

IRENA **VIRTUAL EDITION** INNOVATION WEEK **2020**

Renewable solutions for transport and industry

5-8 October 2020

SUMMARY REPORT

TECHNICAL SESSIONS WERE HOSTED IN PARTNERSHIP WITH:





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ABBREVIATIONS

°C	degrees Celsius
CCS	carbon capture and storage
CCU	carbon capture and utilisation
CCUS	carbon capture, utilisation and storage
CO₂	carbon dioxide
COP26	26 th Conference of the Parties to the United Nations Framework Convention on Climate Change
DRI	direct reduced iron
DSO	distribution system operator
EPRI	Electric Power Research Institute
ERS	electric road system
EU	European Union
EUR	Euro
EV	electric vehicle
GW	gigawatt
IRENA	International Renewable Energy Agency
IVIW2020	IRENA Virtual Innovation Week 2020
ITF	International Transport Forum
NDC	Nationally Determined Contribution
RD&D	research, development and demonstration
TSO	transmission system operator
UAE	United Arab Emirates
UK	United Kingdom
US	United States
USD	US dollar

EVENT OVERVIEW

Limiting the global average temperature rise to 1.5 degrees Celsius (°C) will require all sectors of the economy to reach zero carbon dioxide (CO₂) emissions early in the second half of this century, and a growing number of countries are committing to such net-zero emission goals. There is generally a broad consensus that renewable energy and energy efficiency are the cornerstones of the energy transition and that renewables will provide the bulk of clean electricity in the decades to come. The optimum trajectories for reducing emissions in the end-use sectors of buildings, transport and industry, however, are less clear. That was the topic explored in the International Renewable Energy Agency's (IRENA) [Innovation Week 2020](#) in the context of the agency's role as the accelerator of the global energy transition.

The [3rd IRENA Innovation Week \(IVIW2020\)](#) took place online during 5-8 October 2020 under the theme "Renewable solutions for transport and industry". It aimed to both inspire and inform decision-makers by showcasing emerging renewable-based solutions from around the world and by exploring the actions needed to fully unlock the potential of renewables in the end-use sectors. The [2016](#) and [2018](#) editions of Innovation Week had focused on the energy supply side, exploring zero-carbon power systems based on integrating high shares of renewables. This third edition broadened the discussion into the energy demand side and was informed by IRENA's recent report [Reaching Zero with Renewables](#).

The event brought together leading policymakers, innovators, developers and investors from across IRENA's diverse global membership. More than 100 expert speakers participated, including the energy and climate commissioners from the European Commission and the African Union, energy and climate ministers from four continents, panellists and facilitators from over 35 different countries, and an audience of more than 1 600 from around 1 250 organisations and nearly 140 countries. The level and breadth of participation indicate the expanding recognition of the critical importance of decarbonising industry and transport and its significant implications for global economies.

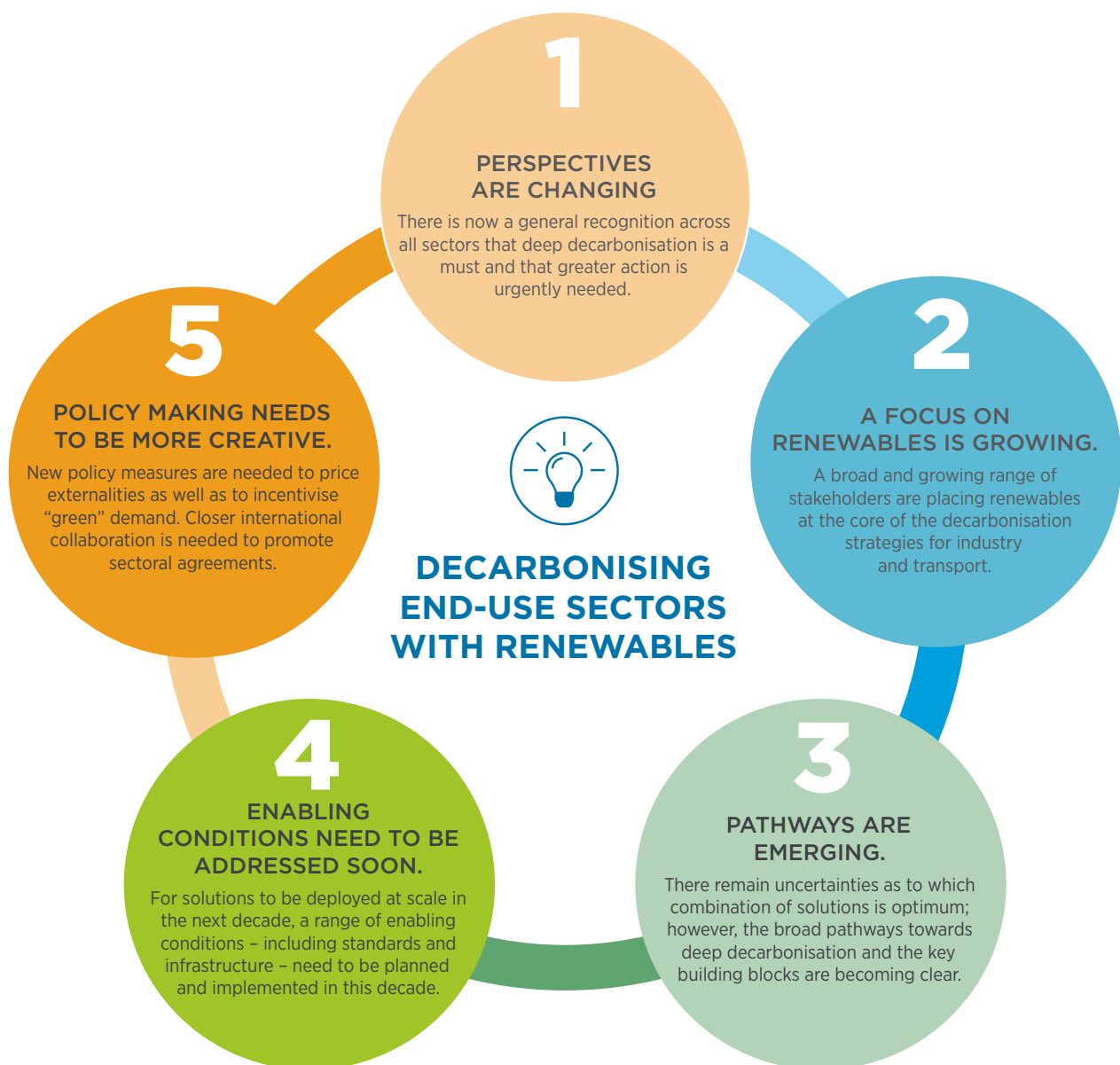


Discussions were structured around six technical sessions aimed at mid-to-senior officials and industry representatives, which were co-organised with partner organisations. In addition, high-level segments opened and closed the event, which included ministers and senior officials from IRENA's membership and senior executives from innovative companies and organisations.

Summaries, presentations and videos of each of the sessions are available [here](#).

KEY TAKEAWAYS FROM IWIW2020

IRENA Innovation Week's four days of discussion showcased many emerging solutions from around the world and explored the actions needed to fully unlock the potential of renewables in the end-use sectors. The discussions demonstrated an important shift in attitudes, with many companies in the industry and transport sectors now actively considering the implications of the zero-carbon goal. In general, the objective of decarbonisation by mid-century seems clear and broadly accepted. What is less clear, however, are the optimum strategies to achieve this. All parts of the energy system are in flux, with changes happening simultaneously on the supply and demand sides, and innovations such as digitalisation expanding their role and shifting business models. Changes on so many fronts make it difficult to chart a clear pathway and increase the risk of negative consequences from poor choices, such as the risk of stranded assets.





KEY TAKEAWAY 1:

Perspectives are changing. There is now a general recognition across all sectors that deep decarbonisation is a must and that greater action is urgently needed.

There is a need to build a shared vision, and a stronger consensus on the urgency to act:

- » The energy transition discourse is shifting rapidly as deep decarbonisation is now a priority for more and more decision-makers.
- » A growing range of affordable and scalable renewable energy solutions for the industry and transport sectors are on the horizon. But most are a long way off from being adopted at scale.
- » There is a lack of a shared vision of the trajectory that sectors should follow, a lack of planning for how to follow this trajectory and a lack of urgency to correct that.
- » Innovation is crucial to accelerate the learning curve of the solutions, improving their performance and competitiveness. Demonstration and pilot projects of commercial-scale have to be promoted.



KEY TAKEAWAY 2:

A focus on renewables is growing. A broad and growing range of stakeholders are placing renewables at the core of the decarbonisation strategies for industry and transport.

Renewables will play a central role among emission reduction options:

- » Renewables will play a large role, accelerated through the rapid declines in technology and [power costs](#).
- » Both direct electrification and indirect electrification via green hydrogen and synthetic liquid fuels are needed and must be pursued in close coordination with the power sector.
- » A larger potential role exists for bioenergy and bio-feedstocks within the industry and transport sectors; the feedstock supply must be demonstrably sustainable, and [good practice examples](#) show that this is achievable.
- » The need to match supply and demand means that a good understanding of cross-sectoral effects is critical.
- » [Digitalisation](#) and smart systems are needed to unlock increased system flexibility in transport and industry through demand response.



KEY TAKEAWAY 3:

Pathways are emerging. There remain uncertainties as to which combination of solutions is optimum; however, the broad pathways towards deep decarbonisation and the key building blocks are becoming clear.

Although the precise route may be hazy, the broad components and the order of priority for a transition pathway are clearer:

- » First, a focus on energy and resource efficiency (including the circular economy);
- » Second, a transformation of power systems to high renewable shares;
- » Third, direct electrification of demand with renewables;



- » Fourth, for those areas of demand that cannot be economically electrified, the use of renewable fuels sourced either from sustainable biomass or through indirect electrification producing green hydrogen and e-fuels; and
- » Finally, as a last resort, for those emissions that cannot be dealt with in other ways, the use of carbon removal technologies including carbon capture and storage (CCS) technologies.

KEY TAKEAWAY 4:

Enabling conditions need to be addressed soon. For solutions to be deployed at scale in the next decade, a range of enabling conditions – including standards and infrastructure – need to be planned and implemented in this decade.

Creating the right enabling conditions – including infrastructure, standards, trade routes and business models – is critical:

- » While the energy transition could be a threat for incumbents, it can also be an opportunity for those that engage early.
- » Enabling infrastructure – for example, [fast-charging solutions for freight](#), and a hydrogen grid – will act as a major enabler, and development must begin immediately. Investment in infrastructure needs to come ahead of the demand and thus will require carefully coordinated planning and targeted incentives.
- » While technical solutions are emerging, the economics need to improve and the applicability of the emerging solutions needs to be better understood – the cost of [green hydrogen](#), for example, will vary widely depending on the location.
- » Large gaps in capability and large cost differences still remain. Increased investment in research, development and demonstration (RD&D) is needed across a range of technologies to reduce costs, improve performance and broaden applicability.



KEY TAKEAWAY 5:

Policy making needs to be more creative. New policy measures are needed to price externalities as well as to incentivise “green” demand. Closer international collaboration is needed to promote sectoral agreements.

