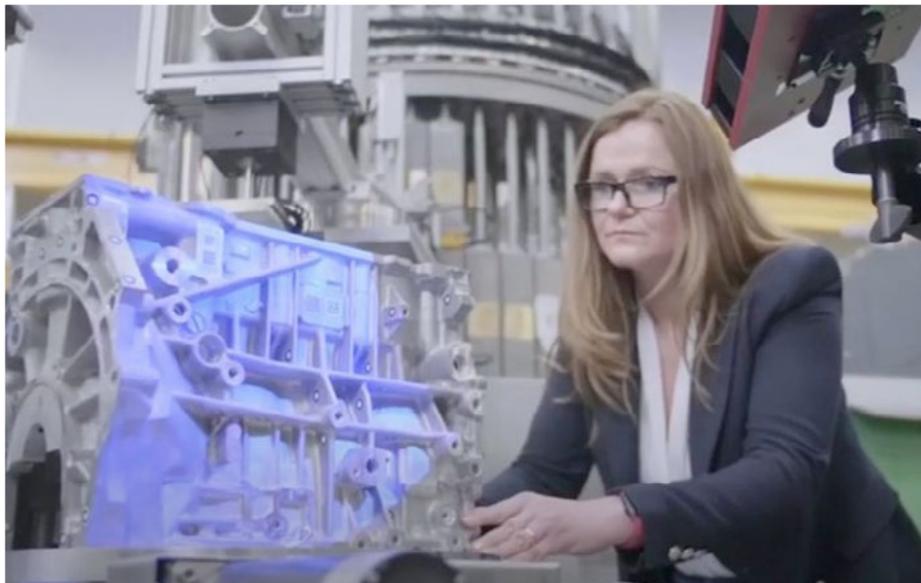
- The aims of this SDG are to ensure sustainability and inclusivity in infrastructure development and industrialisation. One of the ways this is achieved is through research, development, and support of innovative industrial technologies including establishing the appropriate technology transfer networks to have them implemented [39].
- A project, “Solid-State Additive Manufacturing For Recycled Aluminium Alloys” is supported by a University of Sydney- Sustainable Development Goals (SDGs) 1 year seed funding grant with international collaboration with University College London (UCL), Advanced Manufacturing Research Centre (AMRC) North West, UK and the Australian Nuclear Science and Technology Organisation (ANSTO) [80].
- Additive friction stir deposition (AFSD) fabricates structures layer-by-layer using a rotating tool piece fed with metal feedstock through a hole in the centre. No melting occurs during processing; instead, pressure and friction bring metal in its plastic state.
- AFSD provides energy-efficient, large-scale Additive Manufacturing (AM) of a variety of alloy systems. Importantly, it can also utilize waste material from other processes, further reducing environmental impact and contributing to closing the recycling loop. This new technology has huge potential for sustainable development of large scale additive manufacturing for future civil, transport, mining and space structures.
- To optimise the benefits of welding to a country's economy, innovation therefore must play a significant role and this will require a major cultural change in many companies and individuals particularly in consciousness raising of the importance of innovation to company competitiveness and industry survival.
- There are significant challenges in establishing and sustaining a successful technology diffusion capability in a country. In Australia for example, it appears that 97-98% of companies are classified as Small, Medium, Micro-Enterprises (SMEEs) with 60% being companies with less than 10 employees and the remainder with less than 200 employees.
- Anecdotal evidence suggests that on a similar basis to the UK, up to 10% of these may seek to improve themselves through the adoption of proven technology and only 1% are probably prepared to invest in new technology. This situation also appears to exist in some other countries so the secret of true success appears to be able to find mechanisms by which a significantly higher number of such companies will actually invest in new technologies with subsequent benefits.
- The development of sufficient people as both technology deliverers and technology receptors is critical to

ensure that innovation can take place. The implementation of strategies to ensure that sufficient numbers and types of people are entering the industry at all levels is essential.

- ISO Technical Committee 279 (ISO/TC 279) Innovation management documents has completed very good work in assisting countries improve the innovation culture, by introducing a suite of ISO Standards in this area. These include ISO 56000 Standard on Innovation Management Systems (IMS) which is an all-encompassing set of standard operating procedures designed to provide a general framework for all organizations, regardless of type, sector, or size, whether established, temporary or starting, towards the successful implementation, maintenance, and continual improvement of an innovation management system.
- The standard also provides guidance for all types of innovations, such as products, services, processes, business models and methods ranging from incremental to radical, as well as all types of approaches, such as



*Additive Friction Stir Deposition experimental set-up at Advanced Manufacturing Research Centre (AMRC) North West, UK*



*Setting-up an aluminium engine block for residual strain measurement*



*Residual Stress Measurement of Additive Friction Stir Deposition on aluminium components on the Kowari Strain Scanner at ANSTO – Research team, University of Sydney*

internal and open innovation for user-, market-, technology-, and design-driven, innovation activities. The suite of standards includes ISO 56001 to ISO 56008.

- The development and implementation of national and international standards are also essential to ensure the integrity and reliability of welded components and resilient infrastructure. Models are available for a country and its welding industry to help ensure this through their involvement with the country's National Standards Authority and International Organization for Standardization (ISO).

- Welding industry representatives can be involved in Technical Committees related to welding and non-destructive examination, pressure equipment, health and safety amongst others.
- The welding industry in conjunction with the National Standards Authority could regularly organize seminars for the industry dedicated to the development and implementation of new standards and provide newsletters and posting of information via other traditional and social media on international, regional and national standards.

## 4.10 Reduce Inequality Within and Among Countries



### Overview of SDG 10

*SDG 10 aims to help countries reduce income inequalities, promote universal social, economic and political inclusion, ensure equal opportunities and end **discrimination**, adopt fiscal and social policies that promote equality, improve regulation of global financial markets and institutions, enhance representation of developing countries in financial institutions as well as introduce responsible and well-managed migration policies. This could also involve special and differential treatment for developing countries, encourage **development assistance** and investment in **least developed countries** and reduce transaction costs for migrant remittances [6].*

### Introduction

It is important to conduct a needs analysis in a country to establish exactly what exists, and what is required to improve the quality of life in that country and have solutions to improve equality. In the welding related field there are examples of how such needs analyses have been conducted and then used to put in place appropriate strategies and action plans [81], [82], [83], [84], [85], [86].

Appendices 3.4, 3.5 and 3.6 of Volume 2 of the Long Report show examples of other collaborative initiatives by IIW Members during the past three decades which have contributed to reducing inequalities both within the host country but also in other countries in the region. Since 2003, 22 successful workshops covering topics such as promoting the concepts of technology innovation, governance and a national welding capability have been held in various countries by IIW Members and reported on at IIW WG-RA meetings each year [87]. Since 2011, seven IIW Welding Research and Collaboration Colloquia (WRCC) provided a unique opportunity for international researchers from universities, industries and governments to meet, present, and discuss the research and development work they are conducting, or planning to do, alone or in cooperation with other researchers [88]. Since 1988 over 40 International Congresses have been held across the world in various regions promoting cooperation and collaboration between countries [134]. Many of these activities are shown in the IIW book by Barnett, D., "Linking People, Joining Nations: The Impact of the International Institute Welding (IIW) since 1990", Published by IIW 2017 [3]. 6

Page 57 Appendix 3.7 of Volume 2 of the Long Report shows various initiatives related to Young Professionals (YPs).

Such activities could be replicated in other interested countries across the world.

### Some factors to be considered by the Welding Industry

The welding industry in a country is probably in the ideal position to continue to identify such needs and provide appropriate solutions in its field. The results which will be achieved will help improve the SDG significantly.

A good example of such an analysis made is Quality, Productivity and Economy of Welding Manufacturing-Case Study: West Africa [89]. This highlights many of the challenges facing Ghana, Cameroon and Nigeria in West Africa and many of these are applicable to many other developing nations.

Welding industry initiatives arising from such needs analyses could then be used to grow opportunities in the manufacturing, maintenance and construction industries and create the career pathways for people to improve and help reduce existing inequalities.

The results which will be achieved through the country's National Welding Capability (NWC) Project and help improve the SDG could include amongst others:

- The country establishing its own not-for-profit National Welding Institute/Society/Association which will become the NWC and SDG Flagship Programme Lead Organisation as well as become the country's repre-



### Weld Equality

Jackie Morris. *IIW 2023 Digital Collection, Reference [113]*

representative in the 51 Member country International Institute of Welding (IIW).

- The National Welding Institute/Society/Association having a full range of membership categories and membership system to accommodate all appropriate parties in the country and their involvement in the National Welding Capability (NWC) Project.
- The country having a not-for-profit organisation achieving full recognition as an International Institute of Welding (IIW) Authorised Nominated Body (ANB).
- The country's educational institutions including universities, colleges and practical welding training centres having their instructors trained and qualified to the required standard to train the full range of qualified and certified personnel required by its industry.
- A programme of upgrading all training resources required by the country's educational institutions prioritised and implemented.
- A network of IIW Approved Training Bodies (ATBs) established in the country.
- The country's personnel trained, qualified and certified in the country as IIW welding engineers, technologists, specialists, practitioners, welders, supervisors and inspectors and where applicable, to other national and international standards and specifications such as those in Canada, South Africa, USA, EU and ISO.
- The country having a not-for-profit organisation achieving full recognition as an IIW Authorised Nominated Body for Company Certification (ANBCC) and a programme of auditing and certifying companies in the country.
- The country's companies certified to ISO 3834 and/or other national or regional programmes such as that of the CWB Group or EN 1090 suite of standards if required.
- Ongoing comprehensive studies of the country's needs in terms of welding related personnel and companies.
- The creation of required networks to make the NWC Project a success.
- These results will enable the country to be independent and self-sufficient in various welding related personnel and company needs in terms of international and national standards.
- To implement how this can be achieved, the NWC Guidance Notes could be used and appropriate Goals, Objectives, Strategies, Outcomes, Action Plans including Timelines would be implemented.
- All the above will help put a country on an equal footing among many other countries in welding industry related areas as well as reduce income inequality within the country.
- Important recommendations for all countries include the need for periodic strategic planning exercises involving a range of people and organisations, the need to conduct periodic surveys/needs analysis of industry's requirements, the importance of issuing regular progress reports and results of independent audits/reviews of such progress, increasing industry involvement in projects, products and services, stable finances and not asking people to put money into a bottomless pit by continually losing money, as well as being able to show the value to the country of the benefits from the project.



## 4.11 Make Cities and Human Settlements Inclusive, Safe, Resilient, and Sustainable

### Overview of SDG 11

*Important indicators for SDG 11 are the number of people living in urban slums, the proportion of the urban population who has convenient access to public transport, and the extent of built-up area per person.*

*This includes safe and affordable housing, affordable and sustainable transport systems, inclusive and sustainable urbanization, protection of the world's cultural and natural heritage, reduction of the adverse effects of natural disasters, reduction of the environmental impacts of cities and to provide access to safe and inclusive green and public spaces. This would mean having strong national and regional development planning, implementing policies for inclusion, resource efficiency, and disaster risk reduction in supporting the least developed countries in sustainable and resilient building [6].*

### Introduction

There has been an unprecedented growth of cities over the past seven decades with the need to create safe and affordable buildings including housing as well as safe and efficient public transport. In Africa, it is estimated that by 2050, an extra 950 million people will have moved to cities bringing both great opportunities and significant challenges [90].

There has also been a growing trend to make the required structures resilient to disasters such as earthquakes, fires, floods as well as failures due to shoddy quality and explosions due to faulty equipment.

Many developing countries have a major challenge with the rate of urbanisation increasing rapidly in the country and slum proliferation increasing. This also generates environmental, sanitation and health problems with social consequences, precarious housing conditions for the poorer populations, often in irregular areas such as riverbanks and hill slopes, making them more susceptible to natural disasters such as floods and landslides.

Pressures to provide improved access to basic resources such as food, energy, water, sanitation, health, education, mobility and information increase dramatically.

Lessons on planning can also be learnt from past experiences and approaches. For example, a monument commissioned in 2010 by the Diputació de Barcelona through the Town Council of Centelles, the birthplace of the engineer Ildefons Cerdà, to mark the 150th anniversary of the

approval of the Eixample de Barcelona Plan (the plan for the enlargement of the city of Barcelona) [202].

In the Plan, Cerdà focused on key needs: chiefly, the need for sunlight, natural lighting and ventilation in homes (he was heavily influenced by the sanitarian movement), the need for greenery in people's surroundings, the need for effective waste disposal including good sewerage, and the need for seamless movement of people, goods, energy, and information.

His designs belie a network-oriented approach far ahead of his time. His street layout and grid plan were optimized to accommodate pedestrians, carriages, horse-drawn trams, urban railway lines (as yet unheard-of), gas supply and large-capacity sewers to prevent frequent floods without neglecting public and private gardens and other key amenities.

### Some factors to be considered by the Welding Industry

- The welding industry can be heavily involved in developing and applying relevant technologies for use in many applications in human settlements as well as being involved in appropriate organisations related to the metals, pressure equipment and structural steel industry. Developments are taking place in some countries to create pre-fabricated affordable housing stock

including some types made available by clean and fast welding techniques [91], [215].

- The welding industry could increase the promotion of the uniform rollout and implementation of the appropriate national and international standards across the country to ensure the reliability and integrity of welded structures/products.
- With the urgent need to improve the cities, the need for bridges, flyovers and metro tracks is increasing, which also increases the scope of welding in the cities. The certification of fabricators and construction companies to national, regional and international standards to build such products as bridges, flyovers, roads and rail networks is one method the welding industry uses to ensure the reliability and integrity of the wide range of welded products and structures.
- The introduction of the IIW Manufacturers Certification Scheme According to ISO 3834 (IIW MCS ISO 3834) would help ensure the competency of the country's fabrication and construction companies to create reliable welded structures. Such an initiative will also increase opportunities for local manufacture and increased job opportunities.
- Due to the Covid-19 pandemic, IIW Members such as the CWB Group have introduced virtual audits and training which have proved to be successful. With the "tyranny of distance" which exists in many countries, the technologies which have been developed and implemented catering to the challenges of remoteness of both companies and individuals, and in particular poor communities, could lead to more effective training, education, testing and auditing systems in countries. This will naturally assist good progress in a number of the SDGs.

Some examples are given below on how countries have met these challenges and developing countries could benefit from such experiences.

- After the Second World War, the Canadian Welding Bureau (CWB) was formed in 1947 with the main objective of giving government and industry greater confidence and assurance in the design, fabrication, construction and erection of welded steel, particularly in high rise structures. There had been a number of expensive and potentially disastrous welding jobs on bridges built under the interstate highway program.
- The Canadian Standards Association (CSA) had been given the mandate in the 1930s to start welding standards development and the creation of a national body to administer them.
- The formation and role of CWB (now known as the CWB Group) was to act as the official administering body to ensure the uniform rollout and enforcement

of key standards across Canada. This included the inclusion of these standards and requirements in the National Building Code [92].

- The CWB Group has thus become the organisation, supported by industry and government bodies, to ensure the integrity of welded steel, aluminium and rebar structures, welding inspection companies and inspectors and welding consumables through the certification of fabricators, construction companies, inspection and test centres, welding consumables as well as personnel, and the continuing provision of appropriate standards through one of the national standards organisations.
- Such stable and sustainable activities enabled the CWB Group to grow to an organisation with considerable financial reserves and a staff complement in excess of 300 people across all the provinces in Canada and with over 12000 CWB Group company clients and over 100,000 individual clients/members in approximately 60 countries worldwide. Such experiences can be transferred to other countries to make their welded structures safer and more resilient to failures.
- In the US, Japan and New Zealand, due to having parts of their countries on severe earthquake zones as well as suffering a number of major earthquakes, new improved design codes, fabrication and erection techniques were introduced to improve the resistance to failure in earthquake conditions.

A very good case study from New Zealand illustrates the success of a dedicated industry sector approach also involving cooperation and collaboration with government and research organisations.

- Following severe earthquakes in the USA and Japan that occurred in the mid-1990s, HERA in cooperation with the University of Auckland established a seismic research programme focusing on the performance of welded connections. This program continues to this day and includes the contributions from multiple universities. It has led to more resilient welded structures, improved welding requirements and increased use of steel for the seismic resistant buildings in New Zealand.
- This has been shown by the exceptional performance of welded steel structures during the severe Christchurch earthquake in 2011 demonstrating the relevance and robustness of the research outcomes and successful technology transfer to the industry.
- With the help of HERA and Steel Construction NZ (SCNZ), New Zealand's structural steel welding industry also improved the quality and compliance of welded structures by implementing multiple initiatives to drive best practices and help 'raise the bar' across the sector. Some examples are the Steel Fabricator Certifi-

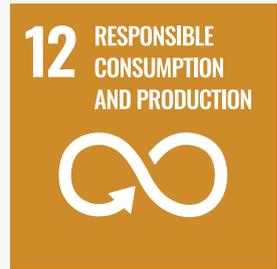


*HERA Seismic Research Programme, low cycle fatigue testing of a welded moment resisting frame connection at the University of Auckland, New Zealand [104]*

ication Scheme (SFC), which also includes IIW MCS ISO 3834 certification, and the development of the steel fabrication quality standard AS/NZS 5131. A number of design and practice guidelines were implemented, as well as the education and training of the required numbers of welding coordination and inspection personnel for industry successfully accomplished.