Creative national policy measures and cross-border collaboration are both needed:

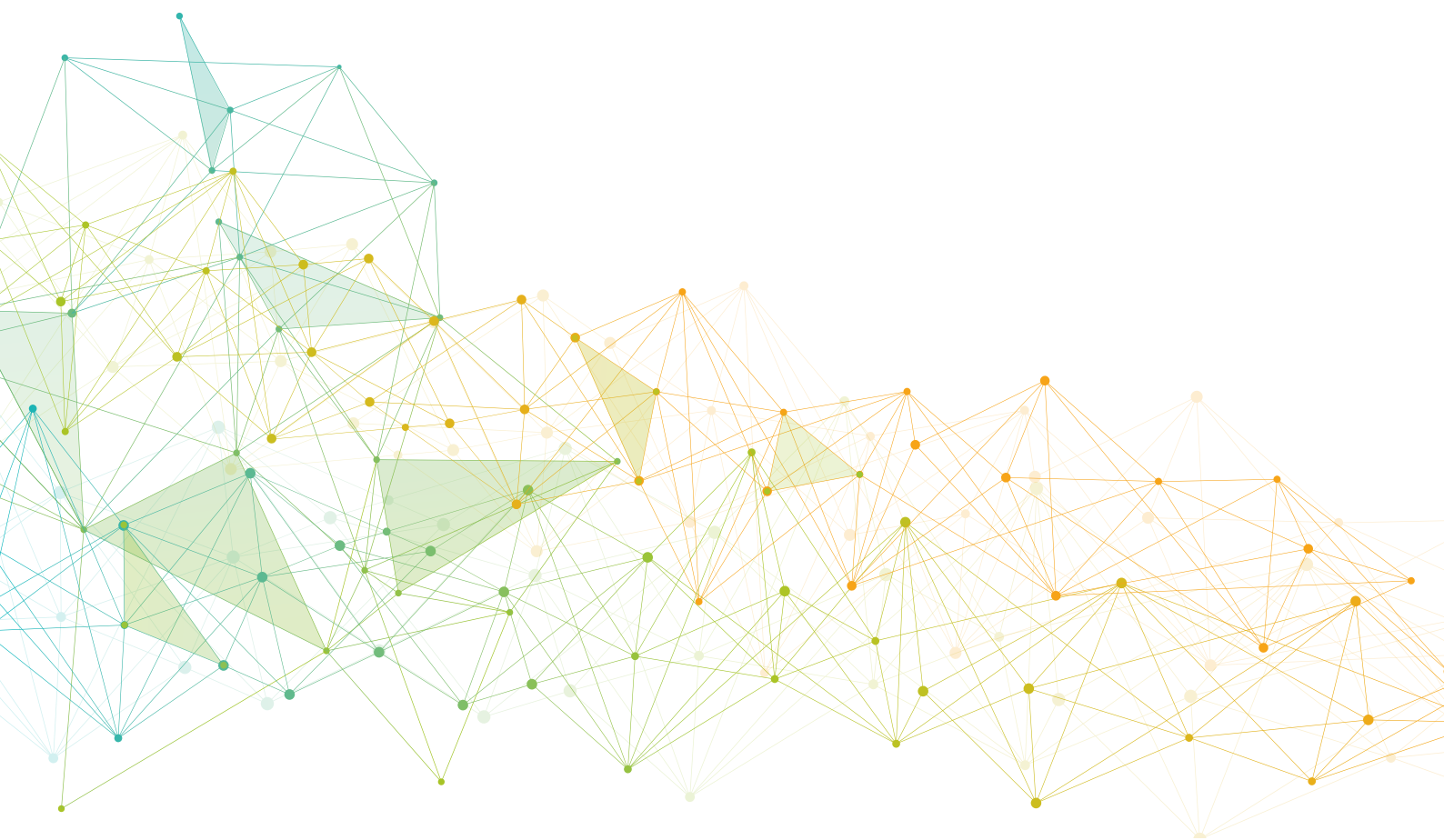
- » Cost reductions can be accelerated through technological learnings and upscaling; however, the gap is large and industry cannot tackle it alone, so policy intervention is essential.
- » Standards and certification for green energy carriers and green distribution infrastructure need to be addressed multilaterally – and soon – to avoid having them become a barrier to progress.
- » Sectoral and cross-sectoral and national and multinational roadmaps are needed that are bought into by key players in both the public and private sectors. This requires linked sectoral strategies at the local, national and international levels, co-developed with broad engagement nationally and internationally to build consensus. International and inter-governmental bodies can assist.
- » International collaboration platforms, such as IRENA, will play an important role in facilitating dialogue and action at the global scale.

In general, the diversity of innovative approaches presented in the discussions was encouraging and showed accelerating progress. However, much remains to be learned. Critically, the effects of such an energy transition on the supply side and at a systems level are not yet well understood. More nuanced answers are needed to key questions such as: Where will all the electricity and green hydrogen and renewable fuels that are needed to power this transition come from? What are the infrastructure implications of such a transition? Can the production of clean energy vectors add much-needed flexibility to the electricity system as shares of variable renewable energy increase? How can countries and trading partners establish standards and regulatory frameworks to ensure fair and sustainable trade in new energy vectors?

Building on its analytical work to date, including the [Reaching Zero with Renewables](#) report and insights from expert discussions such as Innovation Week, IRENA will be deepening its analysis and broadening its engagement to seek answers to these and related questions. Over the coming months IRENA will publish deep dives into specific aspects such as electrolyser cost reduction, the role of biofuels in aviation, the potential of renewable methanol, the sector coupling implications of electrification and others. All these insights will be integrated into the agency's work, particularly the next edition of the *Global Renewables Outlook*, to be launched in Spring 2021.

Findings from IRENA's Innovation Week 2020 and subsequent work will inform the preparatory meetings for the 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change in November 2020 as well as inform the energy transition investment included in post-COVID-19 stimulus packages adopted by IRENA's global members. Innovation Week 2020 has made clear that innovation is key to enabling the energy transition that the world needs. What is required now is action, and there is no time to waste.

SESSION 1 SUMMARY: OPENING SESSION



SESSION OVERVIEW

The **opening session brought together high-level speakers** from around the world to share their perspectives on the importance of action on emissions from end-use sectors and ongoing activities and plans to decarbonise the transport and industry sectors in the context of a global clean energy transformation. The opening session kicked off four days of in-depth technical discussions on emerging solutions as well as current challenges and critical gaps in capabilities.

5

panels

7

high-level speakers

Participants from

95

countries

SUMMARY OF KEY INSIGHTS

High-level speakers shared visions and plans for solutions that are becoming available, as well as steps that they have taken to enable the deep decarbonisation of industry and transport, particularly by leveraging the power of renewables. They also shared the technological, policy, regulatory and economic changes that they see as being key enablers for further progress in the context of both the climate crisis and the global pandemic.

- » **Decision makers are committing to innovation and collaboration as a pathway to both climate and pandemic recovery.** Public-public and public-private partnerships including the [World Economic Forum's Mission Possible Platform](#) play a central role in advancing discussions and actions to ensure a green and sustainable future.
- » **The growing momentum behind green hydrogen is attracting global partnerships, initiatives and investments.** Benefiting from the decline in renewable electricity prices, the public and private sectors recognise the benefits of hydrogen and are joining forces through several public-private partnerships including the [IRENA Collaborative Framework on Green Hydrogen](#) to ramp up production and reduce hydrogen costs.
- » **Energy efficiency is recognised as low-hanging fruit and should go hand-in-hand with renewables in efforts to decarbonise the energy-intensive sectors of industry and transport.** Energy efficiency together with demand reduction is one of the five pillars towards zero emissions, alongside renewable electricity, renewable heat and biofuels, green hydrogen and e-fuels, and carbon removal technologies.

WELCOMING REMARKS

In his welcoming remarks, **Francesco La Camera**, IRENA's Director General, framed the upcoming discussion by highlighting the importance of action in the energy-intensive industry and transport sectors, which, if not mitigated, could account for 38% of energy and process emissions by 2050. He also discussed the potential significant role of renewables.

Highlights from the welcoming address:

- » **Limiting global temperature rise to 1.5 °C requires concerted efforts in all sectors of the economy, including the energy-intensive industry and transport sectors.** While the progress in the power sector has been tremendous, actions must also extend to fully tackle emissions from the transport and industry sectors, including from the production of iron and steel, cement and chemicals, and the transport modes of aviation, shipping and road freight.

- » **Insights into viable solutions and their prioritisation, and enhanced understanding of economic and societal impacts, are key for policy makers to act.** A pathway to zero CO₂ emissions is documented in IRENA's annual [Global Renewables Outlook](#), and IRENA's [Reaching Zero with Renewables](#) report assesses viable solutions to decarbonise the energy-intensive industry and transport sectors.
- » **Renewables have the potential to deliver over half of the emission reductions needed for full decarbonisation.** While some of those solutions looked impossible just a few years ago, declining technology costs and proven synergies have now opened up a credible path to cut CO₂ emissions to zero. Many far-sighted policies and long-term investments in renewables, efficiency and electrification have taken centre stage in countries' pandemic investment packages.

FIRESIDE CHAT ON REGIONAL PERSPECTIVES

Frédéric Simon, Editor on Energy & Environment, Euractiv, moderated a fireside chat with:

- » **H.E. Kadri Simson**, Energy Commissioner, European Commission
- » **H.E. Dr. Amani Abou-Zeid**, Energy Commissioner, African Union.

Highlights from the discussion:

- » **The European Union (EU) is implementing actions to advance hydrogen production to allow deep decarbonisation.** While direct electrification plays a major role in decarbonising the majority of the end-use sectors, the most energy-intensive sectors (cement, steel, heavy trucks) require a mix of measures, including indirect electrification. To benefit from declining renewable electricity costs, hydrogen represents a viable solution but can advance only with targeted activities, such as a Swedish pilot project developing green hydrogen to produce steel.
- » **Digitalisation is seen as a key enabler to electrify urban transport and industry in Africa.** A quarter of all CO₂ emissions in Africa come from the transport sector. This could give leaders an incentive to leverage innovative renewable-based solutions, mostly involving digitalisation, to ensure green and sustainable cities. While action by industrial sectors is still nascent in Africa, there is a recognition that energy efficiency is a low-hanging fruit and a starting point towards decarbonisation.
- » **Cross-border public-public and public-private collaborations allow for complementarity and replicability of solutions to advance the energy transition.** The European Commission launched calls with a budget of EUR 15 million to support innovative co-operation between EU and African partners on productive use of renewables, including the Europe-Africa Green Energy Initiative focused on hydrogen.

PERSPECTIVE ON PUBLIC-PRIVATE PARTNERSHIPS

Frédéric Simon, Editor on Energy & Environment, Euractiv, discussed public-private perspectives with:

- » **Børge Brende**, President, World Economic Forum.

Highlights from the discussion:

- » Public-private partnerships underpin three priority areas to decarbonise industry and transport:
 - › **Digitalisation is seen as a key enabler to reach up to 50% efficiency improvements in the challenging industry and transport sectors.**

- › **Targeted activities to scale up the deployment of clean technologies are essential.** These include ramping up the production of clean hydrogen and sustainable fuels, establishing clean industrial clusters and creating a circular carbon economy to boost the energy transition.
 - › **Mobilising finance is necessary to fill the gap between the global North and the global South.** To get on the pathway to net-zero emissions, mobilising finance, especially in developing countries, is essential.
- » **The World Economic Forum has launched the Mission Possible Platform for decarbonisation** to support 200 companies to reduce CO₂ emissions from the “hard-to-decarbonise” sectors.

MINISTERIAL PERSPECTIVES ON STRENGTHENING ENERGY AND CLIMATE POLICY FOR END-USE SECTORS

Frédéric Simon, Editor on Energy & Environment, Euractiv, discussed ministerial perspectives on strengthening energy and climate policy for end-use sectors with:

- » **H.E. Dr. Abdullah bin Mohammed Belhaif Al Nuaimi**, Minister of Climate and Environment, United Arab Emirates (UAE)
- » **H.E. Kwasi Kwarteng**, Minister of State, Department of Business, Energy and Industrial Strategy, United Kingdom (UK).

Highlights from the UAE:

- » **Commitment, collaboration and investments are viewed as central to transforming industry in the UAE.** The UAE leads the multi-partner Al Reyadah project, which seeks to decarbonise the iron and steel industry by capturing, storing and utilising 5 million tonnes of CO₂. [Emirates Global Aluminium](#) set the performance standards by the Aluminium Stewardship Initiative and has achieved reduced emissions of less than 8 tonnes of CO₂-eq per tonne of aluminium produced.
- » **Different means of transport are seen as complementary to decarbonise the transport sector.** A single train journey removed 300 trucks from the UAE’s roads, which in turn resulted in CO₂ emission reductions of over 60%. For shipping, the UAE is scaling up the use of biofuels, hydrogen and ammonia.