- In Australia, due to many parts of the country being subjected to severe bushfire situations, new design and building codes have been introduced to make buildings safer and more resilient to failure.
- Since the 1920s in Germany, there have been excellent examples of how Government and Industry have cooperated and collaborated to introduce standards, rules and regulations to ensure the integrity and reliability of welded structures and thus the safety of the German public. In particular, this has involved ensuring the competency of the people and companies involved in the design, manufacture, installation and maintenance of welded structures.
- Such approaches and cultures, have formed the basis of what exists in the European Union (EU) today in terms of appropriate standards, regulations, accreditations, education, training, qualification and certification etc related to applications in the welding industry.
- For example, the EN 1090 standards are European Standards that regulate the fabrication and assembly of steel and aluminium structures and are recognized by the Construction Products Regulation.
- EN 1090 for structural steel and aluminium is a requirement for products to be sold in Europe, and any organizations who design and/or manufacture steel or aluminium components must adhere to this standard. EN 1090 comprises three parts all aimed at guaranteeing the quality of the end products:

- ▶ EN 1090-1: Requirements for conformity assessment for structural component (CE Marking)
- ▶ EN 1090-2: Technical requirements for the execution of steel structures
- ▶ EN 1090-3: Technical requirements for the execution of aluminium structures
- Countries also need good, safe and efficient local and cross-country public rail transport systems to ensure sustainable cities and communities. There are many examples of countries which have established the codes and standards for the welding design, fabrication and manufacture of all the components required for such railway systems.
- The EN 15085 suite of European standards are now extensively used for the certification of companies involved with railway applications for the welding of railway vehicles and components. Together with standards for the welding of rail, with the correct technology transfer processes in place, there is no reason why a country's public rail system cannot be built and maintained correctly and operated safely.
- An example of such an initiative is the Thai Ministry of Transport and the German Ministry of Transport and Digital Infrastructure collaborating to raise standards of rail infrastructure in Thailand. The German-Thai Railway Association (GTRA) has been formed and a joint Degree Master in Engineering Programme titled Railway Vehicles and Infrastructure Engineering (RVIE) has been started at the King Mongkut's University of Technology North Bangkok (KMUTNB) and Chulalongkorn University in collaboration with RWTH Aachen University, Germany [93].
- The examples shown indicate that **Industry Sectoral Project (ISP)** approaches can be very successful with this SDG.



## 4.12 Ensure Sustainable Consumption and Production Patterns

### Overview of SDG 12

*SDG12 is about ensuring sustainable consumption and production and promoting resource and energy efficiency, long lasting infrastructure, a circular economy where possible, and providing access to basic services, green and decent jobs and a better quality of life for all. If we don't act to change our consumption and production patterns, we will cause irreversible damage to our environment [6].*

### Introduction

In many developing countries however, some of the main exports and hence export revenue earners are related to mining and to improve efficiencies means building more infrastructure such as mines, roads, rail and ports which of course has significant effects on the emissions produced. In Africa, less than 43% of people have access to electric power and hence the need to build more infrastructure. Some people might therefore claim that achieving major reductions in emissions will be extremely difficult due to such constraints.

Welding and related processes have been used in many ways over the years to create more sustainable products as well as increase the total life cycle of components through improved wear and corrosion resistant surfaces, resistance to failure in both extreme high and low temperature applications, ability to operate at high pressures amongst others.

The use and continuous development of such processes by the welding industry leads to reducing waste generation through prevention, reduction, recycling and reuse. It also encourages companies to adopt sustainable practices, promotes public and industry procurement practices that are sustainable and using effective communication processes, the welding industry helps ensure that people everywhere have the relevant information for sustainable development.

### Some factors to be considered by the Welding Industry

- The steel producing industry has introduced a ResponsibleSteel™ certification programme and four steel-makers in the world have now achieved certification.
- The Australian Steel Institute (ASI) has launched Steel Sustainability Australia (SSA), a certification programme that provides a clear pathway for steel businesses to operate more responsibly and transparently while being part of an environmentally and socially sustainable future. It certifies the entire steel value chain by certifying downstream steel businesses such as fabricators, roll formers and reinforcing processors, and verifying upstream steel producers against best practice environmental, social and governance (ESG) indicators aligned to the principles supporting the Green Building Council of Australia's (GBCA) Responsible Product Framework [211].
- The welding industry also has examples of how it uses certification programmes for various aspects mentioned above but the range and number of individuals and companies, both in the formal and informal sectors, which would need to be addressed is immense. It has however many examples of activities and resources which could be used to improve this SDG in many countries.
- There are many examples of sound environmental and Work, Health and Safety (WHS) management practices around the world to assist in control of many wastes related to welding.



- The welding industry has been heavily involved in the appropriate national and International organisations and IIW Commissions in these areas and the transfer of appropriate technologies into industry and the community at large.
- For example, the increasing use of Additive Manufacturing (AM) and its many benefits over recent decades, have contributed many economic, social and environmental successes globally. As the welding industry has embraced Additive Manufacturing, benefits have also increased quite significantly.
- The use of Wire Arc Additive Manufacturing (WAAM) has led to much larger and complex components being able to be manufactured with less lead times, greater efficiency, large cost savings with less materials used, less storage space, tools and machine wear, greatly reduced time to manufacture, significantly reduced energy usage and hence less carbon footprint. With less material wastage, the cost savings with more expensive materials is even more profound.
- Working with other organisations in their networks, the transfer of information on dealing with wastes, including recycling, from the processes involved in the cutting, fabrication, construction of applications using metals can be continually increased via seminars, workshops, guidance notes, education and training courses.
- Unfortunately in many developing countries, the health and safety of welders as well as environmental issues also remain as a challenge to the welding industry both in the formal and informal sectors. Welding workshop environment and safety issues are less regarded in the informal welding sector with welding operations mostly carried out in structures along the road side and sometimes in miniature workshops and also under trees with scant regard for the use of correct personal protective equipment etc and control of wastes [89].

A key challenge for governments and the welding industry in a country is to rectify these approaches.
- Organisations with a positive environmental culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of welding related activities to the environment and by confidence in the efficacy of preventive measures.
- An environmental culture of an organisation could be defined as the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's environmental management.
- The introduction of ISO 14001, *Environmental management systems – Specification with guidance for use*, is designed to help organisations manage, control, and report on their environmental performance. It therefore specifies the requirements for an effective environmental management system (EMS), providing a framework that an organisation can follow rather than establishing environmental performance requirements.
- The role of an Environmental Welding Coordinator (EnvWC), to be responsible in a company for all the welding related environmental activities, is also growing in some areas of the world and increasingly companies are having to comply with national and/or regional laws and regulations.
- Experience has shown that even with the introduction of such measures, this culture is one of the most difficult to get industry to implement, particularly with the large number of SME operatives in this sector. With the fast growing awareness of environmental problems in the world however, it is anticipated that adoption of this culture in countries will improve.
- In Australia, through a Federal Government programme known as the Industry Cooperative Innovation Project (ICIP), in 2012, WTIA completed a project titled ICIP DS 6: Expert Technology Tools (ETTs) on Welding WHS and Environmental Management Systems, Audit Tools and World's Best Practice for the Shipbuilding Industry. These ETTs were subsequently released publically for anybody to use as a basis for their own environmental management system manuals and self-assessment tools in their particular industry.
  - ▶ Welding in the Shipbuilding Industry: An Environmental Management System (EMS) Manual [96].
  - ▶ Welding in the Shipbuilding Industry: An Environmental Management Self-Assessment Tool [97].
- In parallel, WTIA Technical Note TN23 Environmental Improvement Guidelines [98] and WTIA Guidance Note GN04-Environmental Aspects and Impacts of the Activities Health and Safety [99] are complementary to this work.
- A document entitled *Environmental management systems - Requirements with guidance for use in the fabrication by welding* gives essential interpretation of the criteria in ISO 14001 in the field of welding fabrication [100].
- The role of the EnvWC can be promoted both for the benefit of individual companies, and the advancement of careers in welding. The concept builds upon the role of the Responsible Welding Coordinator (based on Standards ISO 3834 and ISO 14731) which has been successfully introduced into industry around the world to promote improved welding management and productivity [37], [101].
- A Work, Health and Safety (WHS) culture of an organisation, as used by the Health and Safety Executive



*Examples of abuse of the health and safety of young people*



*'Cool, clean and clever' – the goal of occupational health and safety in welding*

(HSE) in the UK, is the 'product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management'.

- Organisations with a positive work health and safety culture are characterised by communications founded on mutual trust, by shared perceptions of the importance of health and safety and by confidence in the efficacy of preventive measures.
- One of the most effective ways to improve the work health and safety culture is through the effective application of the laws and regulations which exist in many countries. This will automatically reduce waste by less people being negatively affected by poor WHS.
- Unfortunately, where such enforcements do not take place, many accidents and health problems related to welding activities do occur.
- The key to development and continuous improvement in a WHS culture is to change attitudes and behaviours at all levels. The mantra "all injuries are preventable" is not a utopian ideal but should be the basis for development and implementation of WHS management systems.
- Hazard identification, risk assessment and implementation of appropriate risk management protocols are essential. This requires identification of, and understanding of, potentially hazardous processes, development and use of better equipment and raising the awareness and competency of individuals to work safely.
- IIW and its members have been very active in creating awareness through education, training and technology diffusion throughout the world but unfortunately,

particularly in developing countries, numerous examples of widespread routine procedural violations occur where people, not just management, put cost or production before health and safety. The situation in the informal welding sector with respect to health and safety can be extremely dire. A major initiative could take place to educate and help people at all ages to prevent the damages that occur because of this. The resources are available for a global effort.

- In any organisation, senior management must commit to produce higher levels of motivation and concern for health and safety throughout the organisation. Managers need to lead by example and appear regularly on the 'shop floor', talk about health and safety and visibly demonstrate their commitment by their actions, for example stopping production to resolve issues.
- Good communications between all levels of employees should be part of everyday work conversations with ownership at all levels. The unique knowledge of employees with their own jobs, their involvement in workshops, risk assessments, plant design etc. all lead to a positive culture.
- The introduction of ISO 45011 *Occupational health, safety management systems* can be a significant aid to improving the culture in many countries and organisations.
- There is so much information available on these subjects that such information and technology can be transferred into developing countries to assist them in this Goal. Part of this technology transfer would be the education and training of personnel in companies accompanied by the establishment of company environmental, WHS and quality management systems and their certification [101].

## 4.13 Take Urgent Action to Combat Climate Change and its Impacts by Regulating Emissions and Promoting Developments in Renewable Energy



### Overview of SDG 13

*SDG 13 covers a wide range of issues surrounding climate action. Strengthen resilience and adaptive capacity to climate-related disasters, integrate climate change measures into policies and planning, build knowledge and capacity to meet climate change and promote mechanisms to raise capacity for planning and management [6].*

### Introduction

The effects of climate change are quite complex with both positive and negative changes taking place and the world working to help ensure that as many as possible will be positive. One approach is to regulate emissions and promote the development and use of renewable energy as well as enhancing end-use energy efficiency.

Energy resources power both domestic and industry needs, and are a key contributor to a country's economic prosperity. The demand for energy increases as a country's economy and population grow. Fossil fuels such as oil, natural gas and coal are examples of non-renewable resources.

In contrast, resources that are referred to as renewable energy sources can be used again and again, without depletion, or can be replenished in a short time frame. The wind, sun (solar) and waves are all sources of renewable energy although concerns are expressed not just about reliability of supply, but also the yet to be fully determined negative effects on wildlife, habitat and other environmental and biodiversity issues.

Critics and observers have also identified 'trade-offs between some SDGs. For example, the growth in use of electric cars is considered good news for the fight against climate change, but the expected boom in mining of rare materials used to make items such as rechargeable batteries raises environmental and social concerns that must be urgently addressed. The United Nations Children's Fund (UNICEF) has identified some major health and safety problems with children in this regard and together with major environmental problems occurring, great emphasis must be placed on reducing these dramatically [102]. The United Nations Conference on Trade and Development (UNCTAD) has recommended that the industry finds ways to reduce the need for mining in the first place [102].

### Some factors to be considered by the Welding Industry

- The welding industry and its networks, have been heavily involved in related work for many years in all these different types of energy ensuring their reliability and integrity and thus having a significant impact to combat negative aspects of climate change and regulating emissions.
- Steel is a significant part of any developing economy and is at the core of a green economy, in which economic growth and environmental responsibility work hand in hand. Once the steel is produced it becomes a permanent resource because it is 100% recyclable without loss of quality and has a potentially endless life cycle [103]. HERA for example has shown that 85% of steel scrap in New Zealand was recycled in the 2022 Financial Year [104]. Despite the need for transport to overseas recycling facilities at 85% recovery, the savings in global warming potential per tonne of steel scrap generated in the sector is 1,249 kg CO<sub>2</sub>-equivalent. If 100% recovery could be achieved, there are potential savings of 1,473kg CO<sub>2</sub> equivalent.
- HERA is also introducing a Zero carbon steel program. Emissions for most steel products used in New Zealand will be calculated using HERA's online calculator. Emissions are then offset via Ekos within the calculator itself. The offsets are focused on the planting and protection of native forests which in turn provides additional biodiversity and human capital benefits. The core offsetting calculations in the program are based on life cycle assessment and environmental product declarations to ensure credibility of the data, and the program rules were developed by independent sus-

tainability advisors at thinkstep-anz. The carbon credits arise from establishing new forests and protecting existing forests indefinitely from logging. These conservation activities create measured, reported and verified carbon benefits [104].

- On a global basis however, one has to be very wary of offsetting in some quarters since it can be open to abuse in a variety of ways [105].
- For many developing countries, self-sufficiency in steel production, including opportunities to expand manufacturing and construction industries through the growing production and use of steel, would lead to many other benefits. For example, according to the World Steel Association, steel use per capita for finished steel products in many developing countries is significantly below the world average of 214.5kg. With increasing levels of unemployment, the growth in steel production has the capacity to employ a large number of a nation's labour force both directly and indirectly [106].
- The welding industry could collaborate with governments and the steel producing and supply industry to meet the challenges ahead including the benefits to the SDGs through the significant growth in steel usage which will be required by 2030 in developing countries.
- Countries will vary as to the amount of renewable and non-renewable energy sources including fossil fuels which they have as well as the speed at which they can move to a fully renewable energy situation. Even with the recent breakthroughs with nuclear fusion, seen by some as a panacea, it is highly unlikely that there will even be a single prototype fusion reactor producing commercially relevant amounts of electricity before 2030.
- India for example, is putting its best foot forward by reducing the consumption of fossil fuels in heavy duty trucks and buses and commercial vehicles by the use of compressed natural gas and liquefied natural gas by reducing the SO<sub>x</sub> and NO<sub>x</sub> levels and pollution.

Solar and wind energy is being given preference over thermal energy to reduce the pollution as well as the road transport industry in India putting stringent norms of emission for vehicles [28]. Countries such as India are also putting greater emphasis on producing electric vehicles.

- In many countries, energy needs are still mostly met by fossil fuels. Coal resources are used to generate high percentages of domestic electricity, natural gas is found in many homes and is increasingly used in industry, and the transport system may be heavily dependent on oil, some of which may be imported. Nuclear energy is favoured in many countries and with the advanced stage of development of small modular

reactors (SMRs) changing the nuclear landscape, many more countries may embrace nuclear energy.

- Although the use of renewables is increasing, they still only account for a relatively small proportion of primary energy consumption and electricity generation. Hydro energy resources were developed early in some countries and are currently the largest renewable source of electricity in some countries. Hydro energy is derived from water within areas of high rainfall and elevation. The wind and solar energy industries are growing rapidly, with wind and solar farms becoming more common. There has also been significant investment in research and development aimed at increasing the efficiency and cost-effectiveness of wind and solar power, including the development of solar thermal power stations.
- In addition, a country could also have geothermal, wave and tidal resources. Geothermal energy can be in the form of buried, high-heat producing rocks. For countries with coastlines there could be world-class wave energy and tidal resources. Bioenergy is another significant potential energy resource. Organic matter (e.g. landfill or sugar cane waste) can be used to generate electricity and heat, as well as for the production of liquid fuels (biofuels) for transport. There is also growing interest in the use of hydrogen by industry and as fuel in cars.
- In addition to other energy-related activities such as energy efficiency measures and the expansion of renewable energy production, some proponents propose that green and clean hydrogen offer significant opportunities to decarbonise industry and a potentially massive new export industry could be developed, either in the form of hydrogen or ammonia as this is easier to store and transport [234].
- This is leading to greater cooperation and collaboration between various countries. Germany and Australia is a good example. German and European strategies focus on developing so-called "green hydrogen" – hydrogen produced from renewable energy sources. The Australian strategy uses the broader term of "clean hydrogen" that includes both green and blue hydrogen (hydrogen produced from natural gas which captures emissions using carbon capture and storage).
- Opportunities are also taking place for developing countries. In order to secure its long-term demand for green hydrogen, Germany is dependent on imports for about 80 per cent. Namibia, on the other hand, is considered one of the countries with the best conditions worldwide for the cheap production of the CO<sub>2</sub>-neutral energy carrier. Within the African continent, it maintains a leading position in this field. In August

2022, the German government therefore decided to establish a hydrogen partnership in a joint declaration of intent with Namibia.

- The Bundesanstalt für Materialforschung und-prüfung (BAM) from Germany and the University of Namibia (UNam) as well as the Namibia Green Hydrogen Research Institute (NGHRI) are intensively cooperating as governmental institutions in the field of green hydrogen technologies. BAM established several doctoral positions in this field and is involved in the training of young academics in Namibia. The common goal is to build up capacities for the safe production of green hydrogen in the country as quickly as possible. A major focus of these activities embraces the compatibility of welds in the field of green hydrogen facilities [228].
- Investments have also been made by various companies that through hydrogen, there is also the possibility to produce Green Steel. This however is the subject of much debate.
- Unfortunately, there is wide disagreement on the commercial viability and achievement times related to a number of these projects including green steel. Bluescope Steel in Australia believes that a lot of the technology to underpin the steelmaking process has yet to be developed and on the other hand, a Swedish Steelmaker recently shipped prototype green steel to Volvo for commercial use in trucks from 2026.
- Irrespective of the type of energy source used either now or in the future, welding and joining will be employed to varying degrees in the manufacture, repair and maintenance of the structures producing, transmitting and distributing the energy or components using the energy source. Coal, gas and nuclear power stations will still function for many years ahead so it is important that the appropriate welding related technologies are available in a country to ensure the optimum life cycle is obtained. Similarly with oil and gas pipelines and structures, both onshore and offshore. With renewables such as wind and solar energy, the components have their own challenges not just in manufacture but also in service ensuring that premature failures do not occur. There are still some concerns with respect to de-commissioning and potential for re-cycling of the materials.



*Wind power has become the world's fastest growing energy source over the last decade*

- With the advent of transport vehicles fuelled by energy sources such as electricity and hydrogen, the efficiencies of manufacture, repair and maintenance by welding and joining will still be required.
- The negative effects related to the mining of the raw materials required for electric cars will need to be addressed possibly by investing more in sustainable mining techniques and technologies for recycling more effectively the raw materials found in spent Lithium-ion batteries [102]. The welding industry will play a key role in the building of any mining infrastructure required.
- Whether the use of energy from ocean and tidal waves or from storage dams is to be used, the infrastructure required will still need the high quality design, manufacture and operation as similar structures required for renewables.
- Promoting the developments in renewable energy, will still require all the benefits of an improving national welding capability. A goal of development will be to reduce life cycle costs to achieve a cost per kilowatt hour of electricity which is attractive to consumers. Lowering fabrication costs, increasing production rates, enhancing durability and reducing maintenance will all contribute to this.
- The IIW and many of its members are active in contributing to this SDG through research and development and technology transfer particularly through innovative welding and joining technologies to achieve Carbon Neutrality and promote Sustainable Development including lower costs [107].



## 4.14 Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development

### Overview of SDG 14

*SDG 14 aims to reduce marine pollution, protect and restore ecosystems, reduce ocean acidification, create sustainable fishing, conserve coastal and marine areas, end subsidies contributing to overfishing and increase the economic benefits from sustainable use of marine resources [6].*

### Introduction

In terms of challenges below the water, there are many concerns about the whole range of pollution taking place which can have a major significant effect on the marine ecosystems. The benefits of the welding industry in fabricating, manufacturing and constructing a phenomenal range of structures and components for use in marine environments are immense. Since welding is used in numerous applications which will be used in water, the integrity of the welds however becomes paramount.

If one considers the range of applications covering ships, boats, oil and gas carrying pipelines and tankers, failures can result for example in fires and oil pollution from small spills to catastrophic damage.

An Industry Sectoral Project (ISP) approach could be used to transfer the knowledge and technologies to assist the industry achieve this SDG.

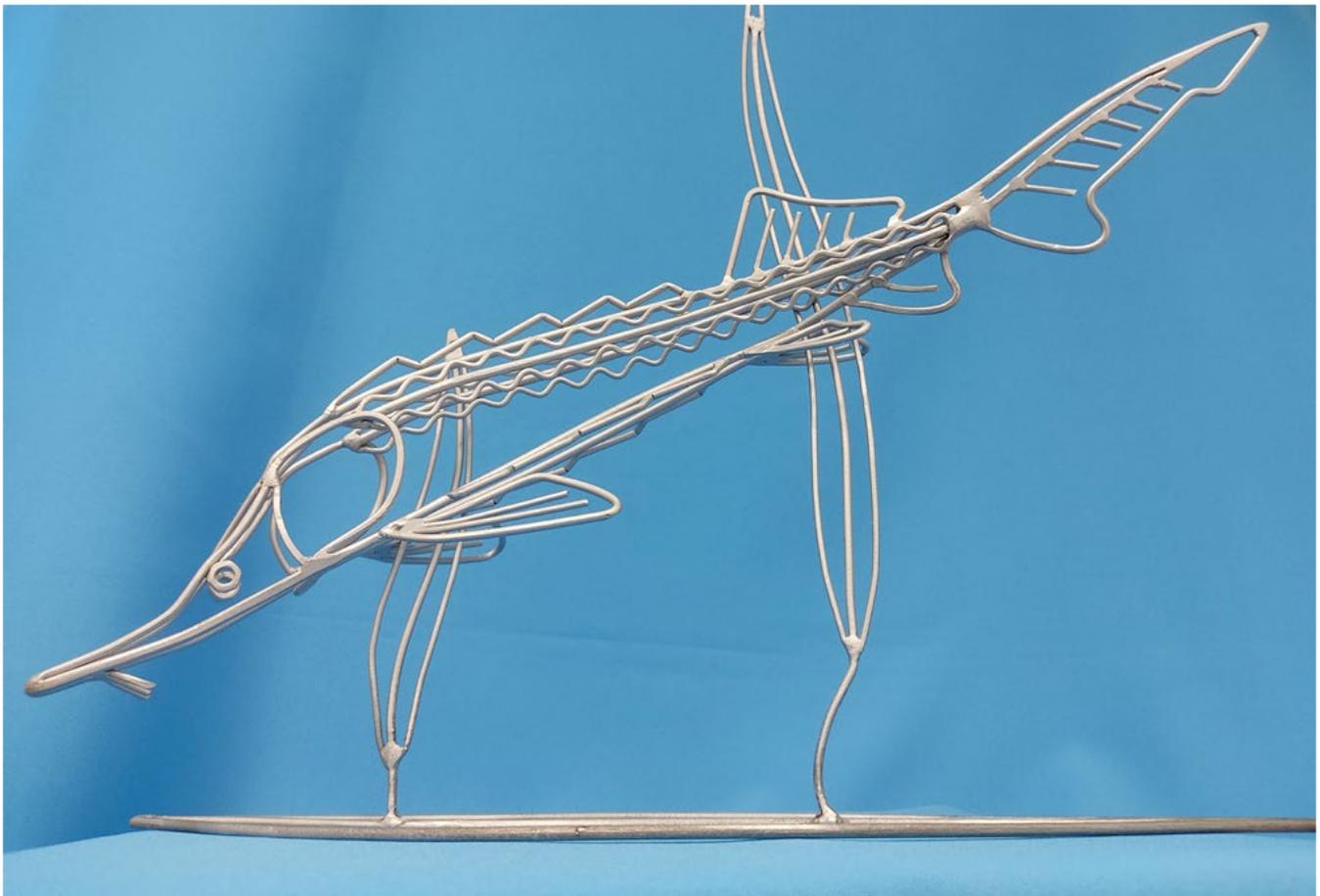
#### Manta Ray

Patrick Knighton  
IIW 2023 Digital Collection  
Reference [113]



### Some factors to be considered by the Welding Industry

- As areas such as the Arctic are being increasingly targeted for use such as for oil and gas exploration, oil and gas production, shipyards and naval bases amongst others, the risk of weld failures in operation increases due to the more demanding conditions existing. At the extremely low temperatures, the chances of weld failures due to brittle fracture and fatigue increase significantly. The conditions for performing repair and maintenance involving welding become far more onerous and give rise to greater possibility of poor quality welds and hence failures.
- The importance of the integrity of welding is illustrated by the Alexander L Kielland platform in the North Sea in March, 1980 which capsized with the loss of 123 people. The official investigations concluded that the root cause of the accident was an undetected fatigue crack in the weld of an instrument connection on the bracing. It was reported that there was no pollution due to this accident.
- When catastrophic accidents have occurred related to oil production platforms and tankers, the effects can be disastrous on animals, birds and marine life. For example, the spill from BP's Deepwater Horizon rig in the Gulf of Mexico in 2010, covered 68000 square miles of sea surface and killed approximately one million coastal and seabirds, 5000 marine mammals and 1000 sea turtles. The long term effects on the environment and animals' health are immense.
- Concern still does arise with respect to the offshore oil and gas industry particularly with the potential catastrophic failures of infrastructure, often due to lack of



*Starry Sturgeon*

*Andrey Makhorin. IIW 2023 Digital Collection, Reference [113]*

appropriate maintenance. For example, back in 2010 there were at least three known oil spills linked to the Jubilee Field in Ghana as well as disturbing reports of seven dead whales washing ashore [108] and in 2012, the Institute for Energy Policies and Research (INTEPR) warned of an imminent oil spillage in the central region if the 65-year old rig located at Saltpond in the region was not immediately decommissioned [109].

- The high integrity and reliability of welded structures in marine applications to this SDG is essential. Repurposing of pipelines and related plant, equipment and structures will also be significant challenges [72].
- The expertise in welding industry networks, particularly with IIW Members, can be used to mitigate such problems particularly through the development work and involvement of its networks of world class experts and technology transfer to countries.
- IIW-India members have developed products for the marine industry using LNG as the fuel for heavy duty ship engines which reduces the pollution in the sea as well as waterways being developed and constructed for ships and barges thus avoiding surface transport on roads [28].
- A major challenge facing this SDG is the massive pollution of waterways, including major rivers, which takes place daily across the world and how the welding industry can influence reducing this. The impacts from marine plastic pollution are well known with major efforts taking place to make plastics a key part of the circular economy. The welding industry can play a major role in the design, construction, operation and maintenance of the required plant infrastructure to achieve this.
- In developing countries, many cities and towns that have a sewerage system do not have sewage treatment and the consequences of continued discharge into the environment are serious with irreversible damage to the aquatic environment as well as health risks from exposure to pathogens entering the environment [69].

## 4.15 Protect, Restore and Promote Sustainable Use of Terrestrial Ecosystems, Sustainably Manage Forests, Combat Desertification, and Halt and Reverse Land Degradation and Halt Biodiversity Loss



### Overview of SDG 15

*SDG 15 aims to help increase financial resources to conserve and sustainably use ecosystem and biodiversity, finance and incentivize sustainable forest management, combat global poaching and trafficking. The proportion of remaining forest area, desertification and species extinction risk are example indicators of this goal [6].*

### Introduction

Environmental issues can include deforestation, illegal wildlife trade, illegal poaching, air pollution, land degradation and water pollution caused by industrial and mining activities, wetland degradation, pesticide use and severe oil spills among others [110]. Although many of these issues are outside the direct control of the welding industry, welding is used in many critical applications which if failure occurs, varying degrees of contamination and destruction can take place.

These can range from catastrophes similar to those mentioned above in SDG 14 through to issues such as sewage and mining spillages onto land and into rivers which is prevalent in many countries. Underinvestment, lack of maintenance and debt can make plants perform below capacity including having explosions taking place [111]. Similarly with transportation systems such as tankers and pipelines carrying hydrocarbons, there are many incidents around the world of failures occurring for a variety of reasons.

In terms of this SDG, welding can have a positive influence in a number of ways. In all the issues mentioned in the SDG, water management plays a significant role in their success. As mentioned in Section 4.6, water sources whether dams, rivers, desalination plants etc, need to be built and maintained. Pipelines need to be constructed, laid and maintained to carry the water to the points where distribution can take place to where the water is required with minimum waste.

### Some factors to be considered by the Welding Industry

- In terms of combatting desertification and using the reclaimed land for agriculture as happens successfully in various countries, efficient storage and irrigation methods are essential and the integrity of welding can have an effect on this.
- With forest management and remediating land which has been degraded, similar challenges with ensuring reliable efficient water supplies exist. Storage tanks, pipelines, piping systems will all require competent people to apply appropriate welding and inspection technologies.
- In addition, reliable heavy moving equipment and other types of vehicles will be required on an ongoing basis. This will require competent welding maintenance workers with the abilities not only to apply the appropriate technologies but also to develop the necessary procedures and application processes often for difficult-to-weld materials.
- In all these cases including biodiversity loss, it is often required to fence-off and protect the land enclosed against feral animals killing off rewilding attempts and damaging the habitat being remediated. Although fencing is one step along the rewilding path, again welding plays a significant role in ensuring the integrity of such fencing. In Australia for example, there are major moves not just to conserve existing and often quite degraded land areas but to revitalise and rewild it.
- Concerns do exist in countries where pristine land could be degraded or degraded land degraded even

further. Examples of the types of catastrophic failures which can occur and dramatically affect numerous people, animals and land include the Bhopal disaster in India and the Chernobyl nuclear power plant failure in Ukraine in 1986.

- On 3 December, 1984, more than 40 tons of methyl isocyanate gas leaked from a pesticide plant in Bhopal, India, immediately killing at least 3,800 people and causing significant morbidity and premature death for many thousands more.
- The organisations fighting for the victims claim however, that the tragedy has killed at least 25,000 people. A report released in April, 2019, by the International Labour Organization (ILO) dubbed the 1984 Bhopal Gas Tragedy as one among the world's 'major industrial accidents' of the 20th century.
- Apart from the dreadful human toll, we also cannot ignore the environmental impacts of the disaster. Over 2,000 animals were killed by the gas that night, most of them livestock that people relied on for food.
- Welding is used in many critical applications which if failure occurs, varying degrees of contamination and destruction can take place. These can range from catastrophes similar to those mentioned above through to issues such as sewage spillages onto land and into rivers.
- There are examples of catastrophic fires in forests, grassland and bushland which have been caused by people or companies ignoring the banning of 'hot works' during periods when such areas are extremely dry. The use of welding and other processes such as grinding create the heat sources to start fires which can spread rapidly to devastating effect on humans, animals and habitat.
- Reference [112] shows a fire caused during welding of a metal post which burnt through 17,141 hectares before it was extinguished on 31 January, 2020 destroying 10 houses, 14 farm buildings and damaging two other homes.





- The great benefits of welding can be realised however with the proper design, materials, procedures, manufacture, conformity assessment, operations including repair and maintenance as well as decommissioning leading to positive contributions to improving this SDG.
- With the rapid development of welding technology and its links to steel as a 100% recyclable material, some people believe that it is becoming cheaper and faster to make use of steel as a material, hence reducing the load on natural materials such as wood, hence reducing deforestation.
- IIW has been proactive in encouraging the holding of welded art exhibitions to show the importance of global biodiversity to the future of the planet and the success of the SDGs [113], [114], [115], [158].
- In terms of cooperation and collaboration in times of adversity, to remember the people lost to the devastating Black Saturday fires of 2009 in Victoria and the brave Country Fire Authority (CFA) men and women who battled the elements to protect the towns, the Australian Blacksmiths Association (Victoria) Inc. invited hundreds of blacksmiths from across the country and around the world in 28 countries to voluntary contrib-

#### *The Blacksmiths' Tree*

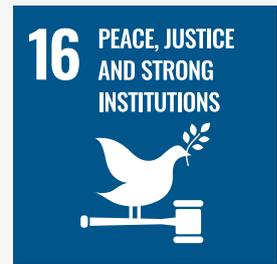
*Australian Blacksmiths Association (Victoria)*

*IIW 2023 Digital Collection, Reference [113]*

*Photo Credit: Amanda Grant, Project Manager*

ute to the creation of a steel gumtree [116]. It took five years to make and was erected on 14 February, 2014, and stands at the Peter Avola Memorial Pavilion, 160 Chadds Creek Road, Strathewen, Victoria, Australia. Due to the international links that were formed during this time, Australian blacksmiths participated in making steel roses for a memorial sculpture following the attacks in Oslo and Utøya in Norway in 2011, <https://www.jernrosene.no/english> and forged poppies for the Ypres Peace Monument, a WWI memorial in Belgium <http://www.yprespeacemonument.com/>.

An Industry Sectoral Project (ISP) approach could be used to transfer the knowledge and technologies to assist the industry achieve this SDG.



## 4.16 Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for All and Build Effective, Accountable and Inclusive Institutions at All Levels

### Overview of SDG 16

*SDG 16 promotes the rule of law and ensures equal access to justice, substantially reduces corruption and bribery, develops effective, accountable and transparent institutions, ensures responsive, inclusive and representative decision-making, strengthens the participation in global governance, provides universal legal identity, ensures public access to information and protects fundamental freedoms [6].*

### Introduction

Often the word sustainable is understood by people to refer only to economic or financial sustainability. It is important to realise that it refers to many other aspects of the SDGs, in particular including the environmental, societal and cultural behaviours. The Engineering Council in the UK for example, has produced a guidance document on sustainability including sustainability tools [208].

Peaceful, just and inclusive societies are priority goals to achieve all the SDGs. People everywhere need to be free of fear from all forms of violence and feel safe as they go about their lives, no matter their faith, ethnicity or gender. National and local institutions must be in place to deliver basic services to citizens equitably and without bribes [18].

As part of the SDGs, politicians promised to substantially reduce corruption from 2016 to 2030. Unfortunately, the corruption perception index from Transparency International shows that at a global level, there has been zero progress over the past decade.

One very good recommendation to reduce corruption straightforwardly and cheaply, is linked to government procurement of works, goods and services from the private sector. Such procurement is worth almost USD13 trillion or 15 per cent of global GDP and in the countries where the poorer half of the world's population lives, procurement makes up an astounding half of all government expenditure.

Electronic procurement, or "e-procurement", lets many companies hear about procurement offers, ensures

more bids can be submitted and means governments lose less money through corruption and waste. It is one of the world's most effective policies to reduce corruption at low cost, while making societies much better off [198].

### Some factors to be considered by the Welding Industry

- The IIW has always promoted inclusivity to its members and the welding industry as one of its core values.
- In NWC projects, it is good to have them led by effective, accountable and inclusive institutions. They should be member based organisation and thus will be accountable to their members. Through having industry committees, they will be accountable to the broader welding industry and being not-for-profit organisations, they should put the needs of industry and communities first.
- To succeed in their objectives, they must ensure that the organisations in their networks are also effective, accountable and inclusive. Through their information transfer mechanisms, they would have the ability to significantly influence this SDG positively through the successful promotion and implementation of the appropriate cultures in industry.
- An ethics culture is probably one of the most important cultures that needs improving throughout the world. Prof. Phil Hopkins, an international authority on integrity of pipelines, relates ethics and engineering in his excellent paper [117]. One definition of ethics



*Helping Hands*

Mike van Dam. *IIW 2023 Digital Collection, Reference [113]*

is a synonym for ordinary morality. 'Morality' refers to those standards of conduct everyone (every rational person at his rational best) wants every other to follow even if everyone else's following them would mean having to follow them too. Morality (in this sense) is the same for everyone, engineers included. The golden rule 'Do to others as you would have them do to you' is an excellent model.