Highlights from the UK:

- » **The UK was the first major economy to pass a net-zero emissions law.** The UK is committed to bringing the country’s greenhouse gas emissions to net-zero by 2050 in part by reducing its dependence on coal and turning towards offshore wind and other renewables. To support the industry and transport sectors in this transition, the UK is focusing on innovative solutions and on collaboration, with a particular focus on spurring and de-risking innovative new technologies.
- » **The UK COP26 presidency calls on countries to bring forward stronger Nationally Determined Contributions (NDCs) towards reducing emissions under the Paris Agreement to accelerate the decarbonisation of all sectors of the economy.** The UK supports cross-border partnerships to advance innovative solutions globally around the five key priorities of finance, adaptation, resilience, transport and energy.

MINISTERIAL PERSPECTIVES ON THE WAY AHEAD

The following **Ministers provided** their perspectives on the way ahead:

- » **H.E. Andreas Feicht**, State Secretary Ministry of Economic Affairs and Energy, Germany
- » **H.E. Arifin Tasrif**, Minister of Energy and Mineral Resources, Indonesia
- » **H.E. Seamus O'Regan**, Minister of Natural Resources, Canada.

Highlights from Germany's perspective on the way ahead:

- » **Green hydrogen is key to decarbonising hard-to-electrify sectors in Germany and to reaching climate neutrality by 2050.** To assume global responsibility in emission reduction, Germany adopted a national hydrogen strategy in June 2020 and established hydrogen as an option to decarbonise these sectors. As an energy importer, Germany will also require all its energy imports to be carbon neutral.
- » **Making hydrogen cost-competitive by ramping up production, and intensifying international co-operation to develop a global market, are central to the German national hydrogen strategy.** To address the former, Germany will establish 5 gigawatts (GW) of green hydrogen production by 2030 and will develop transport infrastructure, alongside regulatory and subsidy schemes to stimulate demand for hydrogen and create critical mass. To enhance international collaboration, Germany has committed EUR 2 billion to fund international projects to create a sustainable global market and has joined IRENA's Collaborative Framework on Green Hydrogen.

Highlights from Indonesia's perspective on the way ahead:

- » **Production of biofuels and biomass have a long tradition in Indonesia.** To bring stability and predictability for new investments and to decarbonise transport and industry, Indonesia increased its biodiesel blending targets to B30 and (for treated vegetable oil) B100. To reduce CO₂ emissions in large-scale industries (cement, steel, pulp and paper), Indonesia has shifted its focus to exploit its immense biomass potential.
- » **Production and increased use of green electricity are the focus of various programmes for economic development.** To benefit from its vast renewable energy potential, Indonesia has launched renewable-based development programmes focused on industry and the local economy, including exploiting geothermal energy.

Highlights from Canada's perspective on the way ahead:

- » **Canada's ambitious climate plan puts a price on pollution, phases out coal-powered electricity and commits to exceeding the country's Paris climate targets for 2030 and reaching net-zero emissions by 2050.** Anticipating the direction of markets and accelerating the deployment of new technologies and innovation will be crucial. To reconcile the economy and energy, a just and inclusive transition will ensure support for workers whose livelihoods depend on carbon-intensive industries.
- » **Canada sees decarbonisation opportunities in the post-pandemic recovery.** Pathways to decarbonise energy-intensive industries recognise a need for a mixture of innovative approaches in electrification, carbon storage and clean technologies, and should simultaneously focus on radical incrementalism and breakthroughs in energy innovation.

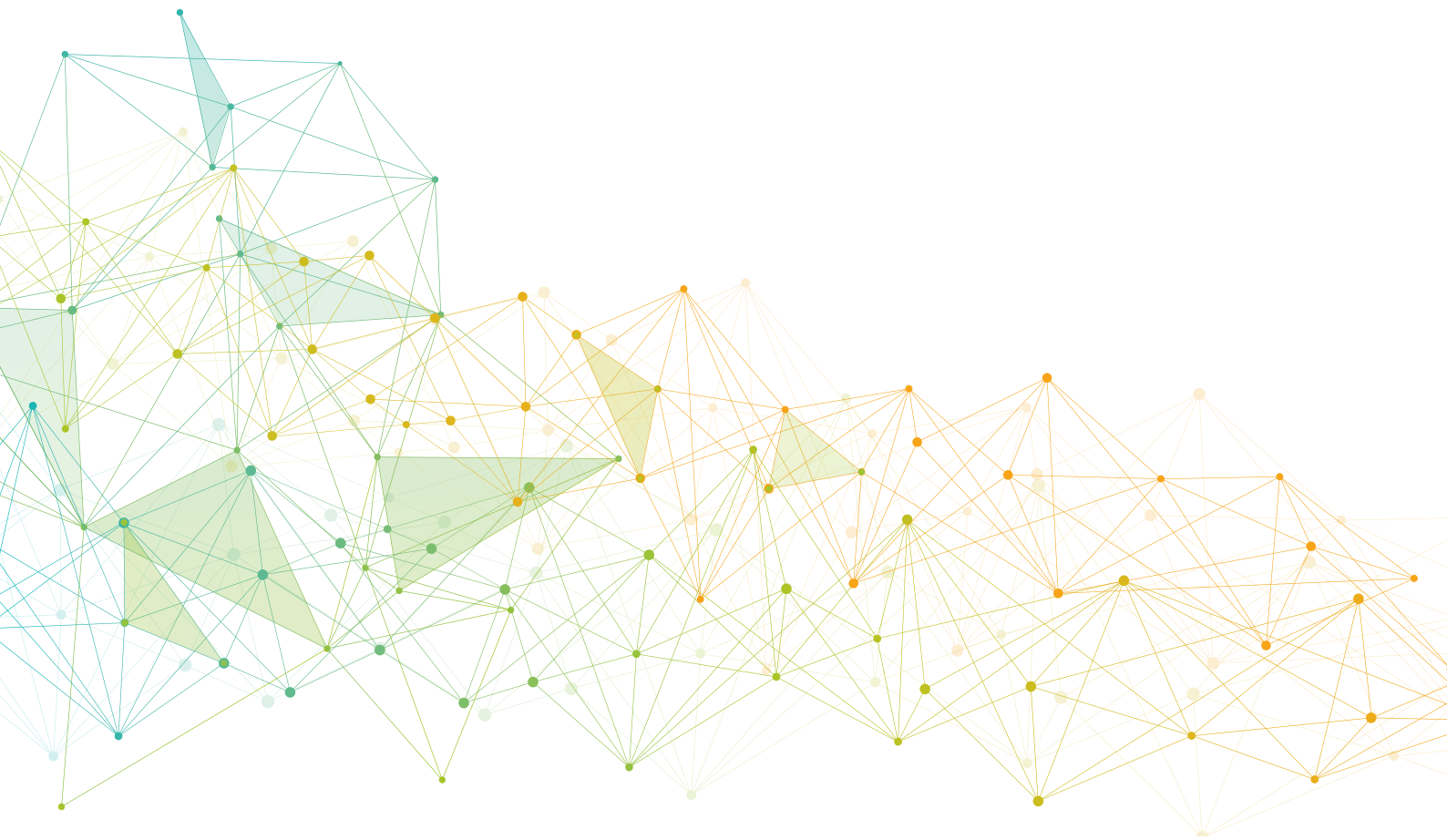
CLOSING REMARKS

In his closing remarks, **Francisco La Camera**, IRENA's Director General, welcomed a broad recognition for deep decarbonisation and appreciated ambitious strategies and policies and innovative approaches that are emerging at scale around the globe.

Highlights from the closing remarks:

- » **Together and by focusing on innovation we can transform the economy into a resilient, inclusive and climate-proof one.** The latest studies from the Intergovernmental Panel on Climate Change (IPCC) urge that the window of opportunity for meaningful action is closing fast. The necessary transformation requires technology and finance, but also a change of mindset.
- » **Strategies for industry and transport must set a clear end goal of zero emissions.** Such a strategy should be built on the five technology pillars of demand reduction and energy efficiency, renewable electricity, renewable heat and biofuels, green hydrogen and e-fuels, and carbon-removal technologies, and requires significant technical and economic focus to bring these solutions rapidly to the market.

SESSION 2 SUMMARY: SMART ELECTRIFICATION OF END-USE SECTORS - IMPLICATIONS FOR THE POWER SYSTEM



ORGANISED IN PARTNERSHIP WITH EPRI



SESSION OVERVIEW

The **electrification of end-use sectors with renewables** will be a major component of plans to decarbonise industry and transport. At the same time, electrifying with renewables is an emerging strategy to maintain value and avoid the curtailment of abundant and low-cost variable renewable electricity. Session 2 explored the **implications for the power system** of massive electrification of the transport, buildings and industry sectors, and discussed which smart strategies are key to harness the benefits of coupling these sectors.

4 panels

12 expert speakers

Participants from **95** countries

SUMMARY OF KEY INSIGHTS

- » **Electrification is a key pathway to decarbonise end-use sectors, but it must go hand-in-hand with the massive deployment of renewables and energy efficiency.**
- » **Smart electrification, unlocked by digitalisation, innovative regulation, business models and system operation, is crucial to manage the extra load for the power sector and to avoid unnecessary investments.**
- » **Despite the implementation of smart electrification approaches, significant investments in electrification technology and infrastructure will be needed. This requires attention and proper planning now for a successful roll-out in the next decade.**
- » **The preferences and role of consumers will shape the effectiveness of electrification strategies. Consumers need to be informed and engaged in a way that is attractive to them.**
- » **Monetising demand-side flexibility through new market designs is one of the main challenges for unlocking this flexibility source.**
- » **Deep electrification, increasing dependency on power systems, calls for highly resilient systems.**
- » **Regulation is key in this transformation.**

SCENE SETTING

Francisco Boshell from IRENA opened the session by introducing the agency's work and how the Innovation Week fits in that. Findings and key messages from this year's Innovation Week will feed into IRENA's next *Innovation Landscape* report focused on the electrification of end-use sectors.

Electrification is the key vector to decarbonise the end-use sectors of transport, industry and buildings. While today only 20% of global energy demand is met by electricity, the share is expected to approach 50% by mid-century, propelled by mass deployment of technologies such as electric vehicles (EVs), heat pumps and electrolyzers for hydrogen production. This will result in cumulative investments of USD 27 trillion between now and 2050, or USD 800 billion per year.

The importance of smart electrification strategies was emphasised as the most cost-effective way to couple the sectors and to manage the extra load in the power system.

PANEL I: GLOBAL EXPERIENCE

The first panel offered a global perspective on electrification strategies brought by leading experts from three different regions: the United States (US), Europe and Asia (represented by Japan). **Francisco Boshell**, Energy Analyst at the IRENA Innovation and Technology Centre, moderated the panel, which included the following panellists:

- » **Robert Chapman**, Vice President of Electrification & Sustainable Energy Strategy, Electric Power Research Institute
- » **Kristian Ruby**, Secretary General, EURELECTRIC
- » **Koshichi Nemoto**, Vice President, Central Research Institute of Electric Power Industry (CIEPRI).

Highlights from the discussion:

- » **In the US, the focus currently lies on electrifying the transport sector.** With the total cost of ownership of EVs now equivalent to that of internal combustion engine vehicles, the technical and economic potential of EVs is clear. Consumer preference is important for mass EV adoption. Dynamic pricing is key to enabling smart electrification and driving customer demand.
- » **In Europe, doubling down on decarbonisation means doubling down on electrification.** Electrification of transport is considered to be the biggest challenge and opportunity. There is a need for policy support for the necessary infrastructure development. The electrification of buildings is closely connected to the trend in building renovation, which is set to double or triple across Europe. Increasing dialogue among the electricity industry, transport and industry is of great importance in this transition.
- » **Meanwhile, in Japan the electrification rate is already high.** The adoption of heat pumps in the residential sector is very high, but a large opportunity remains to increase electrification in the transport sector. Koshichi Nemoto emphasised the importance of energy efficiency in this transformation, and that it should go hand-in-hand with renewable energy.