- Throughout the world, unfortunately, a culture of corruption exists in many countries whether developing or developed. There are many examples of different types of corruption and the welding related industry has tried to implement ways of obviating these. In some examples of corruption, the culture is so prevalent that to overcome it is a major constraint.
- In creating an NWC, it is critical to ensure that the organisations involved all comply with the applicable legal and statutory obligations covering aspects such as financial, tax, governance, law, industrial relations etc. as well as ensuring that Directors, employees, suppliers, etc. do not have conflicts of interest. This is critical since credibility of the organisations and their

employees will be paramount in being successful in both establishing and sustaining an NWC.

- It is also important that the organisations in the NWC team and the NWC and SDG Flagship Programme Lead Organisation have policies for their organisational corporate cultures. A good example of such a policy is given by Geoff Carter in Reference [118]. The Board of a company needs to acknowledge that the organisation's culture is formed by the way people, on the whole, behave-what they believe, the values they hold, the attitudes they adopt-without thinking about any of it.
- The Board must ensure that an appropriate set of behaviours, beliefs, values and attitudes is embedded in the way things are done in the organisation. These behaviours, beliefs, values and attitudes should then be passed through the organisation via communication and imitation, from one employee, volunteer or even director to the next.
- There are many examples of things going wrong ethically and industry and governments attempting to prevent such occurrences in the future. For example:
  - In industry, employees can be tempted to pass non-conforming work in a variety of ways for financial gain, so employers and law makers introduce strict penalties for such people if found guilty. The Alaska Pipeline scandal over 40 years ago is a prime example.
  - Qualification and certification (Q&C) of personnel are methods used by industry through Q&C issuing bodies to show that a person is competent to perform a particular function. Prior to issue, the recipient can be requested to sign a code of ethics and if at some future time the person is not complying then the Q&C can be withdrawn. It is hoped that the application and strict adherence to the code of ethics creates an ethical culture in the industry. Individuals do exist who pretend to have Q&C documentation or positions which they do not hold.
  - There are many examples across the world of students, examination bodies, certification bodies abusing the system so strict governance and quality management systems are implemented to pre-

vent corrupt practices. Cheating in examinations is a common occurrence and with the significant increase in remote teaching, learning and examinations, reports of such cheating have increased [119].

- A useful approach is to look for 'ethical leadership' in people at all levels. The most successful leaders inspire others to embrace a common goal through recognition of shared values. They build and maintain effective relationships by living and leading with integrity.
- The Royal Academy of Engineering in the UK recently had a report published on ethics in the engineering profession [209].
- ISO has also introduced standards which involve ethical behaviour. ISO 19600:2014 – Compliance Management Systems-Guidelines and ISO 26000 Social Responsibility Guidance Document.
- ISO 19600:2014 covers establishing, developing, implementing, evaluating, maintaining and improving an effective and responsive compliance management system within an organisation. They are guidelines and the extent to which they are used depends on the size, structure, nature and complexity of the organisation. The Standard falls under ISO Technical Committee 309, Governance of organisations.
- In the welding related institutions, codes of ethics enable personnel to be accountable for their actions. Welding related professionals have a duty to uphold the highest standards of professional conduct including openness, fairness, honesty, integrity, respect for life, law, the environment and public good, accuracy and rigour, leadership and communication.
- Fidelity to public needs, including safety, health and welfare, needs to be also shown in the welding institutions where at every personnel level, qualifications and certifications plus codes of ethics have been introduced to ensure devotion to high ideals of personal honour and professional integrity, knowledge of developments in the area of professional relevance to any services that are undertaken and competence in the performance of any professional services that are undertaken.

Again, an **Industry Sectoral Project (ISP)** approach could be used to transfer the knowledge including experiences to assist the industry achieve this SDG.

## 4.17 Strengthen the Means of Implementation and Revitalise the Global Partnership for Sustainable Development



### Overview of SDG 17

*SDG 17 emphasises that a successful sustainable development agenda requires partnerships between governments, the private sector and civil society. These inclusive partnerships build upon principles and values, a shared vision, and shared goals that place people and the planet at the centre and are needed at the global, regional, national and local level. Developing multi-stakeholder partnerships to share knowledge, expertise, technology and financial support is seen as critical to overall success of the SDGs.*

*They are about strengthening and streamlining cooperation between nation-states, both developed and developing, using the SDGs as a shared framework and a shared vision for defining that collaborative way forward [6].*

### Introduction

Multi-stakeholder partnerships will be crucial to leverage the interlinkages between the SDGs to enhance their effectiveness and impact and accelerate progress in achieving the SDGs. Developed countries will need to fulfil their official development assistance and partnerships commitments.

An important component of achieving this SDG is the use of both the formal and informal networks which exist within the welding related industries both locally and globally. The sharing of knowledge, expertise, technology and financial support is seen as critical to overall success of all the SDGs.

A general definition of a network is that it consists of a variety of entities (e.g. organisations and people) which are largely autonomous, geographically distributed and heterogeneous in terms of their operating environment, culture, social capital and goals, but that cooperate and/or collaborate to better achieve common or compatible goals.

### Some factors to be considered by the Welding Industry

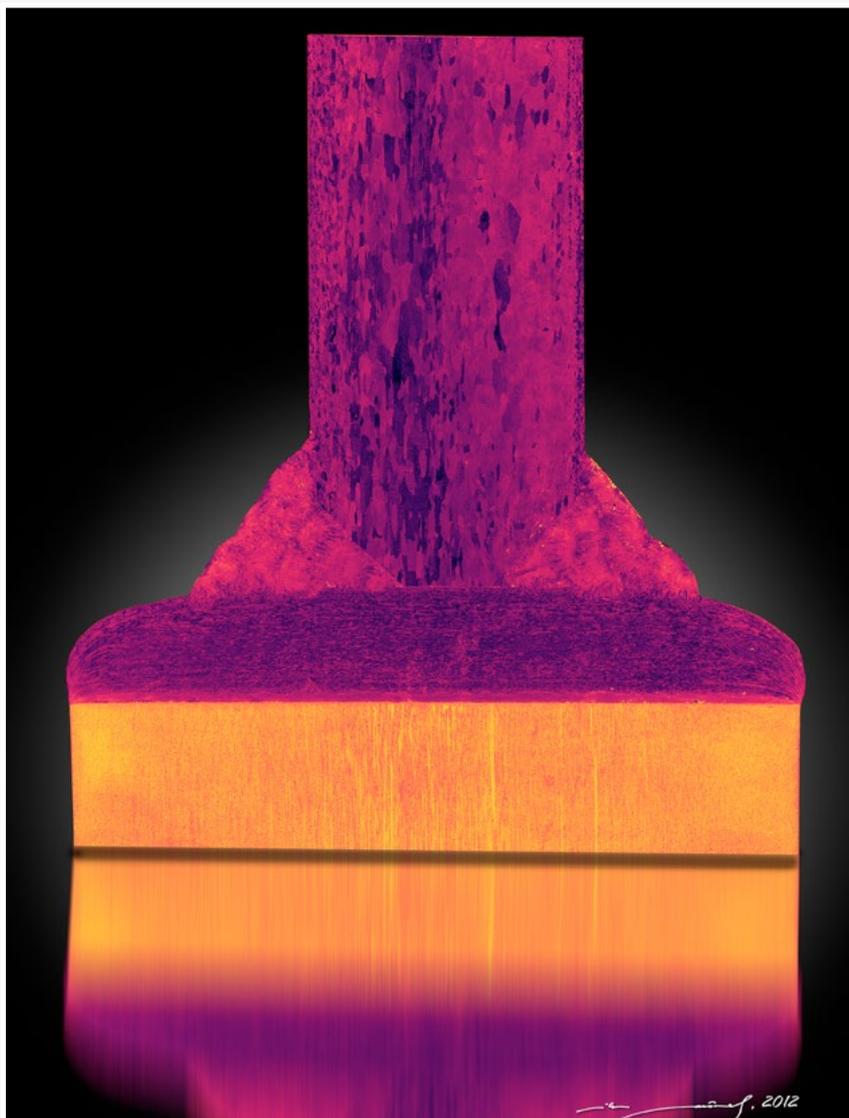
- Many people and organisations think of networking as being the meeting of people at events such as conferences, cocktail parties, social networks etc. or those

linked to personal or professional computer networks. Although these are very useful and can contribute in various ways to the success of achieving an optimum NWC, the more useful networks however, are the more formal networks established closely associated in most instances with the welding industry. Such networks help in producing a multitude of partnerships, both large and small, ready to work together on appropriate activities to assist in meeting SDG targets in a country.

- Companies in industry need to continually innovate to remain competitive. Innovation includes new products and processes, significant changes to existing products and processes and significant changes to management and organisational structures;
- For example, the CWB Group in Canada, Southern African Institute of Welding (SAIW), the Heavy Engineering Research Association (HERA) in New Zealand and The Indian Institute of Welding (IIW-India) have formed the Welding Innovations Network (WIN) working to transfer the knowledge and experience of world experts into as many countries on a global basis. Such cooperation and collaboration can be of tremendous benefit particularly to developing countries.
- Implementation of innovative ideas and processes especially for smaller firms requires an effective link between the firms themselves and sources of technology, knowledge and information. Networks are a crucial fundamental requirement for this.



- A strong NWC and SDG Flagship Programme Lead Organisation can be the catalyst to establish and sustain such networks with most of the organisations in the networks considering themselves as partners in the team achieving the NWC and SDGs and giving their ongoing commitment to establishing the NWC and continuing to progress the SDGs.
- A very successful initiative showing how such an organisation could be started, has taken place in Kazakhstan since 2009, when a project was launched to build up the NWC of Kazakhstan. Reference [120] titled Kazakhstan Welding Project, Kazakhstan Institute of Welding, Kazakhstan Welding Association “Kazweld”, gives an excellent history of all the organisations collaborating on a range of activities resulting in the establishment of the Kazakhstan Institute of Welding with KazWeld as the IIW Authorised Nominated Body (ANB). The supportive organisations also included the Institute de Soudure from France and the Total Company in Kazakhstan, working with the Kazakhstan Government to make the project a great success.
- To truly form a team to progress the NWC and SDGs requires allowing people and companies the opportunity to have some ‘ownership’ of the activities and outcomes involved and one way to achieve this is to allow people and companies to have a form of membership. There are many good examples of such membership in organisations across the world and the organisational structures for this should be readily established. AWS, TWI, DVS, CWB Group and SAIW are worth considering to evaluate the “pros and cons” of different types of membership structures.
- Such members, besides becoming team players, can offer great support in many project activities on a voluntary basis. Such activities could include promoting involvement in progressing each SDG, technology transfer, improving cultures, providing resources such as committee members and meeting venues amongst many others. There are a number of very good examples of IIW Members having such structures and these are worth investigating, in particular, the ways in which members could assist in the activities [35].
- Since all the different building blocks to create a successful NWC are essential, networks and the partnerships which evolve are therefore of great importance in the areas covering funding, government, industry, R&D, technology transfer, education and training, qualification and certification (Q&C), skills and career development, cultures, standards and communications which will all contribute positively to the SDGs.
- There are many examples of such networks around the world but the challenge is to resource, build up and sustain such networks. Whether a country's economy is considered developed, developing or an economy in transition, such networks are essential but obviously countries in different stages of development will have varying challenges and difficulties to succeed in establishing and maintaining the networks.
- There are excellent examples of networks successfully established to bring industry and all levels of government together to supply the R&D, technologies, technology deliverers and technology receptors to create viable industry sectors and overcome constraints as well as fostering partnerships between Small, Medium, Enterprises (SMEs), larger firms and Multinational Enterprises (MNEs) which play a leading role in technological innovation, R&D investing and patenting [39], [40].
- Two good example of how such networks can assist with this SDG including ideas on new institutional models are shown in References [39] and [92]. Reference [39] shows how Australia created a worldwide network of technological experts and organisations with remarkable success with technology transfer. Reference [92] shows how the CWB Group built up an Association from 1000 to over 100000 individual clients/members globally over a ten year period including 19 Chapters across Canada. When one considers the numbers of people welding in a country, a quantum leap by the welding industry's involvement in progressing the SDGs will make an enormous contribution to a country's government's endeavours [187].  
International networks have many benefits across all the activities in an NWC. For example, such networks include amongst many others, those shown below and can all contribute to the NWC Project and SDGs:
  - IIW with 51 Member countries [34];
  - International Organization for Standardization (ISO) with 169 Member countries [122];
  - WorldSkills International with 79 Member countries [49];
  - International Committee for Non-Destructive Testing (ICNDT) with 66 Full Members and 9 Associate Members [123];
  - IIW Authorised Nominated Bodies (ANBs) in over 46 countries [34];
  - IIW Approved Training Bodies (ATBs) in each country with an IIW ANB;
  - Welding equipment/consumable suppliers [124], [125];
  - NDT equipment suppliers [126], [127].



### Colour Tau

Milan Maronek,  
IIW 2023 Digital Collection,  
Reference [113]

Similarly with networks within the NWC Lead Organisation or NWC Project Team in a country:

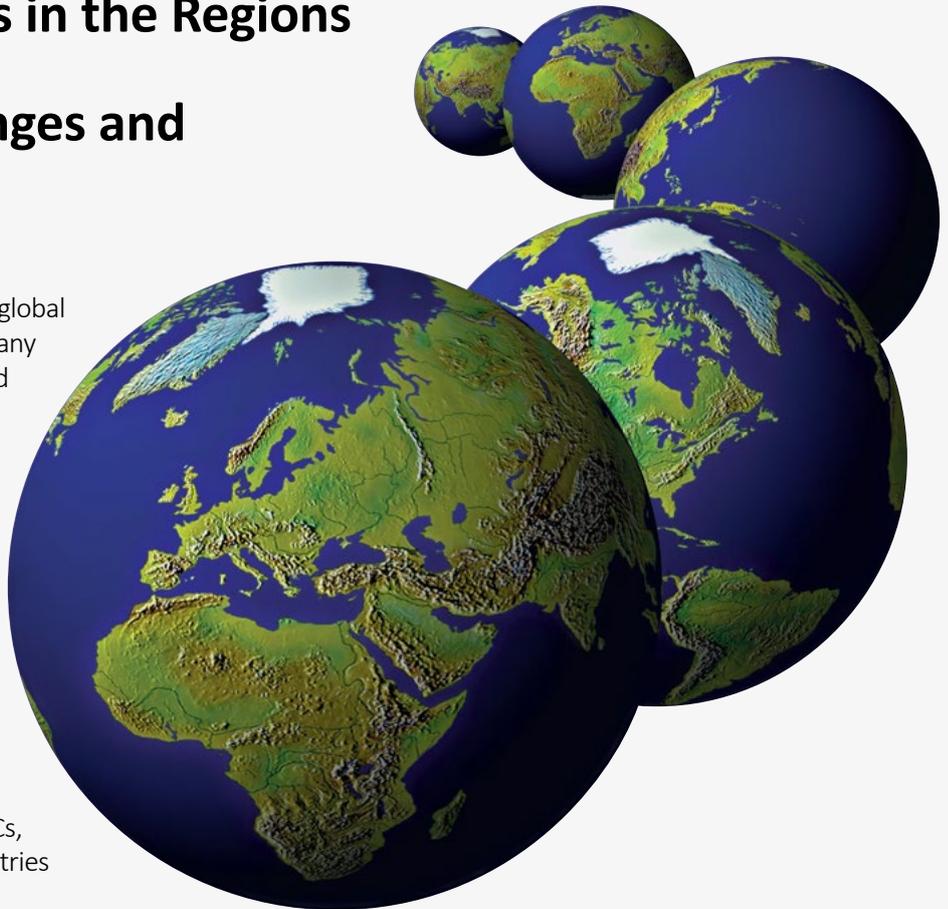
- NWC Project Lead Organisation Technology and Research Board;
- NWC Project Lead Organisation Education and Training Board;
- NWC Project Lead Organisation Qualification and Certification Board;
- NWC Project Divisional or Professional Membership Committees;
- NWC Project User/Asset Owner Groups [39];
- NWC Project Industry Specific Groups (ISGs) [39];
- NWC Project Technical Panels [39];
- NWC Project Technology Expert Groups (TEGs) [39];
- NWC Project Technology Support Centres (TSCs) Network – Local [39];
- NWC Project Technology Support Centres (TSCs) Network – International [39];
- Federal, State and Local Governments;
- Professional Associations/Institutes;
- Industry Groups for Specific Business Needs;
- Standards Developing Organisations;
- Vocational Education and Training Organisations;
- International Government Organisations
- International Technical Organisations
- Individual Experts

The multi-stakeholder partnerships in the SDGs to share knowledge, expertise, technology and financial support are seen as critical to their overall success and is analogous to the partnerships in the welded joint application and sustainable production of aluminium, one of the most environmentally friendly metals on earth including claimed to be infinitely recyclable, as shown on the welded art exhibit Colour Tau above

## 5. Challenges and Opportunities for Improvements in the Regions

### 5.1 Global Challenges and Opportunities

- The UNESCO Report [7] highlights global trends which form the basis in many instances of the challenges to be faced globally, regionally and nationally in meeting the 2030 Agenda. These challenges can vary widely in type and size depending upon the situation in a country and hence in the complexity of finding, and enormity of implementing, solutions. One approach is to create a plan related to improving the national welding capability of a country. Another is for countries in a particular region to cooperate and collaborate to improve all the NWCs, and hence the SDGs, in all the countries in the region.
- IIW and its 51 Members and each of their memberships consisting of companies and individuals, are probably in an excellent position to be the influencers and catalysts for numerous opportunities to improve the SDGs. Since 1948, IIW and its Member countries, have been involved in numerous innovations which have contributed to improving the global quality of life. Linked to these innovations has been the need to transfer both leading edge technologies and appropriate technologies into the welding industry to meet the needs of a country.
- Such approaches also need a suitable organisation, such as a national welding institute, society or association to coordinate such plans. Unfortunately, not all countries have such an organisation and often the initial objective is to establish one.
- Some examples are given in the following sections involving both formally established organisations and informal organisations in various regions which are cooperating and collaborating in this regard, and other regions of the world where such regional organisations probably need establishing to optimise the effects on the SDGs.
- The designated regions do not follow any UN structure but are simply chosen based on the knowledge of countries previously or presently cooperating or collaborating in the welding field.