PANEL II: SMART ELECTRIFICATION AT THE DISTRIBUTION SYSTEM OPERATOR LEVEL

This panel discussed the impact of electrification on low- and medium-voltage power grids. Distribution system operators (DSOs) in Germany and the US shared their experience with increased electrification and engaged in a discussion with providers of demand-side flexibility technologies, especially related to heat pumps and tapping into the storage capacity of EVs. The panel was moderated by **Kristian Ruby**, Secretary General of EURELECTRIC, and the following panellists joined the discussion:

- » **Bastian Pfarrherr**, Head of Innovation Management, Stromnetz Hamburg
- » **Katie Sloan**, Director of eMobility and Building Electrification, Southern California Edison
- » **Gregory Poilasne**, Co-Founder and Chief Executive Officer, Nuvve
- » **Sandra Trittin**, Co-Founder and Chief Business Officer, Tiko Energy Solutions.

Highlights from the discussion:

- » **Digitalisation and EV smart charging are deferring the need for investments in grid reinforcement for the DSO in Hamburg.** Bastian Pfarrherr said the peak load in the distribution network, currently at 1.8 GW, was expected to grow 40% in the next 15 to 20 years, driven mainly by increasing numbers of EVs. He noted that in Hamburg, 100 000 out of 750 000 vehicles are expected to be electric by 2030. The intermediate solution is to decrease the simultaneity factor of EV charging by using digital technologies. In the long term, however, grids will need to be reinforced to accommodate the added load from electrification.
- » **California's DSO is looking to accommodate 26 million EVs by 2040, planning for massive investments to build out EV infrastructure.** California has a clear policy stating that all new passenger cars must be zero emission by 2035, and all heavy-duty vehicles must be zero emission by 2040. Such a policy must be expanded to other US states. However, drivers and companies need to be reassured that the utility is providing the electricity and reliability they expect.
- » **Key success factors for EV integration in power systems are reliability, dispatchability and monetisability.** This means that utilities should be able to access the storage capacity of EVs and also have control over discharge and charge, while EVs owners are remunerated. The challenge lies in the complexity of the ecosystem, which involves manufacturers of charging infrastructure, regulators, utilities, system operators and drivers. Fleets look most promising in providing flexibility to the system, due to the aggregation of EVs and to the simpler ownership structure.
- » **Challenges for unlocking demand-side flexibility are not on the technical side, but on monetising this flexibility.** The lack of markets at the distribution level, and the fact that the actual value of demand-side flexibility is unclear, make it difficult to monetise this flexibility. However, grid reinforcement solutions should be replaced by digital solutions and by smart management of these assets.
- » **Widening the price gap in the tariff structure** between electricity at peak loads and off-peak electricity is a very effective solution for better demand-side management.

PANEL III: SMART ELECTRIFICATION AT THE TRANSMISSION SYSTEM OPERATOR LEVEL

This panel discussed the impact of electrification on the high-voltage grid. The transmission system operator (TSO) in Denmark and the vertically integrated utility in Uruguay shared their experience and plans with regard to increased electrification. In addition, representatives of demand-side applications, such as industry demand and green hydrogen production, presented their challenges and successes in supporting the grid and providing flexibility for integrating higher shares of renewables.

The panel was moderated by **Norela Constantinescu** from ENTSO-E, and the following panellists joined the discussion:

- » **Anders Bavnhøj Hansen**, Chief Engineer, Energinet, Denmark
- » **Pablo Mosto**, Planning & Environment Manager, UTE National Electric Utility of Uruguay
- » **Christopher Greiner**, Chief Technology Officer, EnergyNest
- » **Adele Lidderdale**, Hydrogen Project Manager, European Marine Energy Centre and BIG HIT project.

Highlights from the discussion:

- » **For Denmark, offshore wind resources in the North Sea are a great opportunity for further electrification.** Besides direct electrification strategies (EVs, heat pumps), Denmark is looking at electrifying more end-use sectors, considering also green hydrogen to fuel, for example, aircraft and ships, and for ammonia production.
- » **Electrification of industrial process steam is important since it accounts for 10% of global final electricity consumption.** Christopher Greiner presented the novel energy storage “thermal batteries”, which convert electricity to heat and thus are able to provide fast response and grid flexibility.
- » **Thermal batteries and hydrogen are not competitors, but rather are complementary.** The EU hydrogen strategy focuses on very high temperatures (above 600 °C), while thermal batteries focus on “moderate” temperatures (150-350 °C). Hydrogen therefore is not seen as a competitor at the consumer level.
- » The BIG HIT hydrogen project is looking at how hydrogen can reduce wind curtailment and balance the grid, while demonstrating different demand uses for hydrogen, such as decarbonising ferries between islands.

PANEL IV: NEW POWER SECTOR DYNAMICS WITH SMART ELECTRIFICATION

This panel brought together all power sector actors, DSOs and TSOs, to discuss how increased electrification changes the dynamics in the power system, and how regulation needs to adapt to increasingly renewable-based, decentralised systems. TSO-DSO co-operation also was explored, together with a debate on how to share flexibility resources most efficiently.

The panel was moderated by **Robert Chapman** from the Electric Power Research Institute, and the following panellists joined the discussion:

- » **Anders Bavnhøj Hansen**, Chief Engineer, Energinet, Denmark
- » **Pablo Mosto**, Planning & Environment Manager, UTE National Electric Utility of Uruguay
- » **Katie Sloan**, Director of eMobility and Building Electrification, Southern California Edison
- » **Bastian Pfarrherr**, Head of Innovation Management, Stromnetz Hamburg.

Highlights from the discussion:

- » **TSO-DSO integration is key.** Bastian Pfarrherr explained that with increased decentralisation, the distribution system becomes more flexible, being closer to the end consumer. Increased communication between TSOs and DSOs, and between them and the customers, is needed to keep the entire system in balance in the most efficient way. Smart meters are helping, and digitalisation is likely an important solution.
- » **Regulation is key in this transformation.** Regulation needs to enable flexibility sharing between DSOs and TSOs, to enable sector coupling (electricity and hydrogen), while keeping the system resilient and to prepare the grid for climate vulnerabilities, as have been seen recently in California. Regulation needs to take into account all the impacts of the transformation towards a decarbonised economy/society

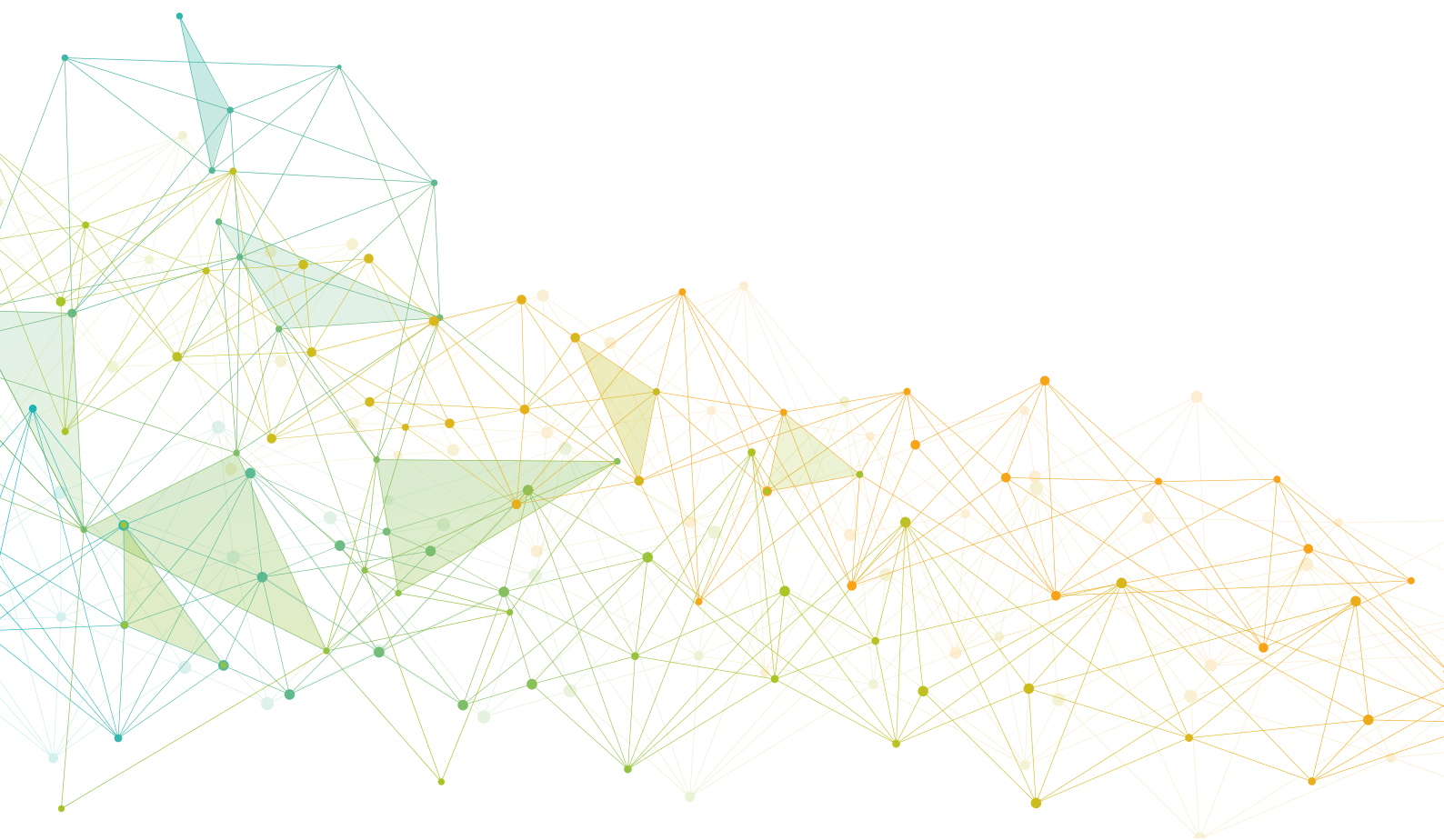
- » **The challenge of net-zero marginal cost in a renewable-based system** was raised by Pablo Mosto. As a vertically integrated, state-owned utility, UTE is in the optimal position to lead this transformation. With 98% of the electricity coming from renewable sources, the marginal cost of the system is zero, but that does not mean that the overall cost of the system is zero. Therefore, a close relationship between the utility and the regulator is needed to maintain the affordability of the entire system.

CLOSING REMARKS

Robert Chapman from EPRI summarised the discussion, presenting the key messages around the “Five Ds” of the energy transition:

- » **Decarbonising** the power sector and using clean electricity in other sectors requires deep electrification of end-use sectors.
- » **Decentralisation** creates more opportunities for customers and end users to support the electricity system.
- » **Digitalisation** helps to capture data and, with the use of analytics, to manage systems efficiently and smartly, optimising the integration of power, transport, buildings and industry.
- » **Dependency** grows with increased electrification, making reliability and resiliency imperative for customers.
- » **Diversity** is valuable from a technological perspective (with more technological options ensuring a more affordable and sustainable transition), but also from a socio-economical perspective (making sure no one is left behind and that the most vulnerable customers are not unfairly burdened).

SESSION 3 SUMMARY: GREEN HYDROGEN – ELECTROLYSIS, AMMONIA AND OTHER E-FUELS



ORGANISED IN PARTNERSHIP WITH THE HYDROGEN COUNCIL

**Hydrogen
Council**

SESSION OVERVIEW

Green hydrogen allows large amounts of renewables to be conveyed to end uses that would otherwise be difficult to decarbonise. Following Members' call for a continuous dialogue on green hydrogen at IRENA's ministerial roundtable in January 2020, IRENA established the Collaborative Framework on Green Hydrogen in June 2020. Building on findings from previous IRENA reports on green hydrogen and from the [Reaching Zero with Renewables](#) report that discusses both hydrogen and e-fuels, this session presented findings from IRENA's recent analysis and explored (along with key partners from government, industry and international organisations) insights on recent developments in electrolyser technologies and e-fuels, the potential for cost reduction and the next steps for the successful scale-up of hydrogen in the industry and transport sectors.