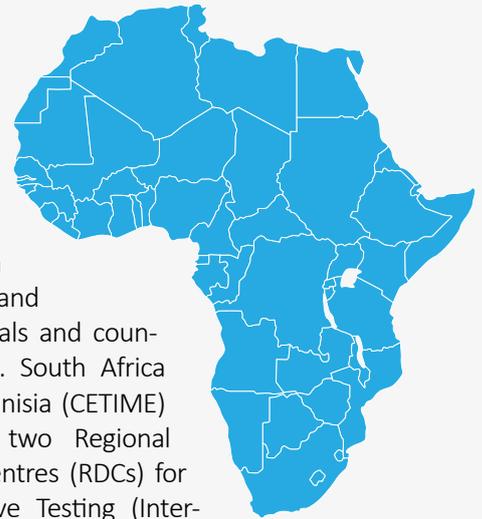


## 5.2 African Countries

- Since 1948, the African countries which have been IIW Members include Algeria (71), Cameroon (139), Egypt (81), Ghana (122), Morocco (70), Nigeria (146), South Africa (110) and Tunisia (58). The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128].
- The Southern African Institute of Welding (SAIW) and the Nigerian Institute of Welding (NIW) have played significant roles in promoting welding technology in Southern Africa and West Africa respectively.
- SAIW (1997, 2006 and 2012), NIW (2009), the Central Metallurgical Research & Development Institute (CMRDI) in Egypt (2004) and the Centre Technique des Industries Mecaniques et Electriques (CETIME) in Tunisia (2010) have held very successful IIW International Congresses, and SAIW (2004 and 2018), NIW (2009), Egypt (2010) held technology innovation workshops as part of their technology transfer strategies in their national welding capability plans and regional support.
- This is besides their own national conferences, seminars, workshops, training courses, R&D and technical support to their industries which they conduct on an on-going basis in their countries.
- NIW and SAIW have also been continental leaders in education, training, qualification and certification as IIW Authorised Nominated Bodies (ANBs) and IIW Authorised Nominated Bodies for Company Certification (ANBCCs). This has included assisting other African countries. For example, with sponsorship from the German Agency for International Cooperation (GIZ), SAIW is working with Ethiopia and has established an IIW Approved Training Body (ATB) and is training welding coordination personnel in Ethiopia.
- Since 1994, SAIW has been involved with a number of initiatives with UNIDO and this has continued even recently with UNIDO creating a video showcasing SAIW's capabilities and facilities in Johannesburg.
- A very good example of African collaboration is shown by the support of the International Atomic Energy Agency (IAEA) in the development of non-destructive techniques for industrial quality control in Africa. In 1994, IAEA started funding a pan-African NDT training, qualification and certification programme conducted at the SAIW. For over 25 years, this has been very successfully implemented through the excellent coop-

eration and collaboration of the IAEA and many individuals and countries in Africa. South Africa (SAIW) and Tunisia (CETIME) became the two Regional Designated Centres (RDCs) for Non-Destructive Testing (International Atomic Energy Agency – AFRA) with the emphasis on training and certification of NDT personnel throughout Africa [129].

- The African Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology (AFRA) was established by African States to further strengthen and enlarge the contribution of nuclear science and technology to peaceful socio-economic development on the African continent. In 2004 this culminated in the formation of the African Federation for Non-Destructive Testing (AFNDT) in Khartoum.
- Projects still continue today with SAIW hosting a delegation of approximately 60 delegates for the launch of the 2022 Nuclear Energy Management Schools programme (NEMS2022). The NEMS2022 saw participants from 12 countries on the continent, along with IAEA Staff Members from Vienna in Austria. Countries represented included Algeria, Egypt, Ethiopia, Ghana, Kenya, Morocco, Niger, Rwanda, Senegal, Sudan, Uganda and Zambia. These initiatives show the potential for similar cooperative and collaborative projects in the welding related industries.
- The IAEA has a very good record of encouraging cooperation and collaboration in training in nuclear science and technology on the continent as evidenced by its work with 27 universities in Africa. A meeting was held in Johannesburg, South Africa on 14-16 August 2023 to progress this subject [231].
- Countries such as Ghana [130], Nigeria [131] and South Africa [19] have already published reports on how improving their national welding capabilities will positively affect the UN SDGs in their countries.
- South Africa and Nigeria in particular, are already sharing their expertise and experiences across Africa at international level in areas such as education, training qualification and certification of welding related per-





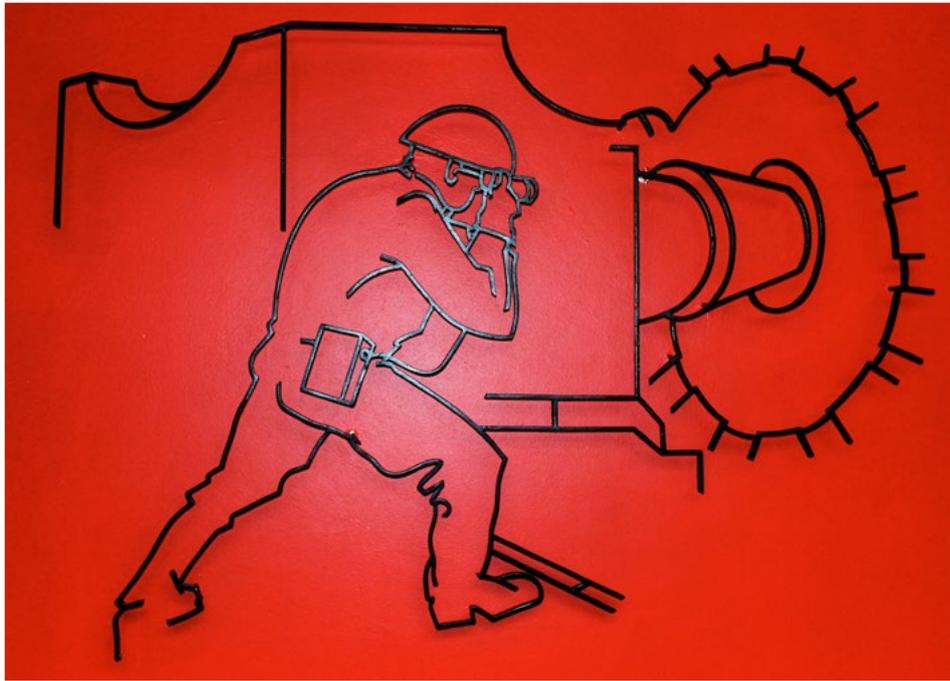
*Dr Cécile Mayer, former IIW CEO, with Dr Emmanuel Gyasi (Ghana, left) and Dr Paul Kah (Cameroon) participating in the IIW Annual Assembly, Helsinki, 2015*

sonnel at all levels as well as certification of companies to international standards. For example, today, SAIW has more than 322 companies certified to the IIW Manufacturers Certification Scheme According to ISO 3834 thus helping cities and human settlements to be safe, resilient and sustainable [19].

- Since the introduction of the IIW programmes in 2003, 151 International Welding Engineers (IWEs) have been trained and qualified at the Universities of Pretoria and Witwatersrand. 181 International Welding Technologists (IWTs), 280 International Welding Specialists (IWSs), 138 International Welding Practitioners (IWP) and 1507 International Welders have been trained and qualified at SAIW [19].
- SAIW's and IIW's welding inspector training, qualification and certification programmes have been so successful with 6034 individuals being successful. Furthermore, 9596 certificates have been issued in the main non-destructive testing (NDT) methods during the past eight years as well as nearly 30000 days of welder training having successfully taken place on a

variety of courses to meet the standards required for employment in industry

- Since the introduction of the IIW programmes in 2010 by NIW, 30 International Welding Engineers (IWEs), 8 International Welding Technologists (IWTs), 4 International Welding Specialists (IWSs), and over 5000 International Welders have been trained and qualified at NIW [131].
- NIW also had 20 IIW international Welding Practitioners and 10 International Welding Specialists trained at SAIW as trainers. Similarly, 11 International Welding Engineers, 40 International Welding Inspectors – Comprehensive were also trained by the German (GSI-SLV) in Turkey while 12 underwater welding technicians were trained in Marseille, France [131].
- Currently, Uganda with the assistance of the Cameroon Welding Association (CWA) has just created the Welders Society Uganda (WESU) and CWA continues to assist WESU in the structuring and development of Young Professional (YP) activities in cooperation with Ugandan industry.

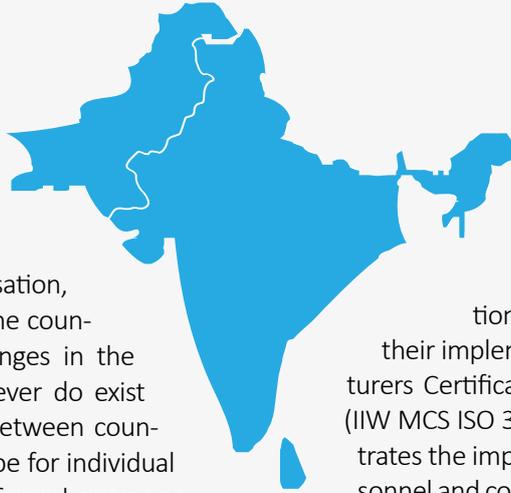


*Welded Wall Murals of Steel-making*

*Victor Ivanoff. IIW 2023 Digital Collection, Reference [113]*

- CWA is also currently working with the Republic of Congo with the draft of the Congolaise Welders Association statutes and constitution. CWA is also active in the International Forum of Welding Professions (FIMS) which organises innovative and unifying events and creates a collaborative platform for exchange of best practices between welding practitioners and technologists.
- All the above show how more opportunities can arise through cooperation and collaboration of African countries with the support of national governments and international organisations such as UNIDO [170], CIDA [171], IAEA [172] and USAID [173], GIZ, JICA amongst others, to build up the national welding capabilities and progress the UN SDGs and improve the quality of life in Africa.

## 5.3 South Asian Countries



- South Asian countries would be an ideal group for regional collaboration on the UN SDGs. The subcontinent has enough common attributes and issues to warrant some regional organisation, cooperation and collaboration. The countries face many common challenges in the UN SDGs. Major problems however do exist particularly related to disputes between countries so the best solutions might be for individual countries to work within existing formal groups or establish their own.
- Formal groups do exist in the region including the South Asian Association for Regional Cooperation (SAARC), the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) and the Bangladesh (101), Bhutan (61), India (112), Nepal (99) Networks (BBIN). India (112) and Pakistan (128) are the only South Asian countries which are members of IIW and it would be very beneficial for the other countries in the region if they could also become IIW members at some future date. Other countries which are included in the SAARC include Afghanistan (158) Maldives (68) and Sri Lanka (83).
- The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128].
- The Indian Institute of Welding (IIW-India) has already published a report on how improving its national welding capability will positively affect the UN SDGs in India [28]. Other South Asian countries producing similar reports could also be used to identify challenges and solutions for their countries.
- Since 2000, IIW-India has made significant efforts in promoting collaborative technology transfer activities across the South Asian region including the holding of five IIW International Congresses in 2005, 2008, 2014, 2017 and 2020 as well as the IIW Annual Assembly in 2011, and an IIW Welding Research and Collaboration Colloquium in 2016 [88].
- It has also held three IIW-India technology innovation and National Welding Capability (NWC) workshops in 2008, 2014 and 2020. This is all besides its own national conferences, seminars, workshops, training courses, R&D and technical support to industry which it conducts on an on-going basis.
  - The development of the International Institute of Welding (IIW) Education, Training, Qualification and Certification programmes and their implementation including the IIW Manufacturers Certification Scheme According to ISO 3834 (IIW MCS ISO 3834) in 47 countries worldwide, illustrates the importance and need for world class personnel and companies to be available in the welding industry in India and other South Asian countries.
  - To ensure that it complies with the appropriate accreditations, IIW-India has been approved as an IIW Authorised Nominated Body (ANB) in 2007, and an IIW Authorised Nominated Body for Company Certification (ANBCC) in 2011, as well as by the Government of India, DGE&T (Directorate General of Employment and Training) as an Assessing Body for all Fabrication sector courses under their MES-SDI (Modular Employable Skill under Skill Development Initiative Scheme).
  - Since the introduction of the IIW programmes in India in 2007, 546 International Welding Engineers (IWEs), 519 International Welding Technologists (IWTs), 117 International Welding Specialists (IWSs), 16 International Welding Practitioners (IWPs) and 259 International Welders (IWs) have been trained and qualified at IIW-India as at 31 December, 2022.
  - Other South Asian countries could be encouraged to introduce the IIW programmes either in their own right or in collaboration with IIW-India.
  - The examples above show how more opportunities can arise through cooperation and collaboration of South Asian countries with the support of national governments and international organisations such as UNIDO, IAEA amongst others, to progress the UN SDGs by improving national welding capabilities.
  - India for example, in 2015 through its *Technology Information, Forecasting and Assessment Council* (TIFAC), produced a report titled *Technology Vision 2035* [132]. TIFAC is a think tank within government setup which looks up to technologies on the horizon, assesses the technology trajectories and supports technology innovation in select areas of national importance. Such an approach, suitably amended, could be used as a model by other countries.

## 5.4 South East European Countries

- An excellent example of how countries in a particular region can work together with the ultimate objective of improving their national welding capabilities and the SDGs can be seen by the efforts of the welding organisations in Bulgaria (44), Greece (28), Romania (35) and Serbia (36). The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128].
  - Prior to the IIW Annual Assembly held in Bucharest in July, 2003, a very successful technology innovation workshop was held by the Romanian Government. The outcomes of the workshop acted as a catalyst to promote greater cooperation and collaboration in the South East European region [133].
  - Since 2004, these countries have collaborated in a regional group, the South East European Technology Transfer Network (SEENET). The collaboration has covered joint activities such as four IIW International Congresses in Timisoara (2006 and 2015), Sofia (2010) and Belgrade (2018).
  - Six technology and governance SEENET workshops, Athens (2008), Belgrade (2007), Sofia (2005 and 2010) and Timisoara (2004 and 2006)) and two National Welding Capability (NWC) workshops were held in Timisoara (2015) and Belgrade (2018). This is besides their own national conferences, seminars, workshops, training courses, R&D and technical support to their industries which they conduct on an on-going basis.
  - Besides Romania hosting the IIW Annual Assembly in 2003, Bulgaria hosted it in 1987 and it is planned for Greece in 2024.
  - This extensive cooperation between the SEENET members such as the Romanian National R&D Institute for Welding and Material Testing (ISIM), Romanian Welding Society (ASR), Bulgarian Welding Society (BWS), Welding Greek Institute (WGI) and Serbian Welding Society (DUZS) is truly remarkable creating significant networking between these centres of excellence and industry in the region.
  - In particular, these efforts, utilising the knowledge and experience of SEENET Members, supported technology transfer and training in the region, including the promotion and support of networks of national and regional Technology Support and Education and Training Support Centres.
- 
- SEENET Members, which are all also IIW and EWF Members, have also encouraged other countries in the region to become involved in these activities and grow their national welding capabilities as part of the SEENET network.
  - This has resulted in many technology transfer activities being held in a cooperative and collaborative manner between the IIW Members for Bulgaria, Greece, Romania, and Serbia and regional countries such as Bosnia and Herzegovina (47), Montenegro (67), Moldova (25), and North Macedonia (60).
  - These initiatives have resulted in outcomes such as funding support from governments and industry for technology support centres in SEENET countries, as well as the transfer to the region of the knowledge and experiences of many world experts across a whole range of critical industrial applications.
  - A good example of this is a significant outcome from the SEENET IIW International Congress held in Sofia in October, 2010. The Bulgarian Welding Society, together with experts and organisations from Belgium, Ukraine, Russia, Hungary and Germany, collaborated to prove the integrity and reliability of Flash Butt Welded joints in gas pipelines up to 1400mm in diameter and 25mm thickness for use across the region and globally. This has led to many economic, health, safety and environmental benefits [134].
  - Examples of collaboration on education, training, qualification and certification include ISIM Timisoara holding the first IWE qualification courses outside Romania in Belgrade (Serbia), Chisinau (Republic of Moldova), and Istanbul (Turkey), before the creation of IIW Authorised Nominated Bodies (ANBs) in these countries. Since the introduction of the IIW/EWF programmes, 1222 International Welding Engineers

(IWEs) and 1153 European Welding Engineers (EWEs) have been trained and qualified in Romania and 79 in the other countries mentioned (Moldova, Serbia and Turkey) [135].

- Individual organisations such as ASR in Romania amongst others have been participating for many years in the realisation of projects within the European Leonardo da Vinci and Erasmus+ programmes.
  - The themes of these projects are related to the development and promotion of education and training actions linked to the European and international qualification system for welding personnel developed by EWF and IIW-IAB respectively. Information about ASR projects can be found at: <https://asr.ro/proiecte/>
  - A good example of a SEENET member cooperating and collaborating with regional countries is that of the Serbian Welding Society-DUZS. It recently held a very successful International Conference to celebrate 70 years of activity including 40 years of joint work with former Yugoslavian republics as part of the Yugoslav Welding Alliance. Six of these countries participated, three of which are IIW Members. This bodes well for future efforts on improving national welding capabilities and progressing the SDGs in the region.
- On 10 October, 2018, in Belgrade, Serbia, a very successful SEENET National Welding Capability (NWC) workshop was held attended by representatives of Serbia, Bulgaria, Romania, Greece, Hungary, Turkey, Bosnia and Herzegovina, Montenegro and North Macedonia. This was held in conjunction with the 4th IIW South-East European Welding Congress [87].
  - SEENET and its member countries would be an ideal group for regional collaboration on the UN SDGs. The Romanian Welding Society (ASR) has already compiled a report on how improving its national welding capability will positively affect the UN SDGs in its country [77], [135].
  - All the above show how more opportunities can arise through cooperation and collaboration of SEENET countries with the support of national governments and international organisations such as UNIDO, IAEA and EU amongst others, to progress the UN SDGs.