2 panels

14 expert speakers

Participants from 72 countries

SUMMARY OF KEY INSIGHTS

Session 3 discussed opportunities for scaling up the production of hydrogen and its derivatives and highlighted key priorities. It also explored what is needed to sufficiently accelerate innovation across different dimensions (technological, regulatory, political, economic, etc.) to produce these energy carriers in a cost-competitive way and in turn to help accomplish the goal of decarbonising the end-use sectors of industry, transport and buildings by mid-century. The key points from the discussion were:

- » **As electrolyser size increases continuously, this leads to a decrease in the total system cost due to economies of scale (for example, the same balance of plant can be used for different stacks, among others). In this respect, the standardisation of processes, materials and system elements is important.**
- » **Electrolysers have long been in operation, yet the technology is still evolving. Research and development initiatives are essential to reduce costs by technology learning at the pace needed for the envisioned energy transition.**
- » As efficiency decreases with higher current density, there is a **need to standardise the definition of efficiency at rated power based on the alternating current (AC) input to the plant.** Project developers should be transparent regarding the plant efficiency for different operation levels, which also depends on the specific project application and set-up.
- » **Investment and the elaboration of the required supporting schemes** are required to unlock the full potential of renewable hydrogen.
- » **The integrated design of e-fuel production processes could mitigate the variability of renewables and minimise the cost of ammonia or methanol.**
- » **Green hydrogen definitions based on carbon content and certification schemes are key elements in hydrogen and hydrogen-based e-fuel production.**
- » **The absence of a liquid market for hydrogen and its derivatives poses a significant offtake risk that requires underwriting.** Ensuring long-term off-takers is essential at the current early stages of the market.

SCENE SETTING

The opening to the first panel was delivered by **Emanuele Taibi**, responsible for Power Sector Transformation Strategies at IRENA, and focused on providing context on the relevance of green hydrogen for the energy transition and on IRENA's work (to date and upcoming) in this space. The presentation explored how the overall costs of green hydrogen behave for different values of renewable power and electrolyser investments. It also touched on the main elements of green hydrogen facilities that have the best potential to be improved to reduce costs further, as a preview of the upcoming IRENA report on electrolysers for green hydrogen production.

PANEL I: ELECTROLYSIS PRODUCTION

The main objective of this session was to discuss the most promising innovative technological pathways, as well as regulatory and market solutions, to produce cost-competitive green hydrogen. Panellists evaluated the potential of different technology options, identified their deployment challenges, weighed their pros and cons, and closed the panel discussion with their visions on which solutions are more likely to succeed. The panel was moderated by **Tim Karlsson**, Executive Director, International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), and the following panellists joined the discussion:

- » **Armin Schnettler**, Executive Vice President, New Energy Business, Siemens Energy
- » **Eiji Ohira**, Director General, Fuel Cells and Hydrogen Technology Group, New Energy and Industrial Technology Development Organization (NEDO), Japan
- » **Thorsten Herbert**, Director for Market Development and Public Affairs, Nel Hydrogen
- » **Denis Thomas**, Global Business Development Leader, Water electrolysis, Cummins-Hydrogenics
- » **Jan-Justus Schmidt**, Co-founder, Enapter.

Highlights from the discussion:

- » The **size of electrolysers is increasing continuously**, bringing down the **total system cost due to economies of scale which, jointly with the technology learning, should further greatly reduce the costs of green hydrogen in the coming years.**
- » For mobility and hub stations, a 10-20 megawatt electrolyser size is becoming more frequent.
- » Not only are the investment costs of electrolysers important when assessing the economics of green hydrogen, but so too are the **balance of plants** and **service availability.**
- » Countries with different national contexts have acknowledged green hydrogen as a key part of COVID-19 recovery plans, illustrated by the momentum in Europe, with the European Commission announcing a **new Hydrogen strategy** in July 2020.
- » The industry needs to co-ordinate in the most efficient way to utilise funding schemes.
- » Ensuring **balance of stacks** and partnering with **engineering, procurement and construction (EPC) companies** with the right know-how are crucial.
- » The industry's greatest challenge is bringing down costs and making them cost-competitive with fossil fuels. To achieve this, **standardising commodities** is key.

SCENE SETTING

The second panel was opened by **Michele Azalbert**, Chief Executive Officer, Hydrogen Business Unit at Engie, representing the Hydrogen Council, the partner organisation for this session. The opening remarks focused on how ammonia and e-fuels could be used to decarbonise the future energy sector and how these power fuels could be produced from green hydrogen, with case illustrations from real projects. The presentation also highlighted the key activities of the Hydrogen Council in supporting the development of the sector.

PANEL II: AMMONIA AND OTHER E-FUELS

E-fuels – whether hydrogen-based fuels obtained from syngas; derived through biomass gasification or by synthesising green hydrogen with a source of carbon (carbon monoxide and CO₂ captured from emission streams, biogenic sources or directly from the air); or derived with nitrogen (in the case of ammonia) – represent an attractive direct replacement of their fossil fuel-based counterparts. This is particularly relevant for applications that are hard to electrify, for example shipping and aviation.

The storage, distribution and consumption of e-fuels are possible with existing infrastructure, without the need for adaptation. But according to IRENA's analysis, the production costs of green ammonia, green methanol and synthetic oil products are two to three times higher than those of fossil-based products. To realise the benefits of e-fuels, challenges need to be overcome including high electrolyser costs and the need for a cheap and clean carbon source.

This session discussed the key challenges of ammonia and e-fuel production, as well as the main barriers to scaling up their production. The panel was moderated by **Fernando Gomez**, Head, Chemical and Advanced Materials Industry, World Economic Forum, and the following panellists joined the discussion:

- » **Badr Ikken**, Director General, Research Institute for Solar Energy and Renewable Energy (IRESEN), Morocco
- » **Kilian Crone**, Team Lead, International Cooperation Hydrogen and Powerfuels, German Energy Agency (DENA)
- » **Karan Bagga**, Chief Engineer, Thyssenkrupp Green Hydrogen & Chemicals Technology
- » **Dan Feldman**, Partner, Shearman & Sterling LLP.

Highlights from the discussion:

- » **Ammonia** is used today mainly for **fertiliser** production (80-90%), but in the future it could be used for **electricity generation** (co-generation or in coal power plants) or **mobility** (via fuel cells).
- » **E-fuels** will be useful mainly to fully **decarbonise the transport sector**, including shipping, aviation, rail and freight transport.
- » Countries are working together to build hydrogen and hydrogen-based fuel markets; however, **investment and the elaboration of the required supporting schemes** are required to unlock the full potential of renewable hydrogen, ammonia and e-fuels.
- » As an example, countries like **Morocco have plans to become front-runners in exporting hydrogen and its derivatives, while replacing imports of hydrogen-based commodities such as ammonia**, and plan to develop a technological ecosystem based on green molecules.

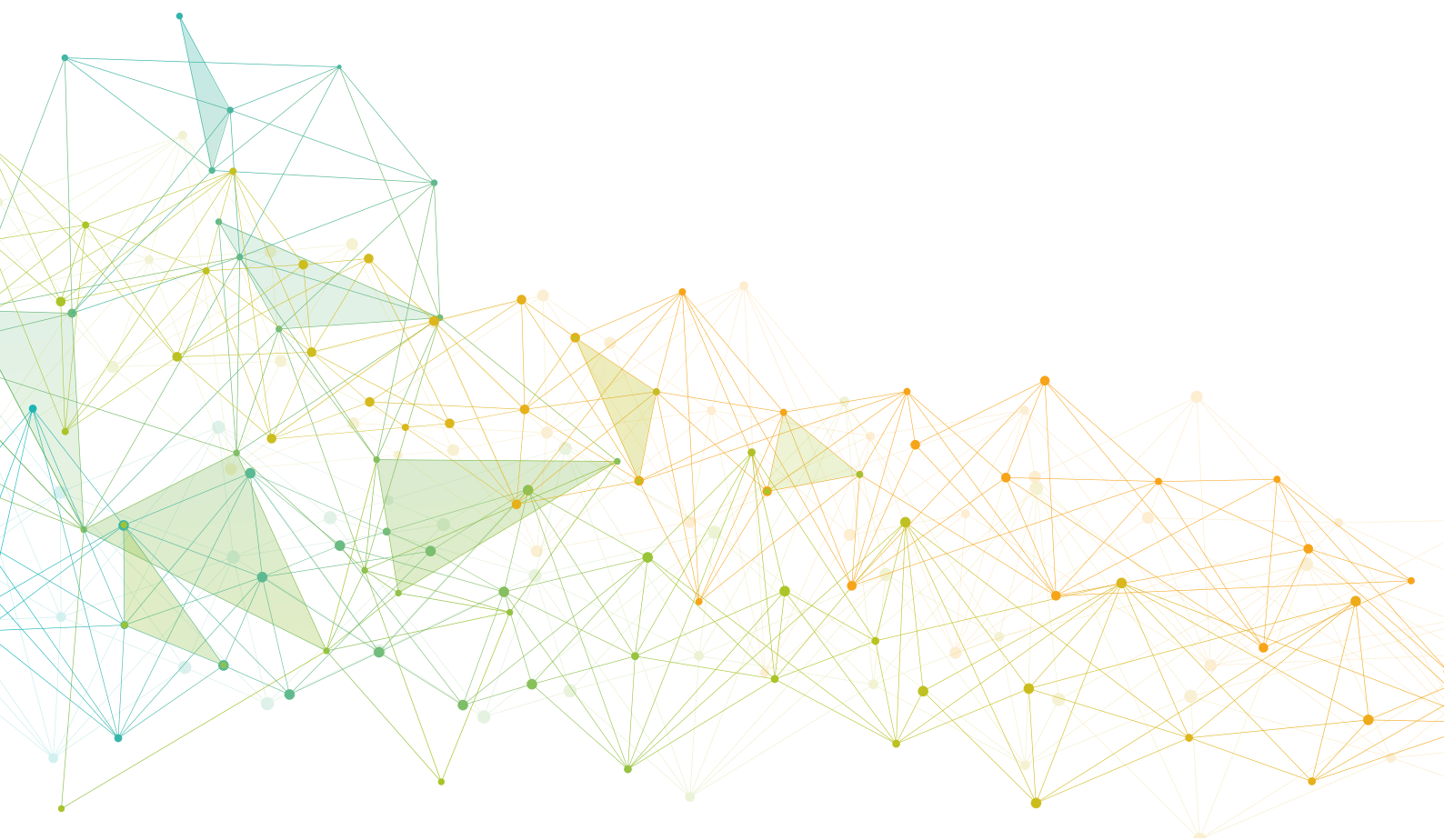
- » One of the main challenges in ammonia and e-fuel production is that while electrolyzers can deal with the variability of solar and wind (at a cost), chemical synthesis processes cannot do this. The challenge can be mitigated by **integrated design from power to electrolysis and then to chemical synthesis**. By optimising in this way, the whole system costs can be minimised.
- » Another key element in e-fuel production is a **green definition based on the entire chain's carbon content and certification**, especially after hydrogen production. There is a need for additional green electricity for producing ammonia (*i.e.*, powering the Haber-Bosch synthesis), to compress or liquify hydrogen for transport, to power direct-air-capture facilities where carbon is required, etc. There is no consensus on the need for this electricity to be renewable to be able to call the hydrogen green, and this needs to be addressed to create a global market.
- » **The absence of a liquid market for hydrogen and its derivatives**, such as ammonia, poses a significant offtake risk that requires underwriting (for example: What if an off-taker goes bankrupt? Who will buy the product and at which price?). However, there is a **global market for methanol**, which limits the power of policies and regulations in providing a green premium for green methanol, as it is a tradeable commodity that competes in a global market (currently in the absence of a global carbon price). Nevertheless, ensuring long-term off-takers for hydrogen-based commodities is essential.

CLOSING REMARKS

Roland Roesch from IRENA summarised the discussion into the following key messages:

- » **Electrolyser sizes are increasing, which can lead to a decrease in the total system cost due to economies of scale. But for further scale up, the standardisation of processes, materials and system elements is equally critical.**
- » **National strategies** with ambitious targets and clear pathways, complemented by collaborative platforms such as the **IRENA Collaborative Framework on Hydrogen**, are key to bringing public and private investments, priorities and activities together to act in a concerted fashion.
- » **The integrated design of e-fuel production processes could mitigate the variability of renewables** and minimise the cost of ammonia or methanol.
- » **The absence of a liquid market for hydrogen and its derivatives poses a significant offtake risk** that requires underwriting.

SESSION 4 SUMMARY: GROWING THE BIO-ECONOMY – SOLUTIONS FOR THE SUSTAINABLE SUPPLY OF BIOMASS AND BIOFUELS

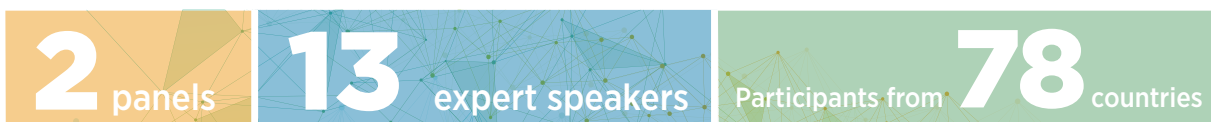


ORGANISED IN PARTNERSHIP WITH THE GLOBAL BIOENERGY PARTNERSHIP



SESSION OVERVIEW

The panellists, brought together from across the globe, engaged in an interactive, in-depth discussion that showcased best practices and innovative approaches to secure sustainable biomass and to turn it into valuable feedstocks indispensable for the decarbonisation of the transport and industry sectors. The panel also discussed new and emerging approaches to maximise biomass value streams through co-processing and co-production in biorefineries or in the biomass industry cluster as innovative solutions towards the bio-based economy. A key question explored by the panels was how these experiences can be replicated and further expanded at scale in a sustainable fashion to make extensive use of modern bioenergy potential as alternatives for fossil-based feedstocks and fuels in order to make zero emissions a reality.



SUMMARY OF KEY INSIGHTS

- » **Bioenergy has a key part in the energy transition and is expected to play an expanded role in the decarbonisation of hard-to-abate sectors. Technologies are developing rapidly and have significant potential to scale up by 2050.**
- » **Confidence in the sustainability of biomass is a key requirement for its contribution to energy and environmental objectives, its widespread use, its public acceptance and investors' confidence.**
- » **A holistic approach is key to maximising synergies across the entire biomass value chain (land use, agriculture, forestry, processing, conversion, waste streams and end use), and biomass use for the industry and transport sectors should be seen in the context of the entire bioeconomy.**
- » **Supportive policy and regulatory frameworks are key to scaling up the deployment of bioenergy.**

SCENE SETTING

Maria Michela Morese, Executive Secretary, Global Bioenergy Partnership, opened Session 4 by presenting the key role of bioenergy in decarbonising the economy. Bioenergy presents excellent opportunities but is not without challenges. It should not be looked at in isolation, as increasing demand brings pressure on natural resources. Sustainable bioenergy and the integration of biomass conversion through innovative approaches need to be considered as part of the broader bioeconomy, which makes it possible to create synergies and trade-offs between different demands of biomass. The sustainability indicators are a tool that provides guidance and informs policies for further deployment of bioenergy and decarbonisation of the industry and transport sectors.

Toshimasa Masuyama, Bioenergy Analyst, IRENA, provided a scene-setting presentation with the objective of highlighting the essential role of bioenergy in decarbonising the industry and transport sectors, based on the key findings of IRENA's [Global Renewables Outlook 2020](#) and [Reaching Zero with Renewables](#) reports. In IRENA's Paris-compliant scenario, a dramatic expansion of biomass supply is expected not only to displace fossil energy but also to substitute fossil-based hydrocarbon feedstocks. Effective bioenergy policies would drive bioenergy deployment by creating an enabling environment for investments and encouraging off-takers. Notably, the real benefits of using bioenergy go beyond the decarbonisation spectrum, as bioenergy use provides externalities such as rural development, farming and forestry practice improvement, waste management, job creation, etc.

PANEL I: SCALING UP BIOMASS FEEDSTOCK PRODUCTION FOR THE TRANSPORT AND INDUSTRY SECTORS

The first panel discussion provided an overview of strategies for diversifying biomass feedstock production and outlined key challenges for its scale-up, as well as solutions to overcome these challenges based on experiences and innovative approaches from different regions. The discussion was moderated by **Gerard J. Ostheimer**, Chief Sustainability Officer for the Global Bio-future Solutions, and leading experts were brought together from four regions: Africa, Europe, Latin America and North America. The following expert panellists joined the discussion:

- » **Rainer Janssen**, Managing Director Projects, WIP Renewable Energies
- » **Phosiso Sola**, Scientist, World Agroforestry Centre (ICRAF)
- » **Carolina Grassi**, Business Development Lead – Latin America & Sector Lead – Ground Transport Roundtable on Sustainable Biomaterials
- » **Keith Kline**, Distinguished Researcher, Environmental Sciences, Oak Ridge National Laboratory, US Department of Energy.

Highlights from the discussion:

- » **Bioenergy has strong synergies with land management, forestry and agriculture. Exploiting these synergies can have wider benefits for the economy, society and environment.** This aspect was highlighted by three speakers:
 - › Rainer Janssen presented two EU-based projects, funded under the EU Horizon2020 programme, which assessed the sustainable bioenergy production potential on “MUC (Marginal, Underutilised and Contaminated) lands” in Europe at a local and site-specific level. The projects’ innovative approaches showed that bioenergy feedstock production could be a remedy for bringing MUC lands back to productive use, and that this doubles the positive impacts of bioenergy.
 - › Phosiso Sola shared her experience in the Kenyan context, where the eradication of an invasive plant species could be done by converting it into biomass feedstock. This is good example of how bioenergy could be expanded in ways that would bring positive synergies with agriculture and pastoralism. However, the interaction of technology with society is fundamental. Key challenges hindering the success of this approach are the lack of community acceptance, engagement and understanding of its beneficial effects and consequently the lack of demand.
 - › Carolina Grassi presented energy cane as an example of how improved species can create synergies in the ecosystem. Energy cane not only offers higher energy yield, but its root also helps to increase carbon sequestration and improve soil stability.
- » **Certification is key to ensuring sustainability.** As highlighted by Carolina Grassi, sustainability schemes should be strengthened with the implementation of internationally recognised certification mechanisms, based on clear indicators and principles.
- » **Having a holistic approach is key to scaling up biomass feedstock production.** As highlighted by Keith Kline, feedstock production improves ecosystem services and food security. However, priorities for the achievement of a successful synergy include: systematic monitoring and analysis to support adaptive management, stakeholder engagement from the beginning and throughout the whole value chain, and the creation of a market for biomass and bioenergy

feedstocks. Potential synergies could be further explored to address emerging challenges such as increasing risks of forest fires and insect infestation. In this context, the complexity around the sustainability of biomass industry in the face of rampant wildfires across the globe was also addressed in the following panel discussion.

PANEL II: INNOVATIVE SOLUTIONS FOR MAXIMISING BIOMASS VALUE STREAMS

The second panel showcased innovative technologies and approaches to maximise biomass value streams while ensuring the sustainable production of biomass for its applications. The panel was moderated by **Bharadwaj Kummamuru**, Executive Director, World Bioenergy Association, and leading experts were brought together from four regions: Asia, Europe, Oceania and North America. The following expert panellists joined the discussion:

- » **Henrik Brodin**, Strategic Business Development Manager, Södra
- » **Timothy Ong**, Senior Vice-President, Agensi Inovasi Malaysia
- » **Geoffrey Bell**, Chief Executive Officer, Microbiogen
- » **James Spaeth**, Programme Manager, Bioenergy Technologies Office, US Department of Energy.

Highlights from the discussion:

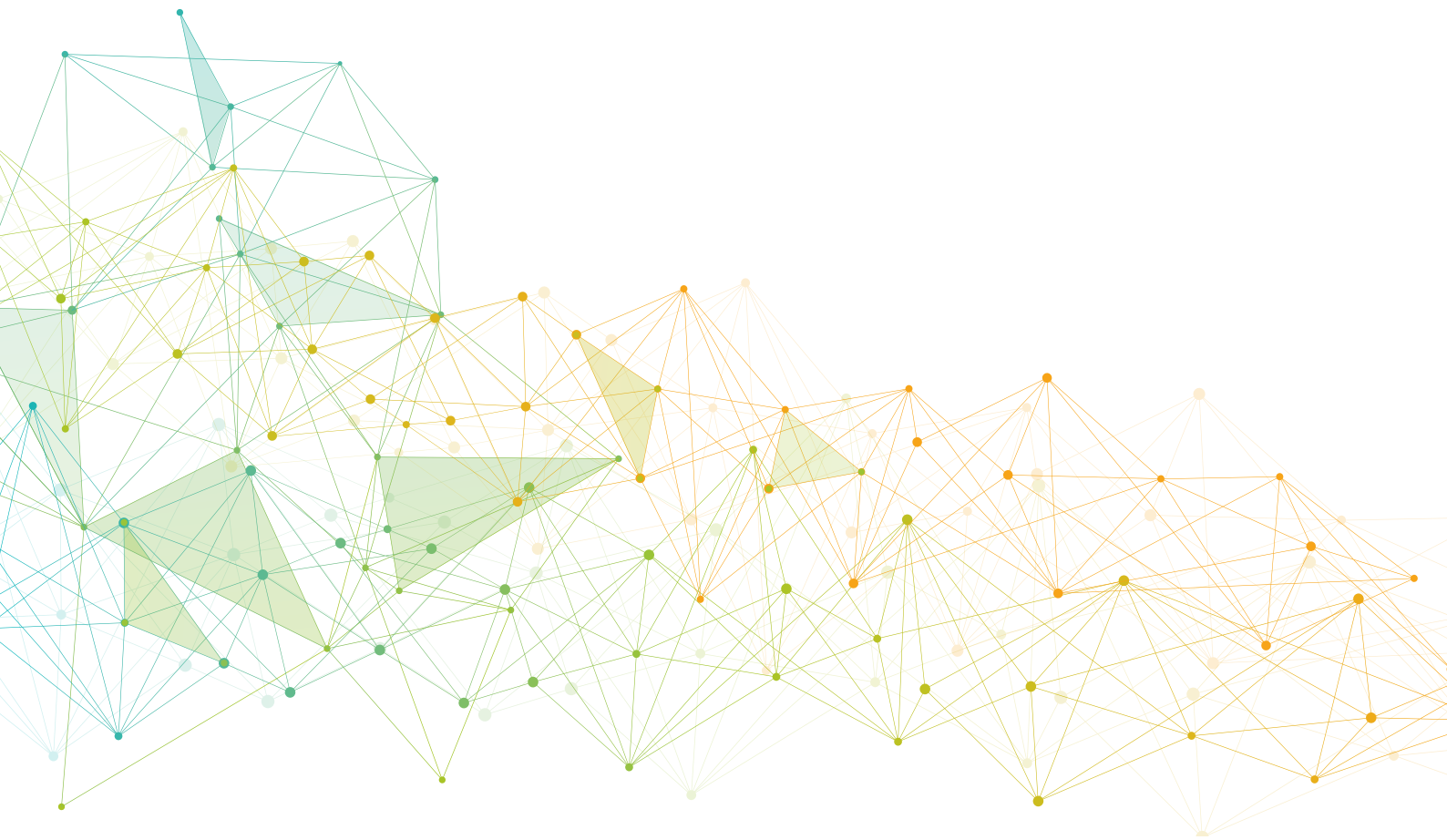
- » **Innovative technology provides value-added to biomass and enhances sustainability.** Henrik Brodin presented how the innovative technology created a new biomass value stream by upgrading pulp mill residues to useful bioenergy. The mission is to create more value by maximising the use of biomass, which can only be achieved through innovations. Such innovation increases the sustainability of final products together with a sustainably managed biomass supply. A financial support mechanism such as a carbon tax would enhance the economic competitiveness of biomass products and keep innovation moving forward.
- » **A circular bioeconomy creates synergies in the entire biomass value chain.** In this context, Timothy Ong presented the bio-hub concept in Malaysia where all stakeholders in the ecosystem from downstream to upstream are brought together to create a symbiotic relationship. This innovative approach gives greater flexibility and dynamism that can diversify biomass feedstock, applicable technologies and products. It thus eventually creates multiple biomass value streams throughout the entire ecosystem. The government plays a role in providing the platform with a strategy covering different aspects such as economy, society and environment.
- » **An innovative approach for the scale-up of biomass includes taking established knowledge and applying it in the context of new technology applications.** Geoffrey Bell outlined two innovative approaches for biomass application technologies in the Australian context: the use of next-generation biocatalysts for second-generation biofuels and the use of lignin as a metallurgical coal replacement. These applications both showed higher revenues, as well as successful replacement of conventional resources and improvements in sustainability. Lignin from biomass wastes at an ethanol biorefinery could provide an opportunity for maximising the value of biomass and present a good example of the bioeconomy approach.
- » **Several biomass feedstocks are available, besides traditional ones, and their production must be handled sustainably and used accordingly.** As pointed out by James Spaeth, each type of biomass feedstock has different characteristics. The biorefinery concept is thus critical for maximising the use of biomass by diversifying both biomass feedstock and products. Biotechnology has been a tremendous source of propelling the development of new biomass value chains.