## 5.5 Asian Countries

- The Asian Welding Federation (AWF) is a federation formed by Asian Welding Societies/Institutes/Associations in 2004. Currently it has members from China (63), Indonesia (75), India (112), Japan (21), Korea (31), Malaysia (78), Mongolia (106), Myanmar (125), Philippines (98), Singapore (64), Thailand (43) and Vietnam (55).
- The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128].
- Except for Mongolia, Myanmar and Philippines, all the other countries have IIW Members. Each IIW Member is an IIW IAB Authorised Nominated Body (ANB) and all are also successfully using the IIW education, training, qualification and certification personnel programmes.
- China and India are successfully using the IIW Manufacturers Certification Scheme According to ISO 3834 (IIW MCS ISO 3834) since they are each also an IIW IAB Authorised Nominated Body for Company Certification (ANBCC).
- Between the AWF Members, 31,801 IIW Diplomas for welding coordination personnel and welding inspection personnel have been issued with China also issuing 644 Certificates to the IIW Manufacturers Certification Scheme According to ISO 3834 (IIW MCS ISO 3834).
- The AWF is a non-profit making organization devoted to the improvement and promotion of welding technology through the exchange of scientific information and knowledge for the betterment of the welding communities in Asia in terms of economic and technological progress and growth.
- Its Mission is: To provide excellent value added products and support services to its members and their communities in the field of welding, joining and related technologies.
- Its Vision is: To be the leading organisation in the field of welding, joining and related technologies in pursuit of its strategic objectives.
- Its Strategic Objectives are to:
  - Promote the advancement of welding, joining and related technologies through industry forums, seminars, workshops, trade exhibitions, etc,
  - Participate in the development of international standards related to welding, joining and related technologies and adopt common welding standards among members
  - Facilitate international harmonised schemes for the certification of welding companies and personnel
  - Develop common guidelines on education, training and qualification system to provide the welding industry with qualified and skilled personnel
  - Represent the interests of its members by promoting welding, joining and related technologies to all industries
  - Collaborate with industries, trade associations, professional organisations, research and educational institutions on joint projects involving welding, joining and related technologies
- In meeting these objectives, the AWF has formed various committees/sub-committees to work independently or in co-operation with other bodies having similar or complementary goals
- These Committees are; Standardization, Certification, Education & Training, Welding Technology & Application, Membership, Website and Marketing, Common Welder Common Standard (CWCS) and Steering.

- Members have made significant efforts in promoting collaborative technology transfer activities across the Asian region including the holding of 15 IIW International Congresses in India (2005, 2008, 2014, 2017, 2020), Iran (1998, 2002, 2003, 2009), Singapore (2002, 2013), Thailand (2006, 2010 and 2019), China (2008) as well as the IIW Annual Assembly in China (1994 and 2017), Singapore (2009 and 2023), India (2011), South Korea (2014), Japan (1969, 1986, 2004 and 2022).
- These are all besides the national conferences, seminars, workshops, training courses, R&D and technical support to industry which each organisation conducts on an on-going basis in their own countries.
- Some excellent examples of AWF members assisting other member countries includes the Japanese International Cooperation Agency (JICA) working with the Japan Welding Engineering Society (JWES) since 1974 on the training of welding engineers from overseas countries in Japan as well as training courses for welding personnel in various countries in the region.
- The AWF has also collaborated with the member societies to organise bi-annually the AWF Welding Technology and Application Forums since 2018.
- Various members have also held welding skills competitions to encourage people in welding careers as well as raise the image and profile of welding.
- A good example of a developing country in the region progressing its national welding capability and SDGs is Thailand. The Welding Institute of Thailand (WIT) held the 8th IIW Asia-Pacific International Congress 2019 (IIWAP2019) in Bangkok in March, 2019 which also included sessions for Young Professionals. Although the Covid 19 Pandemic followed shortly afterwards, WIT has been able to expand the number of IIW Approved Training Bodies from five to seven to assist industry. More training courses and programs are to follow in 2023 and onwards for young people and young professionals to come together for career path development through IIW courses, welding seminars and workshops. Among this, the plan is also to upskill welding teachers and educators with the right skill and knowledge to teach and share welding knowledge and subjects to young students and community to improve the quality of life.
- The examples above show how more opportunities can arise through cooperation and collaboration of Asian countries with the support of national governments and international organisations such as UNIDO, IAEA, GIZ, JICA amongst others, to build up the national welding capabilities and progress the UN SDGs and improve the quality of life in Asia.



*Photos supplied by INOXCVA show four 311,000L liquid hydrogen tanks manufactured by INOXCVA in India for one of the largest prestigious projects for liquid hydrogen in South Korea. The liquid hydrogen is stored in vessels and is used for charging stations nationwide for buses, trucks and trams – with hydrogen as the ultimate clean fuel.*

## 5.6 European Countries



- European countries and their governments have a long history of assisting developing countries in the welding field. For example, Germany with Vietnam, Ethiopia, China and South Korea, Portugal with Brazil, Angola and Mexico, Spain with Peru and Mexico, France with Morocco and Kazakhstan and the UK with Malaysia, amongst others. Numerous projects have been conducted over the years, most of which would contribute to progressing today's UN Sustainable Development Goals. In many cases, the national welding societies have been involved in such projects.
- The European Federation for Welding, Joining and Cutting (EFW) was created in 1992 by all the welding institutes of the European Community with the aim of updating and harmonising training and education in the field of welding technology. This evolved to provide world class, European focused, value added products and support services to its members and their communities in the field of joining, welding, cutting and related technologies on an international basis. It now has 28 European Member countries and two Observer Countries from outside Europe all represented by their national welding societies.
- Over the past three decades, the European Community has put in place a comprehensive legislative and regulatory framework with a number of key objectives including one of ensuring the safety of products. This includes European Directives and Regulations, codes and standards amongst other items, all of which contribute to improving the UN Sustainable Development Goals.
- European Federal, State and Provincial governments have helped build up world class vocational education and training systems. Extensive networks of colleges across each country offer vocational education and training in welding, fabrication, non-destructive testing, pressure equipment inspection and other welding industry related disciplines.
- Europe also has networks of both government and industry organisations responsible for the accreditation, qualification and certification of both organisations and personnel across the range of industry requirements including those mentioned above.
- Since the late 1980s, European countries introduced a vast range of European Standards, many of which were converted to ISO standards for adoption globally. The use of such standards has had major impacts on

the quality of life in countries both through improving their national welding capabilities and progressing the SDGs.

- In terms of research and development and technology transfer, the European welding industry has been very successful in bringing together research organisations, universities, vocational education and training organisations and industry to cooperate and collaborate on improving the national welding capability.
- At various times, the welding industry has conducted extensive studies on the European welding industry related needs and published these findings as models which other countries could use [14], [15], [17].
- Since many products are welded, competence in welding was recognised in European Standards such as EN 729 and EN 719 which were subsequently adopted by the international community as ISO 3834 and ISO 14731 respectively.
- To ensure the competence of both individuals and companies, the EFW has established products and services to meet the needs which have arisen.
- The EFW was a pioneer organisation in developing the first harmonised system in any field embracing all the European Countries when it established the qualification of welding personnel at a number of levels for both welding coordinators and welding inspectors
- During the 1990s, the IIW was investigating the establishment of a harmonised international system for education, training, qualification and certification

of welding personnel. In 2000, the EWF licensed its system to IIW and it has been offered in 45 countries worldwide through the IIW International Authorisation Board (IAB).

- EWF also has an integrated Manufacturers Certification System complying with ISO 3834-welding quality requirements, ISO 14001- Environment and also Health and Safety. IIW has adopted the ISO 3834-welding quality requirements in its worldwide system.
  - EWF is involved in the preparation, participation and management of vocational educational, training, research and technical development projects to assist the progress of the welding and joining community [136].
  - It has also developed support tools for its members, in particular related to the implementation of new standards, translation of welding terminology and training materials [136].
  - EWF participation in a number of EU projects such as Erasmus and Horizon 2020 projects has also contributed to align EWF systems with new and emerging technologies thus ensuring that the trainees have access to innovative training on such technologies.
- Such collaborative projects involve training centres, research centres, universities and companies across a wide range of countries [136].
- With the new challenges of digital transformation, IoT, Industry 4.0, amongst others, the projects help ensure the continuing evolution of the systems ensuring that they effectively adapt and meet the new requirements.
  - For example, with the rise of additive manufacturing [AM], EWF established the International Additive Manufacturing Qualification System [IAMQS]. Together with the various AM stakeholders and in close connection with standards requirements and the support of EU funding, AM qualifications have been introduced adding great value to the industry sector.
  - The system is managed by EWF and recently has been joined by the IIW with the objective of creating a global network of qualification and training institutions across the world [136].
  - When one considers the welding related experiences and resources available both in the EWF, the EU and individual European countries, excellent opportunities exist for developing countries to receive assistance with UN SDG related projects.

## 5.7 Latin American and the Caribbean Countries

- The Brazilian Welding Association (ABS), the Center for Research and Development of Welding Processes (LAPROSOLDA) at the Uberlandia Federal University (UFU) and the Brazilian government are supporters of the United Nations (UN) 2030 Agenda. ABS and UFU recently completed a report on how improving its national welding capability will positively affect the UN SDGs in its country [137].
- Brazil, including ABS and its universities, has led the way in encouraging cooperation and collaboration throughout Latin America. ABS has held three IIW International Congresses in 1992, 2008 and 2014, and instigated the forerunners of the IIW Welding Research and Collaboration Colloquia by holding the European-South American School of Welding and Correlated Processes in 2011. This has led to a means by which participants could exchange ideas and information and discuss emerging research projects, thus providing the opportunity to generate a network with participating research institutions, resulting in long term research cooperation, and the building of national welding capability in their respective countries.
- Since international technical cooperation is an important and diversified modality of Brazil's contribution to the development of institutional and individual capacity of developing countries in Latin America and the Caribbean, opportunities for greater cooperation and collaboration between countries exist.
- The formation of a regional technology transfer group could result in many technology transfer activities being held in a cooperative and collaborative manner between the Latin American and the Caribbean countries. These initiatives could result in outcomes such as funding support from governments and industry for technology support centres in these countries, as well as the transfer to the region of the knowledge and experiences of many world experts across a whole range of critical industrial applications.
- Similarly, the formation of a regional education, training, qualification and certification group could result in the introduction of the International Institute of Welding (IIW) programmes both for personnel and companies into many countries in the region.
- Since the introduction of the IIW programmes in 2000, 64,800 International Welding Engineers (IWEs) have been trained and qualified worldwide, 13,830



International Welding Technologists (IWTs), 49,738 International Welding Specialists (IWSs), 4554 International Welding Practitioners (IWPs), 32,337 International Welders, 15211 International Welding Inspectors and 283 International Welded Structures Designers and 3015 companies have been certified to the IIW MCS ISO 3834 programme at some stage.

- With the agreement and support of IIW, various models could be established in the Latin American and Caribbean region to cover the needs and circumstances of each country. For example:
  - A country could establish its own IIW Authorised Nominated Body (ANB) and IIW Authorised Nominated Body for Company Certification (ANBCC), appoint the IIW Approved training Bodies (ATBs) in its country and manage the IIW programmes.
  - A small number of countries in a particular part of the region could appoint an IIW ANB and an IIW ANBCC for that part of the region which could manage the IIW Programmes in those countries including the appointment of IIW ATBs.
  - All the countries in the Latin American and Caribbean region could work together and appoint an IIW ANB and IIW ANBCC for the whole region managing the IIW programmes including appointment of IIW ATBs.
  - A country could have IIW ATBs appointed by an IIW ANB from another country.
  - A country could have its companies certified to the IIW Manufacturers Certification Scheme According to ISO 3834 (IIW MCS ISO 3834) by an IIW ANBCC from another country.
- There are previous examples of a number of major training projects involving countries in Latin America and the Caribbean which were initiated and supported by the International Atomic Energy Agency (IAEA) through the promotion of advanced inspection tech-

niques and applications in Non-destructive testing [138], [139].

- A good example of countries cooperating with the assistance of the IAEA is the Cooperation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL). The countries involved included Argentina (51), Bolivia (87), Brazil (50), Chile (30), Colombia (76), Costa Rica (52), Cuba (46), Ecuador (74), El Salvador (73), Guatemala (127), Haiti (152), Honduras (116), Jamaica (82), Mexico (80), Nicaragua (104), Panama (97), Peru (65), Dominican Republic (62), Uruguay (32) and Venezuela (117). The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128].
- Projects still continue to this day and could also be viewed as models for welding related training projects on a regional basis working in conjunction with international and national aid agencies. The IIW programmes would be ideal for such projects.
- Developed countries can play a key role in assisting developing countries implement projects which could easily lead to improving lifelong learning. These include efficient and economical education and training via upgrading of schools and educational facilities, modern training course resources, remote training, education and examination methods, inexpensive virtual reality training, grants, scholarships and career opportunities for a diverse range of people [92].
- There are excellent examples of networks successfully established to bring industry and all levels of government together to supply the E&T, skills and career paths to create viable industry sectors and overcome constraints as well as fostering partnerships between Small, Medium Enterprises (SMEs), larger firms and training providers [39], [40], [41].
- With respect to educational, training, skills and careers activities, organisational structures in a country are often determined by the rules and requirements of national or international bodies involved in education and training. For example, over 46 countries have established IIW Authorised Nominated Bodies (ANBs) in line with the IIW International Authorisation Board (IAB)'s rules and guidelines [34] and similarly if one wishes to comply with a country's national system, then one must comply with its rules, guidelines etc. Some countries have successfully introduced both their national programmes and IIW programmes as complementary to each other.
- Each country will also have its own national education and training requirements for organisations to comply

with for recognition in that country. Again whichever structure is to be established, the most important thing is to have all the relevant organisations involved. These organisations must feel that by contributing to the work involved in meeting the education and training needs, the benefits will arise for their industry sectors in terms of better trained, qualified and competent personnel who can be employed in their industry sectors and required to work on applications to both national and international standards.

- In terms of research and development, there will be a need to bring together research organisations, universities and industry in the region to cooperate and collaborate on improving the national welding capabilities.
- At various times, the countries in the region will need to conduct extensive studies on their countries welding industry related needs and introduce these findings as part of their strategic planning. There are examples of developed countries conducting such studies which would be very useful for the countries in the region [13], [81], [83], [85], [86].
- Important recommendations which emanate from such studies are the need for periodic strategic planning exercises involving a range of people and organisations, the need to conduct periodic surveys/needs analysis of industries' requirements, the importance of issuing regular progress reports and results of independent audits/reviews of such progress, increasing industry involvement in projects, products and services, stable finances and not asking people to put money into a bottomless pit by continually losing money, as well as being able to show the value to the country of the benefits from the project.
- Key lessons for a developing country could be the need to aim to have financial stability and sustainability in a Lead Organisation without the reliance on on-going government grants for sustainability. There are examples throughout the world of countries which have succeeded in achieving this and these can be used as guides to achieve such sustainability. An internal report on how improving its national welding capability will positively affect the UN SDGs in its country may be the first step in achieving this. This IIW report could be used for this.
- All the above show how more opportunities can arise through cooperation and collaboration of Latin American and Caribbean countries, with the support of national governments and regional and international organisations such as IIW, UNIDO [170], CIDA [171], IAEA [172] and USAID [173], GIZ, JICA amongst others,

## 5.8 Oceanian Countries



- Australia (40), Micronesia, Fiji (57), Kiribati, Marshall Islands, Nauru, New Zealand (27), Palau, Papua New Guinea (148), Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu are the 14 countries in this region. The governments of both Australia and New Zealand have very good records of assisting countries in the regions with aid programmes to meet specific needs. The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128].
- Australia and New Zealand are the two countries with sizeable welding industries in the region and fine records of working with other countries both in this region but also in other regions such as South East Asia, Africa and South East Europe.
- The governments of both countries are keen proponents of the UN SDGs and assisting countries to continually improve their national welding capabilities. The scope of activities involving the welding industries cover the “Total Life Cycle of Welded Products/ Structures.”
- At various times, both countries have conducted extensive studies on their countries welding industry related needs and published these findings as models which other countries could use [22], [82], [214].
- For two countries with relatively small populations, both are fine examples of how a range of key organisations, including the IIW Members, built up similar welding-related organisational structures to improve the NWC and quality of life in both countries. The history of such efforts are shown in [140] and [141].
- In 2000, the Australian IIW Member Welding Technology Institute of Australia (WTIA), currently Weld Australia, also successfully established its IIW Authorised Nominated Body (ANB) and in 2006, its IIW Authorised Nominated Body for Company Certification (ANBCC).
- For a number of years it assisted the New Zealand IIW Member, the Heavy Engineering Research Association (HERA) to operate through WTIA as an IIW Approved Training Body (ATB) with WTIA issuing the IIW Diplomas until HERA also became an IIW ANB in 2013, and IIW ANBCC in 2014.
- Between the two countries, 103 IWE, 66 IWT, 960 IWS, 321 IWP, 1,824 IWIP, 2 IWSD-S Diplomas and 159 company certifications have been issued.
- Both Australia and New Zealand have very strong networks of institutions offering vocational education and training in welding, fabrication, non-destructive testing, pressure equipment inspection and other welding industry related disciplines. These include the Australian Technical and Further Education (TAFE) Institutes and the New Zealand Institutes of Skills and Technology.
- They also have networks of both government and industry organisations responsible for the accreditation, qualification and certification of both organisations and personnel across the range of industry requirements.
- Both countries have a strong record of training international students in Australia and New Zealand as well as providing training in various countries abroad. Such training also involving qualification and certification could cover many of the requirements for the SDGs in regional countries. Many personnel in both countries have been trained and qualified as welders, welding supervisors, welding inspectors and NDT technicians to both local and overseas standards.
- The two countries also promote the harmonisation of standards. The primary objective is to adopt an existing International Standard or if not, have joint AS/NZS standards or in some cases national standards. This approach is also of benefit to the countries in the region.
- In terms of research and development, Australia has been very successful in this role and in particular the bringing together of many research organisations and industry companies to cooperate and collaborate on improving the national welding capability. The Australian Cooperative Research Centre (CRC) Programme, industry specific research groups, government centres and universities all play their roles.

- With an increasing emphasis on both assisting organisations on improving their efficiencies in undertaking research programmes as well as improving the cost-benefit ratios, the Australian Federal Government introduced an Impact Tool for organisations to use when making applications for grants under the Cooperative Research Centre (CRC) Programme [213].
- It also had a very good system of producing and implementing the necessary resources and activities as part of its technology transfer to industry [39]. In both Australia and New Zealand, government departments also produce resources which can be of benefit to other countries in the region.
- To achieve the SDGs in the regional countries, technology transfer is probably an important tool and for the welding industries in each country in the region, examples of past government programmes supported by industry from 1998 to 2010 could be models to follow [142], [143], [144], [145] and [216].
- Many examples of how various countries have been assisted in applying such models as well as conducting needs analyses and implementing solutions to meet these needs are available and could be used in each regional country to identify strategies and actions required.
- Important recommendations for all countries in the region include the need for periodic strategic planning exercises involving a range of people and organisations, the need to conduct periodic surveys/needs analysis of industry's requirements, the importance of issuing regular progress reports and results of independent audits/reviews of such progress, increasing industry involvement in projects, products and services, stable finances and not asking people to put money into a bottomless pit by continually losing money, as well as being able to show the value to the country of the benefits from the project.
- The importance of small companies as key employers of people and the need to support them with technology transfer is shown by a report of the Australian Prime Ministers Science, Engineering and Innovation Council (PMSEIC) [146].
- Both countries are very strong in supporting recognition of individuals and organisations through grants, scholarships, awards, exhibitions and competitions amongst other activities which would benefit many of the SDGs.
- Australia and New Zealand also cooperate in holding IIW related events. For example, the IIW Annual Assembly was held in Sydney in 1976 and Melbourne in 2016, IIW International Congresses in Hobart (1988), Auckland (1996), Melbourne (2000), Sydney (2007), Cairns (2011), an IIW Welding Research and Collaboration Colloquium in Wollongong (2014) and a National Welding Capability (NWC) workshop in Auckland in 2018.
- This is all besides the other national conferences, seminars, workshops, training courses, R&D and technical support to industry which are conducted on an on-going basis in both countries.
- Oceania would be an ideal group for regional collaboration on the UN SDGs. HERA has already compiled a report on how the steel industry and improving its national welding capability will positively affect the UN SDGs in its country [104].
- This IIW report could be used as a model for other countries in the region for compiling their own reports on how improving their national welding capabilities will positively affect the UN Sustainable Development Goals in their countries.
- All the above show how more opportunities can arise through cooperation and collaboration of Oceania countries with the support of national governments and regional and international organisations such as UNIDO, IAEA, EU amongst others, to progress the UN SDGs.
- An example of present cooperation between countries in the Asia and Oceania regions is shown by the Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific (RCA). Countries cooperating with the assistance of the IAEA are Australia, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Japan, South Korea, Laos, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Pakistan, Palau, Philippines, Singapore, Sri Lanka, Thailand and Vietnam.
- Projects still continue to this day and could be viewed as models for welding related training projects on a regional basis working in conjunction with international and national aid agencies. The IIW programmes would be ideal for such projects.

## 5.9 North American Countries



- The North American region from an industrial viewpoint could be considered to consist of Canada (26), Mexico (80) and the USA (39). The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs. The score can be interpreted as a percentage of SDG achievement [128]. Each Country is a member of the G20 Group of Countries.
- Welding related industries in the three countries are substantial and have a significant influence on many countries in the world. This is mainly from economic, trade and standards aspects.
- The US and Canada in particular can have major effects on assisting many countries progress their NWCs and SDGs due to these links.
- The US-Mexico-Canada Agreement (USMCA) signed in 2020, supports mutually beneficial trade leading to freer markets, fairer trade and robust economic growth in North America. The SDGs in the three countries should benefit from such results.
- Both the US and Canada have IIW members which have been involved in many activities including holding the IIW Annual Assembly in New York (1961), Toronto (1972), Boston (1984), Montreal (1990), San Francisco (1997), Quebec (2006) and Denver (2012). Vancouver also hosted an IIW International Congress in 2014. Mexico is also now an IIW Member and will benefit from the cooperation and collaboration of other IIW Members. AWS now holds its FABTECH Mexico Expo in Mexico contributing greater technology transfer to Mexican companies.
- Canada is a good example of a country with a relatively small population coping with different situations existing at various stages of its welding history and cooperation and collaboration taking place between key organisations to keep its national welding capability moving forward which leads to progress in meeting the SDGs.
- The US, Mexican and Canadian Federal, State and Provincial governments have helped build up world class vocational education and training systems with an extensive network of colleges across each country offering vocational education and training in welding, fabrication, non-destructive testing, pressure equipment inspection and other welding industry related disciplines.
- They also have networks of both government and industry organisations responsible for the accreditation, qualification and certification of both organisations and personnel across the range of industry requirements including those mentioned above.
- The three countries also promote the use of standards to both improve their national welding capabilities and progress the SDGs. This approach has also been of great benefit to many countries trading with North American companies.
- In Canada two key standards, W59 and W47.1 were put in place after the second world war and the role of the CWB Group has been to act as the official administering body to ensure the uniform rollout and enforcement of the standards across Canada, including embedding the requirement for adherence to these standards in the National Building Code.
- The CWB Group is thus the organisation, supported by industry and government bodies and a suite of Canadian Standards, to ensure the integrity of welded steel, aluminium and rebar structures, welding inspection companies and inspectors and welding consumables through the certification of fabricators, construction companies, inspection and test centres, welding consumables as well as personnel, and the continuing provision of appropriate standards through one of the national standards organisations.
- Such stable and sustainable activities has enabled the CWB Group to grow to an organisation with over 12000 company clients in approximately 60 countries all contributing to improving the NWCs and the SDGs in these countries.
- The American Welding Society (AWS) was started in 1919 and introduced education, training, standards

production and technology transfer activities including expos in the 1920s. It now has in excess of 70000 welding industry professionals as members.

- It is the main organisation in the US producing welding related codes and standards approved by the American National Standards Institute (ANSI). Its suites of codes and standards are used in many countries across the world and together with those of other US organisations such as the American Society of Mechanical Engineers (ASME) and the American Pipeline Institute (API) help add significant benefits to countries progressing their SDGs and economic growth
- In terms of research and development, both countries have been very successful in this role and in particular the bringing together of many research organisations, universities and industry companies to cooperate and collaborate on improving the national welding capability.
- At various times, both countries have conducted extensive studies on their countries welding industry related needs and published these findings as models which other countries could use [13], [81], [83], [85], [86].
- Important recommendations which emanate from such studies are the need for periodic strategic planning exercises involving a range of people and organisations, the need to conduct periodic surveys/needs analysis of industries' requirements, the importance of issuing regular progress reports and results of independent audits/reviews of such progress, increasing industry involvement in projects, products and services, stable finances and not asking people to put money into a bottomless pit by continually losing money, as well as being able to show the value to the country of the benefits from the project.
- Lessons learnt in both organisations includes the enthusiasm and strength of volunteers to make things happen, the importance of team work, a "win-win" situation for all participants and the recognition of people through qualification and certification and their importance in technology transfer. These experiences can be transferred to developing countries.
- Both countries have also implemented projects in North America which could easily be used in many developing countries. These include efficient and economical education and training via upgrading of schools and educational facilities, modern training course resources, remote training, education and examination methods, inexpensive virtual reality training, grants, scholarships and career opportunities for a diverse range of people.
- Information on these examples is shown on the AWS and CWB Group websites [147], [92].
- In terms of growing the Canadian, Mexican and the US national welding capabilities, the main reasons for success have been through the continued success of the vocational education and training systems, their universities and the activities of organisations such as the CWB Group and AWS which through their strength in financial and human assets have been able to maintain many activities related to technology transfer.
- Key lessons for a developing country could be the need to aim to have financial stability and sustainability in a Lead Organisation without the reliance on government grants for sustainability. Due to its success, the CWB Group is receiving a considerable number of grants from both industry and Federal, State and Provincial Governments to perform work more of a nature of improving various welding activities in the different communities across Canada but not needing to rely on a grant for its sustainability and stability as an organisation.
- The North American countries are an ideal group for regional collaboration on the UN SDGs. The CWB Group has already compiled an internal report on how improving its national welding capability will positively affect the UN SDGs in its country.
- This IIW report could be used as a model for other countries in the region for compiling their own reports on how improving their national welding capabilities will positively affect the UN Sustainable Development Goals in their countries.
- All the above show how more opportunities can arise through cooperation and collaboration of North American countries, with the support of national governments and regional and international organisations such as UNIDO [170], CIDA [171], IAEA [172], USAID [173], amongst others, to progress the UN SDGs in many countries throughout the world.

## 5.10 Middle Eastern Countries



- The countries in the Middle East region which have not been included in other regions in this report have been grouped together as Saudi Arabia (94), Kuwait (108), Oman (90), Qatar (100), United Arab Emirates (79), Iraq (105), Jordan (77), Lebanon (95), Syria (130) and Yemen (163). The numbers in brackets show the 2023 rankings given by the UN for each country to the total progress towards achieving the SDGs [128]. None of these countries are IIW Members nor does there appear to be any group representing them in the welding related field.
- The countries range from oil rich countries with a range of industries requiring significant amounts of welding and countries undergoing major problems such as war, devastation, hunger and serious monetary problems.
- An example of a cooperative arrangement with the assistance of IAEA is the Cooperative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA). The countries involved are Iraq, Jordan, Kuwait, Lebanon, Saudi Arabia, Oman, Qatar, Syria, United Arab Emirates and Yemen. They host five Regional Resource Centres that serve as hubs for capacity building in nuclear science and technology in the region.
- Some 55 regional cooperation projects have been carried out under the agreement. Over the past two decades, ARASIA has achieved success in areas that include food security, human health and environmental monitoring. Seven ARASIA State Parties now have national plant breeding programmes that include nuclear-derived techniques to ensure food security. New varieties of crops such as wheat and barley have led to an increase in yields in the region.
- The IAEA has also enhanced regional capabilities to diagnose and treat cancer through the provision of radiotherapy equipment and capacity building activities in the field of human health. Since 2002, there have been 116 human health training courses, 234 fellowships and 72 expert visits all hosted under the umbrella of ARASIA [148].
- IIW members from Australia, Germany and Japan have also assisted various countries in the region. For example, a Conference, Development of Welding Technology in the Arab World was held from 7-9 January, 2009, in Damascus with more than 100 representatives from Syria, Lebanon and Jordan participating.
- Representatives of the DVS GSI SLV Mannheim, Germany and the IIW President met with the Director General, Public Authority for Industry, Kuwait and his colleagues during the period 25-27 January, 2007. Subsequently, SLV Mannheim held training courses for engineers in Kuwait. The DVS GSI SLVs in Germany offer a range of services which will benefit the countries in the region [149].
- TWI Ltd offers training, examinations and certifications through a subsidiary based in Dubai, United Arab Emirates to meet industry requirements in the region for welding inspection, welding procedures, plant inspection and non-destructive testing (NDT) and occupational health and safety. It also has a network of organisations which can assist in different countries in the region [150].
- Based on the situations above, to progress the NWCs and SDGs in the countries in the region, significant assistance could be provided by countries with highly developed welding industries.
- Examples could include, establishing national welding organisations in each country, education, training, qualification, certification (E, T, Q, C) infrastructure, facilities and training resources, technology transfer networks and other programmes to meet the SDGs.
- Discussions could take place between IIW and ARASIA representatives on cooperation and collaboration in the welding industries in the region.

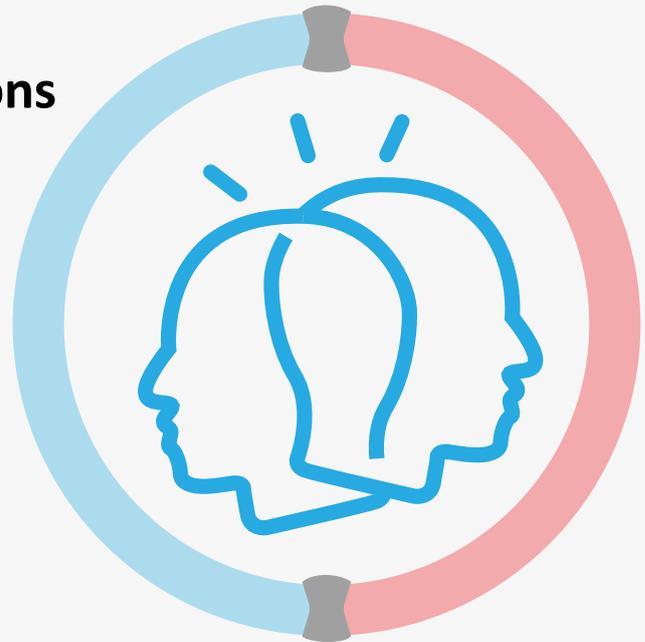
## 6. General Recommendations including Possible Future Actions

### 6.1 Introduction

Cooperation and collaboration both locally and internationally are very important to the success of the Flagship Programme.

There are four possible options for the global welding industry to move forward in helping as many countries to improve their national welding capabilities and progress the SDGs. To link the NWC and the SDG will involve strategies being introduced by a country including implementing the Flagship Programme with a single global focus “To Assist the Country to Establish, Sustain and Improve Its National Welding Capability and Progress its UN Sustainable Development Goals”. Such a Programme may have many initiatives and projects associated with it but all related to the single global focus:

- firstly, each country's welding industry could work on its own in deciding what actions it will take if it so wishes. The welding industry would appoint its own Lead Organisation to implement a Flagship Programme.
- The second approach is to promote a global cooperative and collaborative approach between as many nations as possible and hope that an organisation such as IIW could be the catalyst and lead and promote such a Flagship Programme but leaving each IIW Member to drive its own Flagship Programme.
- The third approach is for the welding industries in regional groups to lead and promote. If a formal legally established group exists, then a Lead Organisation could be appointed (for example in the EWF and AWF). If such a formal group does not exist, then the members of the group would need to determine their way forward (for example SEENET) or an individual country might take the initiative to lead a regional group.
- The fourth approach could be where individual countries simply assist another country by mutual agreement. There are many examples over the past three decades of how IIW member countries have previously cooperated and collaborated with developing



countries to assist in improving their national welding capabilities. Such examples include amongst others: Germany has assisted China, Vietnam, Ethiopia, South Korea and Indonesia; France has assisted Thailand, Morocco and Kazakhstan; UK has assisted Malaysia; USA has assisted Trinidad and Tobago; Japan has assisted Vietnam and Egypt; Austria has assisted Indonesia; South Africa has assisted Africa (IAEA); South Africa has assisted Nigeria; Holland and Canada have assisted South Africa; Portugal has assisted Brazil, Angola and Mexico; Spain has assisted Peru and Mexico. The main emphasis in all of the examples mentioned was on education and training and transfer of appropriate technologies.

- In practice, it is likely that a range of approaches may be taken depending on the situation in each of the 193 UN member countries. For example, many countries do not have a Lead Organisation such as a national welding organisation to lead such a Flagship Programme. Regional groups may not have the resources to introduce a regional Flagship Programme unless it is given or raises sufficient resources to do so. In some regions such as Oceania, or South America, Central America and the Caribbean, a formal group could be established with the support of organisations such as the UN or International Atomic Energy Agency (IAEA) amongst others. Examples of successful initiatives involving the IAEA with respect to nuclear health and safety exist globally [29], [55], [129], [138], [139], [148], [172].

## 6.2 IIW's Potential Role

For IIW to introduce the second approach above, an overarching NWC and SDG policy framework could be created to achieve coherence with all its members and other parties at national and global levels.

To deliver on building up the national welding capability and progressing the SDGs will require clear leadership on many fronts, appropriate financing, clear implementation plans with targets and indicators, excellent communication, and in particular, a willingness for numerous parties to cooperate, collaborate and accept accountability in many areas.

For each country involved, it is important that a framework is established within a country which enables all relevant parties to be included.

- The scale of the industries and people affected by welding and needing to be involved in the NWC Project and SDGs means that it often needs one national organisation to play a leading role in managing the cooperation and collaboration required amongst a team of organisations to drive the progress to an optimal national welding capability and UN 2030 Agenda.
- Such an organisation may or may not already exist in a country but once established it must be a well-regarded organisation so that it can build up the trust and confidence to obtain the support of all other parties interested in being involved in the establishment of the NWC and SDGs. Some of its attributes are that it must be able to:
  - (i) be correctly established in terms of a country's legal, ethical, financial and other compliance requirements with correct governance and management systems in place;
  - (ii) cooperate and collaborate with the relevant organisations in the country to ensure that the NWC is achieved and sustained;
  - (iii) have adequate highly credible human resources to succeed in the agreed plans;
  - (iv) be open for as many of the other organisations and people in the industry to have membership and have ownership of the NWC where applicable;
  - (v) enable companies and people to access technologies and technical information to meet their needs;
  - (vi) respond to demonstrated needs of companies and have relevant support for solutions within the organisations in the NWC;
  - (vii) develop strong links with industry and other agencies particularly in the NWC;
  - (viii) provide ready access to facilities and services in the NWC;
  - (ix) not unnecessarily duplicate facilities and services already existing in the country and be capable to proactively highlight how to readily access such facilities and services to any enquirer;
  - (x) seek to collaborate with national and international organisations/agencies to meet the needs of industry, the country and SDGs;
  - (xi) provide the Forums/Boards/Committees etc. necessary to have all relevant organisations collaborating in the various NWC 'Building Blocks' and SDGs.
- Normally such a national organisation driving the common good plan would need to be a not-for-profit body assisted with some government and industry funding particularly since many of the activities which will need implementing will not be income generating. This will become clearer when one considers these different activities in a business plan. Its scope in terms of roles, responsibilities and activities will be determined as the relevant organisations to be involved in the national organisation meet, strategize and establish or modify the organisation to meet the NWC and SDG objectives.
- In the business plan there will be strategies to assist a country without a national organisation, to establish such an organisation to lead the NWC and SDG Flagship Programme.
- Experience also shows however that in many countries, although such an organisation does exist already, it is struggling to survive and it might be wise for its representatives to also study and implement strategies including strategies on restructuring or even establishing a new national organisation which may help them to reassess themselves and improve their efficiency, effectiveness and sustainability.
- In either case, the new or existing national organisation has to have the ability to convince governments, industry and other potential NWC Project organisations that they are the organisation capable of being the NWC and SDG Flagship Programme Lead Organisation and then the structures in such an organisation should enable the NWC Project organisations to work together to achieve a successful NWC and SDGs.
- Successful countries where welding is a fundamental part of its economy tend to have one or more organisations which represent the technological interests of the welding industry in that country.