CLOSING REMARKS

The closing remarks were delivered by **Paul Durrant**, Head of End-use Sectors and Bioenergy at IRENA. He welcomed the session's discussions, the complementarity of the two panels and the insightful interventions from the distinguished speakers. The discussions were summarised by reiterating:

- » the indispensable role of biomass and bioenergy in delivering deep decarbonisation goals,
- » the proven ability to sustainably source biomass if managed and monitored carefully,
- » the broader benefits of a holistic approach where bioenergy is seen in the context of the bio-economy and
- » the growing range of innovative solutions that can support the decarbonisation of all sectors of the economy.

SESSION 5 SUMMARY: RENEWABLE SOLUTIONS FOR INDUSTRY SECTOR TRANSFORMATION



ORGANISED IN PARTNERSHIP WITH THE MISSION POSSIBLE PLATFORM



SESSION OVERVIEW

This session explored the most promising technology-driven systemic innovations for four industrial sub-sectors that together produce more than 85% of energy and process-related emissions and account for over two-thirds of all industrial energy use. Focusing on the **iron and steel (Panel I)**, **cement and lime (Panel II)** and **chemical and petrochemical (Panel III)** sectors, experts showed what is possible now and explored how to accelerate the development and dissemination of innovative solutions based on key technological options: 1) electrification with renewable energy, 2) the use of green hydrogen and 3) the use of biomass.



SUMMARY OF KEY INSIGHTS

- » **Realising a renewable-based strategy to decarbonise industrial sectors is feasible by mid-century.** Technologies and financial resources are available, and key public and private stakeholders are increasingly aware of the need to act in a concerted way to make the energy transition in the industry sector happen by mid-century.
- » **Several technological pathways need to be pursued in parallel to decarbonise the industrial sectors, combining conventional and innovative approaches.** For each sector there is not only one low-emission technology available, but several ones, and only a combination of these options, chosen and applied according to local specificities, can enable the scale-up and the energy transition in the industry sector. By accounting for around half of the economic emission abatement potential in the “hard-to-abate” industry sub-sectors, renewables could play a more important role than previously estimated.
- » **The development of ambitious and long-term joint industry and government plans, the alignment of policies across countries and new regulatory frameworks are critical to support the energy transition in the industry sector.** Current policies and regulations are not incentivising new low-emission processes and are often biased towards existent technologies, preventing competition and innovation. Industry experts identified a global level playing field, with a global and transparent CO₂ accounting and pricing mechanism, as a key objective.
- » **The costs of new low- or zero emission technologies are higher than those they seek to replace, which makes investments difficult to justify from a pure economic point of view.** However, support for RD&D and early deployment projects and measures to incentivise early demand for green products could help the scaling-up of these technologies, making them cheaper than and more competitive with conventional ones.
- » **New low-emission technologies require new infrastructure to support the industry from production to distribution.** Investment needs to begin now to make sure that infrastructure is ready at the right time and that confidence is built ahead to drive the demand for low- or no-carbon products. **Industry experts highlighted that the COVID-19 pandemic creates additional challenges but also an opportunity to build back better.**

SCENE SETTING

In his welcoming remarks, **Dolf Gielen**, Director of the IRENA Innovation and Technology Centre, highlighted that while the need to accelerate the energy transition five-fold is clear, the path to get there for the industry and transport sectors is not.

Via video, **H.E. Andreas Feicht**, State Secretary for Energy at the Federal Ministry for Economic Affairs and Energy, Germany, provided an overview of Germany's ambitious green hydrogen strategy, which is key to decarbonise hard-to-electrify sectors and to reach carbon neutrality in Germany by 2050. Making hydrogen cost-competitive by ramping up production and intensifying international co-operation to develop international supply chains lie at the heart of this strategy.

In his scene-setting presentation, **Anthony Hobley**, Executive Director of the Mission Possible Platform, World Economic Forum, highlighted that the COVID-19 pandemic is a unique opportunity for a great reset towards resilient and sustainable societies achievable through *ambition* from the private sector, *action* to implement it and *alignment* across global initiatives, including governments, banks and institutional investors, as well as industry and end consumers.

Claire O'Neill, Managing Director, Climate & Energy, World Business Council for Sustainable Development, underlined three key requirements: 1) clear policy support; 2) innovation in financial and contractual arrangements (for example, auctions); and 3) integration of value chains and infrastructure (pipelines, transmission lines, etc.).

Paul Durrant, Head of End-use Sectors and Bioenergy at the IRENA Innovation and Technology Centre, provided an overview of IRENA's recent [Reaching Zero with Renewables](#) report, which indicates that reaching a deeper decarbonisation by 2060, particularly in industry and transport, requires a change of mindset to focus on those few options that are consistent with reaching zero emissions. Achieving deep decarbonisation in the seven "hard-to-abate" sectors can be achieved through a combination of:

- 1) Reduced demand and improved efficiency (circular economy)
- 2) Direct use of clean, predominantly renewable electricity
- 3) Direct use of renewable heat and biomass
- 4) Indirect use of clean electricity via synthetic fuels and feedstocks
- 5) Use of CO₂ removal measures (with lower potential than other estimates).

PANEL I: SOLUTIONS TO DECARBONISE THE IRON AND STEEL SECTOR

This panel focused on the cutting-edge technologies that address the decarbonisation of iron and steel-making processes. Two key innovative technologies are promising to be game changers for this sub-sector, when paired with renewables: 1) hydrogen-based direct reduced iron (DRI) and 2) smelting reduction for iron and steel-making. The panel was moderated by **Faustine Delasalle**, Director, Energy Transitions Commission. The following panellists joined the discussion:

- » **Yoon-Gih Ahn**, Senior Vice President, Management Consulting Center, POSRI (POSCO Research Institute), who provided the insights after the session due to an unstable connection
- » **Åsa Ekdahl**, Head of Environment and Climate Change, World Steel Association
- » **Andreas Regnell**, Chairman of the Board of HYBRIT, Vattenfall.

Highlights from the discussion:

- » **A small number of options exist to decarbonise the iron and steel sector.** Among the most promising technological pathways is hydrogen-based DRI and electric arc furnace-based steel production. However, other technologies such as the use of biomass and hydrogen; carbon capture, utilisation and storage (CCUS) as well as direct use of electricity through electrolyzers could play a role, perhaps in combination. The appropriateness of specific technologies will depend on the region and sites.
- » **CCUS will play a role for the iron and steel sector, but likely only a limited one as blast furnaces are gradually replaced with DRI and electric arc furnaces.** Capturing and storing process CO₂ emissions is a pathway being considered, which can be combined with renewables for energy supply. However, in the long term most of the blast furnaces will be phased out, so CCUS is an intermediary solution. A carbon capture and storage (CCS) project in Norway that ships captured CO₂ can serve as an example that innovation on infrastructure goes beyond the physical infrastructure and can shape the overall energy system.
- » **Outside China, half of the primary steel capacity will reach the end of its investment cycle in the next 10-15 years,** which creates a window of opportunity that requires fast and concise actions. The HYBRIT project in Sweden provides an example of actions that can be replicated elsewhere (innovative background, access to reliable and low-cost renewable electricity and government support).
- » **A global level playing field is required for low-carbon steel to take off.** Currently, steel is traded on a global market with high competition and low margins. Low-carbon steel costs 20-100% more than conventional steel. For low-carbon steel production to become competitive and be further commercialised, a market must be created for these technologies. Policy instruments, such as increasing the CO₂ price in Europe, or government support at early stages to reduce investment risks (for example, through public procurement), as well as global and transparent tools to quantify and price CO₂ footprints, would help. A transparent and international agreement would be needed, and a clear policy signal is lacking today.
- » **Long-term plans and infrastructure investments are key enablers.** A concrete and long-term national climate policy is crucial, as the changes implemented today will take decades to have effects. The complexity of this sector requires partnerships and the involvement of different stakeholders. Required infrastructure includes the supply of reliable renewable electricity, storage capacity and pipelines. As the market currently lacks sufficient incentives for decarbonisation, governments will need a clear and consensual plan, at both the national and international levels.

PANEL II: SOLUTIONS TO DECARBONISE THE CEMENT AND LIME SECTOR

This panel, which focused on the cutting-edge technologies available to reduce carbon emissions in cement and lime manufacturing, was moderated by **Jim Rushworth**, Industrial Policy Director, CEMBUREAU. The following panellists joined the discussion:

- » **Kiran Ananth**, Principal Counsellor, Confederation of Indian Industry – Godrej Green Business Centre
- » **Rob van der Meer**, Director EU Public Affairs, Heidelberg Cement
- » **Davide Zampini**, Head of Global R&D, CEMEX.

Highlights from the discussion:

- » **Several technological pathways need to be pursued in parallel to decarbonise the cement and lime sector, combining conventional and innovative approaches.** In addition to bottom-up company strategies, CEMBUREAU's 2050 Roadmap sets out the European pathway to climate neutrality by 2050 down the cement and concrete value chain, thanks to *alternative raw materials* (use of decarbonated waste materials to replace limestone), *fuel switching to renewables* (a combination of electrification of calcination, use of solar energy, plasma burners, hydrogen and the use of biomass and waste), *energy efficiency* improvements in kilns and ancillary processes, *partial substitution of clinker* in cement and cement in concrete, *capturing and storing CO₂ emissions* (apply CCUS to abate remaining fuel and process emissions; use biomass with CCS (BECCS) to produce negative emissions that can offset some uncaptured clinker emissions), and *recarbonation* in the built environment and through recycled concrete, among others.
- » **Incumbents are investing in RD&D projects, in addition to collaborating with start-ups to find innovative solutions.** Both Heidelberg Cement and CEMEX are intensively working on common projects and fronts such as the LEILAC initiative (direct separation of process emissions) and amines. Among the specific pilot projects mentioned were CEMEX's co-operation with Energy Vault (gravity and kinetic energy-based storage), Synhelion (solar-driven process) and clinker-free chemical activated materials, and Heidelberg Cement's Oxyfuel, micro-algae, hydrogen and kiln electrification projects, which are at different RD&D stages. Other projects in Austria, Denmark, India and Norway also featured prominently.
- » **Valorisation of CO₂ is needed for further deployment of CCS and carbon capture and utilisation (CCU) technologies and will enable the establishment of a broader carbon circular economy.** While the European industry targets climate neutrality by 2050, India, the world's second largest cement producer, aims to reduce its greenhouse gas emissions 45% by 2050, compared to 2010. A regulatory or market driver such as an emissions trading scheme would be needed in India to pursue CCS, which is a key lever in achieving the country's 45% emission intensity reduction target by 2050. In Europe, a key challenge is the lack of incentives to use captured CO₂ (CCU), beyond incentivising CCS. Notably, using captured CO₂ in ways that result in it eventually being released is not consistent with a zero emission goal.
- » **While decarbonisation is technically feasible, policy, regulation, infrastructure investment and the demand side of the market will be the key driving forces.** Although the available conventional and innovative technological pathways face challenges, experts expressed confidence that these can be managed. However, the key decarbonisation challenge is the absence of (or in the presence of low) CO₂ prices, low returns on investments, lack of infrastructure as well as lack of financial and regulatory measures. Creating a level playing field and providing infrastructure for production, supply and transport of waste materials, recycled concrete and access to renewable electricity will therefore be key.