- A key objective of the NWC and SDG Flagship Programme Lead Organisation and other key organisations in the team, is to have built up excellent credibility such that they are perceived as being key representatives for the welding related industries, similarly to being the voice of the industry.
- Achieving such credibility is shown when the NWC representatives are continually invited by governments and top industry bodies to be involved in activities such as national strategic planning, round table meetings on national challenges, policy submissions, government Inquiries etc.
- Conversely, when the NWC project requires having top government and industry representatives involved in

its own NWC Project strategic planning, boards, committees etc, then the key government and industry organisations willingly nominate people to regularly attend and become involved in such NWC Project activities.

- References [14], [15], [17], [92], [140], [142], [166] and [167] are good examples of such activities showing the high credibility of the welding related organisations involved in various countries and how governments and industry appreciate their value. Obviously in a new NWC Project one has to also earn such credibility and perceived value.



*IIW Commission I: Involved with advanced cutting methods*



*IIW Commission VI: Involved with advanced robotised solutions for welding and allied processes*

## 6.3 Typical Organisations Which Could Be Involved in the NWC and SDG Flagship Programme

- With regard to which organisations should be involved in the boards, committees, working groups of the Flagship Programme, examples can be shown that by involving employer associations, government agencies, trade unions, industry training boards, university groups, government research organisations, larger companies and Multinational Enterprises (MNEs) amongst others, these have the necessary power and influence to assist in positively moving the NWC Project building blocks in the right direction.
- Consider the typical types of organisations which could have a role in the different NWC building blocks and progressing the SDGs:
  - **Industry:** purchasers, specifiers, owners/end users, project managers, design, fabrication, construction, manufacturers, repair and maintenance companies and their related industry associations, compliance, NDT and inspection companies and their related associations, welding equipment and supply companies, material producing and distribution companies, trade unions.
  - **Research and Development:** government supported national laboratories, universities, colleges, private companies, public companies, welding supply companies, national welding institutes/associations/societies.
  - **Technology Diffusion:** government supported national laboratories, universities, colleges, private companies, public companies, welding supply companies, national welding institutes/associations/societies.
  - **Standards-Making and Regulatory Bodies:** Many countries have either established or supported a not-for-profit organisation in the country to coordinate standardisation activities and facilitate the development of national standards by working with government, industry and the community. Such organisations have a multitude of committees in numerous industry sectors thus becoming excellent avenues for networking. In some countries the national body may delegate the responsibilities for standards development to organisations with the specific expertise.
  - **Education and Training:** universities, colleges, technical and vocational colleges, private training centres, industrial training centres, education and training industry boards.
  - **Qualification and Certification:** universities, professional engineering or scientific associations, national welding institutes/associations/societies, compliance, inspection, NDT institutes/associations/societies, accreditation bodies, certification organisations.
  - **Government Departments:** Federal, State and local levels.

## 6.4 Typical Personnel Who Could Be Involved in the NWC and SDG Flagship Programme

- Consider the different types of personnel involved in the welding industry:
  - **Research and Development:** researchers
  - **Technology Diffusion:** technology developers, technology manufacturers, technology suppliers, technology deliverers and technology receptors
  - **Education and Training:** lecturers, teachers, instructors, students
  - **Qualification and Certification:** examiners, auditors
  - **Industry Personnel:** managers of all levels and types, designers, sales, marketing, purchasing and contracts personnel, specifiers, engineering personnel, welding engineers, technologists, specialists, practitioners, welders, artisans, apprentices using welding, inspectors, hobbyists and handymen
  - **Government:** regulators, representatives of departments related to science, research, technology, education, training, industry development amongst others.

## 6.5 Industry Sectors Which Could Be Involved in the NWC and SDG Flagship Programme

Industry Sectors utilising welding include amongst others: Mining, rail, bridges, buildings, residential and commercial steel construction, pipelines, medical, rolling stock, roads, automotive, aircraft, shipbuilding, trucks/buses, pressure equipment, oil and gas, alumina processing, petrochemical, power generation, coal fired, nuclear, gas turbine, solar energy, wind, renewables, water, aerospace, pharmaceuticals, agriculture and food.

### Some Potential NWC-SDG Industry Sectoral Project (ISP) Areas

*Photos supplied by INOX India*



**Agriculture & Food**



**Rail & Road Transport**



**Water**



**Energy**



**Pipelines**



**Renewables**



**Building & Construction**



**Marine Platforms**



**Pharmaceutical & Medical Devices**



**Pressure Equipment**



**Aerospace**

## 6.6 Key Challenges in Establishing and Sustaining the Resources of the NWC and SDG Flagship Programme

- The establishment and sustainment of the resources to maintain an optimal NWC and SDG Flagship Programme in a country and hence progress the NWC and SDGs is probably the biggest challenge to be faced. In terms of the types of resources, sufficient people with the right dedication and drive will be the major challenge. In the first instance, key people representing key organisations need to agree to be part of the Flagship Programme and bring with them the appropriate team players with the relevant skills to implement and succeed with the various plans.
- Having both industry and government “champions” will become essential to help overcome the constraints which will be faced along the way, in particular, the financial challenges which will arise. Agreement will also need to be reached on how the Flagship Programme Lead Organisation will be chosen either from an existing organisation, restructuring an existing organisation or establishing a new organisation. Whichever one is chosen, the goodwill of all participants needs to be harnessed with all people pulling in the same direction from the beginning. If one can receive sufficient support for the acceptance of the existing national not-for-profit welding organisation to be the Lead Organisation or establish such an organisation, then the structures in such an organisation should enable the Flagship Programme organisations to work together to achieve successful outcomes.
- The Flagship Programme Lead Organisation should be able to establish all the appropriate networks within the constitution and legal framework which it operates under and have all participants working in unison. References [39], [92], [140], [143], [144], [145], [152], [153], [166], [216], [239] cover many of the elements for resourcing the Programme.
- Five critical success factors for such a Flagship Programme involve [152]:
  1. **Purpose:** what the programme aims to achieve and why achieving this goal makes sense for the government, industry and other stakeholders in the country.
  2. **Space:** the specific niches within the most relevant societal, environmental or economic issues that the programme will focus on to assist the country to improve its national welding capability and its contribution to the country's Sustainable Development Goals (SDGs).
  3. **Resources:** the obtaining and efficient use of financial and non-financial contributions which are allocated to the programme over time including internal and external resources.
  4. **Impact:** the measurement and impact assessment framework that will guide the management of the programme and the evaluation of its success including methods to measure its ongoing success, value and benefits of the programme and its activities.
  5. **Story:** the core messages of the programme and how to reach key audiences with them on an on-going basis. This will involve creating and implementing successful communication, marketing and promotional strategies.

Working through these five success factors as a framework for designing the Flagship Programme will have profound benefits for the country and all stakeholders involved.

## 6.7 Some Ideas for Obtaining Flagship Programme Resources Including Examples of Previous Funding Resources

The information below is to present examples of how some organisations have succeeded in building up a Lead Organisation and it is recommended that by studying these and others in more depth, the necessary resources could be obtained from their experiences as well as others throughout the world. Appendix 3.8 of Volume 2 of the Long Report lists some examples of aid/donor agencies which could also be interested in participating in such a Flagship Programme.

- The Flagship Programme organisational structures to be implemented in a country will vary depending upon the legal requirements in a country, opportunities which arise to progress various NWC Project building blocks whilst at the same time some aspects of the structure will be defined by rules such as those for establishing an IIW Authorised Nominated Body (ANB) or meeting the requirements of ISO 9712 *Non-destructive testing - Qualification and certification of NDT personnel*.
- At some stage, the necessary groups (boards, committees, working groups etc) for education and training, qualification and certification, research, development and technology diffusion as well as membership of the NWC Project will need to be established. Global experiences are such that a national not-for-profit body as the Flagship Programme Lead Organisation is often the best place to establish it in accompanied by correct Governance.
- Irrespective of which building blocks exist in a country's NWC, it is also incumbent upon both government and industry in the country to work together to investigate, develop and establish strategies which will assist the country in implementing the plans to produce the optimal outcomes to meet the needs of the different industries and peoples in the country.
- Whatever national plan is arrived at, it will need resourcing. It is worthwhile looking back at how other countries have built up their national welding capabilities over many decades. A common thread is that both governments and industry in those countries have realized the importance of the welding industry to the country and somehow have assisted an organisation to build up aspects of the national welding capability through providing funding to various degrees.
- In economics, market failure is a situation in which the allocation of goods and services by a free market is not efficient, often leading to a net social welfare loss. Hence intervention to rectify the situation through funding support. In dealing with governments and industry, one must make sure that you can show the market failure, the identified and verified needs of the country and or industry, the proposed solutions to rectify the market failure, support from industry and other appropriate organisations and an acceptable return on the government and industry financial support.
- It is worthwhile investigating previous examples of funding support both to understand the mechanisms used for funding as well as the motivations and resulting benefits enabling further support. In some cases, individuals or small groups of individuals have motivated and championed the approaches in their countries. Consider the following examples which all helped countries make a quantum leap with their national welding capabilities:
  - Back in the 1950s and 1960s, the UK government financially supported the British Welding Research Association (BWRA), a forerunner of the present TWI, by matching its industry contributions to research to varying degrees with government funding. TWI has now grown to an organisation with over 800 employees and operates worldwide [153].
  - In the late 1940s, the Canadian government supported the establishment of the Canadian Welding Bureau (CWB) to help ensure the integrity of welded structures such that today, the CWB Group has a staff of over 300 with over 12000 company clients currently linked to it in approximately 60 countries [92].
  - In 1966, the Australian Government helped fund the establishment of the Australian Welding Research Association (AWRA) and with ongoing government funding combined with industry funding this helped fund welding research and technology diffusion in Australia until 1989 when the government changed its funding model to that of the Cooperative Research Centres [140].
  - In New Zealand, the Government with the support of New Zealand industry established the Heavy Engineering Levy Act 1978 which helped create HERA (Heavy Engineering Research Association) in 1978. This also

led to the formation of CBIP (Certification Board for Inspection Personnel) in 1983 and the New Zealand Welding Centre in 1987. Funding via a levy programme still helps fund aspects of HERA's work today [141] [226].

- In the USA, The Edison Welding Institute was established in 1984 with the help of a grant of USD5m from the State of Ohio and similar funding from the US Federal Government. Ohio Governor Richard Celeste established the Thomas Edison Program, an initiative to establish the Edison Technology Excellence Centres within the State including a centre for welding research and development. Working closely with TWI from the UK, EWI was able to build up a strong organisation particularly in R&D.
- EWI also now has a Buffalo New York facility (in addition to their Columbus, Ohio, Head Office) funded in part by the New York State Government to help enhance innovation in the local area as well as assist SMEs. An affiliation of EWI and the CWB Group was formed in 2022 to help both organisations drive a broader array of products and services to their respective customers.
- From 1980 to 1990, the South African Institute of Welding had phenomenal success in building up from an initial staff of three people to a staff of 49 in a fully owned 3500sqm specialist facility in Johannesburg [166], [167]. This was achieved with minimal government financial support. During 1990 a survey of industry's needs was performed by an independent organisation on behalf of South African Industry and based on the results, the steel producers in South Africa agreed to fund SAIW to recruit nine senior engineers and technologists to provide additional technical and training services. These and a range of technical services were funded annually to varying degrees through the SAIW Welding Industries Training and Technology Fund which the steel producers helped fund [167].
- From 1998 to 2012 in Australia, the WTIA was very successful in funding the achieving of its objectives to meet Australia's welding related needs, through a combination of earned income, a multitude of relatively small financial contributions from companies in industry with matching government contributions from competitive grant programmes (more than \$15m in total) at both Federal and State government levels [140].
- Other industry sectors also have examples of funding mechanisms used to establish and sustain organisations which they feel are necessary for the well-being of the industry. For example, raw material producers such as steel, copper, aluminium, stainless steel have applied either formal or informal levies amongst the various producers in a country to do this. Such levies have funded the organisations promoting the particular usage of such materials and also some activities in welding related to the particular material.
- In both Australia and South Africa, the national not-for-profit steel institutes/associations which would have as their main objective the promotion of steel, have received a considerable percentage of their annual funding over the years from such a mechanism.
- In all the above cases, excellent outcomes resulted including the establishment and sustainability of other essential organisations which may not have resulted without the initial "seed funding" made available to the organisations mentioned above. Examples of such organisations are SAQCC (NDT), SAQCC (IPE) and Skills SA Foundation in South Africa and AICIP in Australia amongst others.
- These days, many governments have moved to positions where they have created a multitude of funding programmes whereby organisations can apply for funding on a competitive grant basis. This does not make it ideal however for people trying to start new organisations so it is important to realise that one can still approach governments and industry with new innovative ideas in starting initiatives such as the NWC and SDG Flagship Programme in a country. Experience shows that Ministers and industry leaders welcome innovative approaches from dedicated people to establish "common good" initiatives [239].

## 6.8 Specific Recommendations

According to the United Nations latest report at the midpoint of the 2030 Agenda, Sustainable Development Report 2023 ([sdgindex.org](https://sdgindex.org)) [5], all of the Sustainable Development Goals (SDGs) are seriously off track. “From 2015 to 2019, the world made some progress on the SDGs, although this was already vastly insufficient to achieve the goals. Since the outbreak of the pandemic in 2020 and other simultaneous crises, SDG progress has stalled globally. In most high-income countries (HICs), automatic stabilizers, emergency expenditure and recovery plans mitigated the impacts of these multiple crises on socioeconomic outcomes. Only limited progress is being made on the environmental and biodiversity goals, including SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life On Land), even in countries that are largely to blame for the climate and biodiversity crises. The disruptions caused by these multiple crises have aggravated fiscal-space issues in low-income countries (LICs) and in lower-middle income countries (LMICs), leading to a reversal in progress on several goals and indicators. Despite this alarming development, the United Nations believes that the SDGs are still achievable. None of their objectives are beyond our reach. The world is off track, but that is all the more reason to double down on the SDGs.”

While IIW is playing its role in supporting the welding and manufacturing sectors in achieving the SDGs on a global level, efforts should be taken at different levels. The global welding industry and the national welding industry in each country can still play transformative and influential roles in achieving the optimum NWCs and SDGs in a country, and be a model for other industry and technological sectors to follow.

As part of this report, the following specific recommendations were developed:

1. A country's welding industry should publicly support its Government's work on the UN Sustainable Development Goals including working with Government and other agencies to increase the capability and capacity of the country to achieve the SDGs.
2. The welding industry in each country should agree on a Lead Organisation to establish a Flagship Programme with a single global focus “To Assist the Country to Establish, Sustain and Improve Its National Welding Capability and Progress its UN Sustainable Development Goals”.
3. All organisations in the Flagship Programme should integrate the SDGs into their own policy-making and accountability providing a blueprint for national cooperation and collaboration.
4. A national campaign should be implemented to promote the Flagship Programme and obtain the support and involvement of purchasers, specifiers, owners, end users, project managers, design, fabrication, construction, manufacturing, repair and maintenance companies and their related industry associations; compliance, NDT and inspection companies and their related associations; welding equipment and supply companies; material producing and distribution companies; trade unions, research and academic organisations, government departments, regulators and standards making bodies.
5. The welding industry in each country should promote the concept of each organisation in industry, government and academia integrating the improvement of their welding capabilities and SDGs into their policy making and accountability and committing to achieve the SDGs within the scope of their operations and resources.
6. Where appropriate, use an Industry Sectoral Project (ISP) approach to improve the National Welding Capability (NWC) and SDGs. Industry sectors utilising welding which help improve the SDGs include amongst others: agriculture, food, water, mining, rail, roads, bridges, residential and commercial buildings, steel construction, pipelines, medical equipment and devices, pharmaceutical, rolling stock, automotive, aircraft, shipbuilding, trucks/buses, pressure equipment, oil and gas, mineral processing, petrochemical, power generation, coal fired, nuclear, gas turbine, hydro, solar, wind, renewables and aerospace.
7. Prioritise the strategies and projects to be implemented, particularly in relation to the resources available in the country, so that the resources and efforts are devoted to do the most good and realise beneficial outcomes in improving the NWC and progressing the SDGs. Examples of possible welding industry projects for each SDG are shown in Section 1 of Volume 2 of the Long Report.
8. The Lead Organisation, together with industry, governments and aid agencies, analyses and supports

worthwhile projects and initiatives in building up the NWC in a country or region to progress the SDGs.

9. A system be established within the Lead Organisations and welding industries in the various countries in a region to share ideas and methods on conducting strategic planning exercises, needs analyses, regular auditing, reviewing and reporting progress, success stories and lessons learnt, even from failures on initiatives and SDG projects.
10. Where appropriate, countries in a region, or a regional group which may already exist, can be encouraged to cooperate and collaborate on projects and activities as indicated in Section 5 of Volume 1 of the Long Report.





## IIW Vision, Mission and Core Values

### Vision

The leading global welding community linking industry, research and education

### Mission

Advance welding and joining through a worldwide network

### Core Values

IIW is committed to the advancement of welding and joining for a safer and sustainable world

IIW operates based on mutual respect for diversity, culture and languages



**Joining to the future**