PANEL III: SOLUTIONS TO DECARBONISE THE CHEMICAL AND PETROCHEMICAL SECTOR

This panel focused on the cutting-edge technologies available to reduce fossil carbon intensity in the chemical and petrochemical sector. The panel was moderated by **Değer Saygın**, Director, SHURA Energy Transition Center, and the following panellists joined the discussion:

- » **Florian Ausfelder**, Head of Energy and Climate, Dechema
- » **Eelco Dekker**, Chief EU Representative, Methanol Institute
- » **Babette Pettersen**, Vice-President Europe, Lanzatech.

Highlights from the discussion:

- » **The chemical industry has a vital role to play in the climate discussion.** Besides being one of the largest CO₂-emitting sectors, it also has a large portion of hydrocarbon feedstock, and options for its decarbonisation are limited. Indeed, the decarbonisation of the chemical sector is complex and could follow different pathways. However, the focus should not be solely on the production side, but a life-cycle approach is needed to capture all CO₂ emissions and to offer a full portfolio of mitigation opportunities. The term “decarbonisation” risks being misleading in the chemical sector context because “carbon” is an essential element for chemicals. Decarbonisation needs to be understood to refer to the avoidance of CO₂ emissions into the atmosphere.
- » **A range of solutions are needed to move away from fossil-based chemicals.** For both energy and feedstock, a switch to green hydrogen and biomass would be required; however, the circular carbon economy also plays a key role, especially in the context of plastics recycling. All solutions should be considered, rather than focusing on a few technologies. In addition, a mix of conventional and innovative pathways is needed for the transition. Markets beyond the chemical industry (for example, transport) for chemicals produced from new routes can play an important role to help commercialisation.
- » **Price is a decisive factor determining whether new chemical processes can compete with CO₂-rich processes.** New chemical production routes are more costly than conventional ones, but CO₂-free chemical production is possible with existing technologies. However, the potential of low-emission technologies can be realised only if the necessary infrastructure exists and pioneering work is incentivised. Currently, costs are not well distributed across the entire value chain, and transferring them would help increase the competitiveness of new and cleaner alternatives. Such distribution needs to be viewed through potential regional implications for decarbonisation.
- » **A collaborative effort is needed across the sector.** Individual companies cannot transform the chemical industry on their own, and partnerships among actors across the value chain are key to overcome obstacles and challenges from production to final consumption. These can be through alliances, in the form of public-private partnerships, bilateral projects, as well through the involvement of private sector financing earlier in the value chain.
- » **Governments should create an enabling regulatory and legislative framework for new low-carbon solutions in the chemical sector.** A general lack of regulatory and supporting schemes is found in the chemical sector, unlike in the transport and fuel sectors. Lessons from other sectors can serve as a good basis.

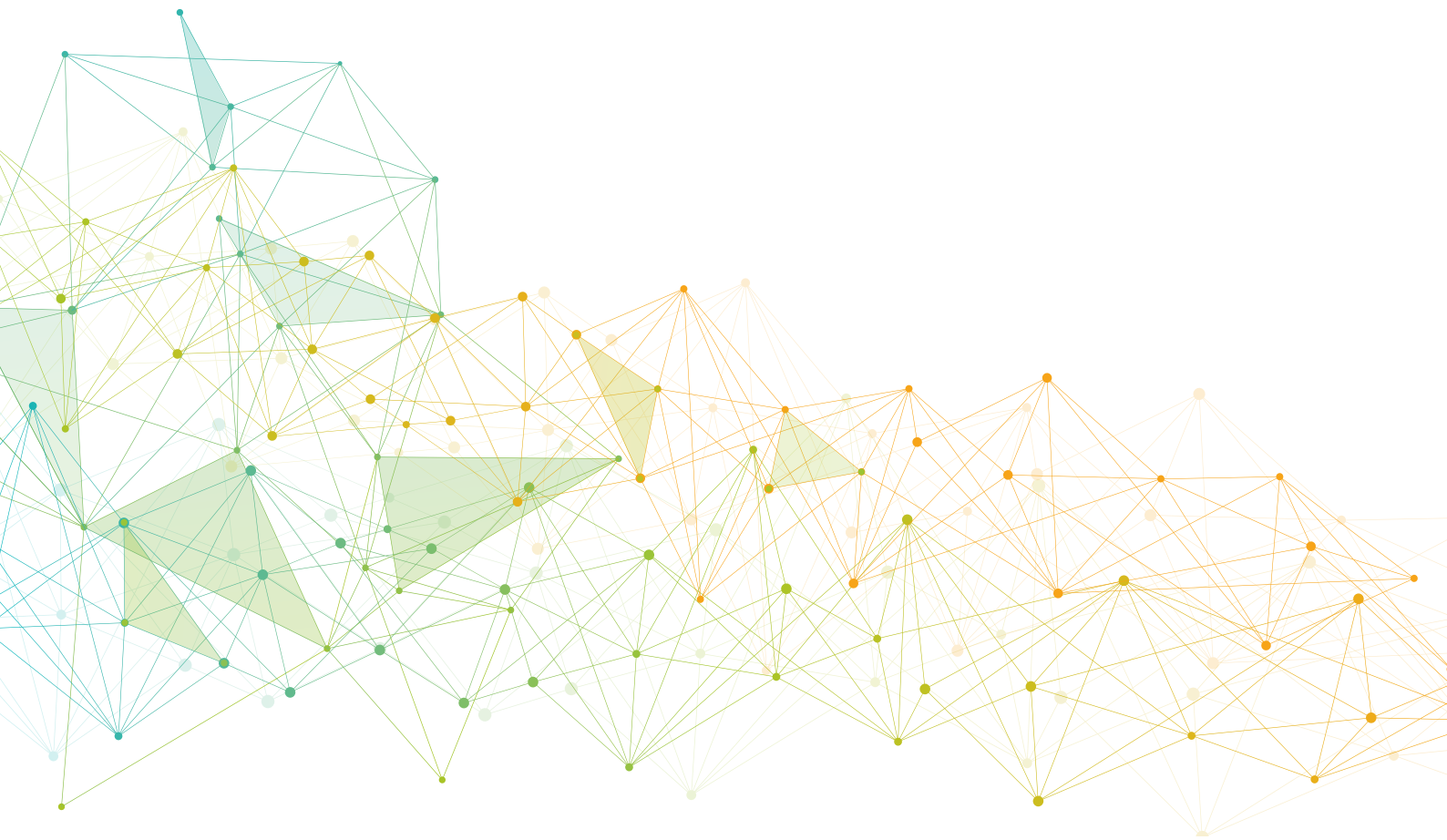
- » **A proper carbon accounting mechanism would enable synergies between the chemical sector and other industry sectors.** Most of the alternative pathways need CO₂ as a raw material, which could be sourced from other carbon-intensive industries such as the iron and steel and cement and lime sectors. Balanced carbon credit allocation would encourage the recycling of CO₂ in the broader industry ecosystem. Measures to avoiding product use or end-of life emission would still be needed to be consistent with a zero emission goal.

CLOSING REMARKS

The closing remarks were delivered by **Dolf Gielen**, Director of the IRENA Innovation and Technology Centre. He welcomed the three sessions' discussions and all speakers' interventions. He summarised the discussions as follows:

- » **Learn from the power sector and consider deep decarbonisation** or even zero carbon by mid-century, which is different than emission-halving strategies. Currently, the industry does not have the incentive to shift towards low-carbon products, and those companies that do are undertaking this on a voluntary basis.
- » **Consider the combination of various emission abatement strategies in an integrated manner.** The falling cost of renewable power is changing the paradigm. So far, renewable solutions in the industry sector have been underestimated. System coupling implications must therefore be considered for green hydrogen and renewable electricity supply, which have emerged as key solutions in recent years. Energy efficiency and circular economy concepts, direct and indirect electrification, and biomass energy and feedstock use all have a role to play. CCUS will have a role, too, but less than anticipated previously. (With a few exceptions, it will be mainly an intermediate solution to be used in existing plants until their infrastructure is upgraded or replaced.)
- » **Provide a long-term plan for the development of a global market for low-carbon products.** Low-carbon solutions exist, but they often increase the production cost and hence the cost for end consumers. This is why a global market is needed, especially when product prices are set in a global market as is the case for steel products. Governments can create demand for low-carbon products via foresighted policies and public procurement as a tool (for example, innovation in contractual arrangements). Setting global and transparent CO₂ accounting and pricing methods would allow the creation of a level playing field. A carbon tax adjustment would require further international debate since it impacts current trade arrangements under the World Trade Organization.
- » **Learn from lighthouse projects.** Pilot projects such as HYBRIT illustrate the key ingredients for success: an innovative climate with supporting government, assets that are already approaching the end of their life cycle and reliable access to clean electricity at a low price.
- » **Invest in infrastructure as a fundamental.** We need to produce, supply and transport CO₂, waste materials, recycled concrete and a reliable renewable energy supply.
- » **Adopt systemic thinking** by integrating the real economy with climate change action, for example by distributing the high costs of replacing existing plants across the entire value chain of the iron and steel industry or the chemical industry and by shifting perceptions of value from cost to environmental and social values.

SESSION 6 SUMMARY: TRANSFORMING TRANSPORT – INNOVATIVE RENEWABLE-BASED SOLUTIONS IN ROAD FREIGHT, SHIPPING AND AVIATION



ORGANISED IN PARTNERSHIP WITH THE INTERNATIONAL TRANSPORT FORUM



SESSION OVERVIEW

Electrification of end-use sectors with renewables will be a major component of plans to decarbonise industry and transport. This session, co-organised with the International Transport Forum, explored renewable-based solutions to achieve net-zero emissions in road freight transport, shipping and aviation. Experts discussed the key innovations that can help decarbonise these sub-sectors. The discussion focused on what must be done to accelerate innovation across different dimensions (for example, technical, political, regulatory, commercial) to accomplish the goal of transport decarbonisation by mid-century.

4 panels

24 expert speakers

Participants from 91 countries

SUMMARY OF KEY INSIGHTS

From a 2020 perspective, the decarbonisation efforts in the transport sector look completely different than they did five years ago.

- » **Progress on the uptake, cost competitiveness and performance of renewable energy options has triggered action in the sector and points towards significant additional demand for renewable energy.**
- » **The biggest challenge to decarbonise the transport sector is scalability.** Many technologies and renewable fuels are now available and have been tested; however, more demonstrations and small-scale deployment is needed.
- » **Another challenge is economics.** While technologies are available, they generally are far too expensive. The market alone will not bring down sufficiently the cost of sustainable transport solutions. Policy innovations such as carbon pricing, which alone will not suffice, are needed.
- » **Infrastructure is a critical issue**, although difficult to address. It needs to be placed ahead of the demand ramp-up, and some choices need to be made on fuel types to inform infrastructure decisions.
- » **A systemic view and cross-sector co-ordination – including a managed, planned, progressive approach – is key.** The whole sector needs to move broadly at the same time. While action is urgent, we cannot do everything at once. We are making progress, but delivery will take time. It is a gradual transition.

SCENE SETTING

Opening the session, **Roland Roesch**, Deputy Director of IRENA's Innovation and Technology Centre, highlighted the [Reaching Zero with Renewables](#) report that outlines the best available decarbonisation options for the key transport sectors, including reduced demand and improved efficiency, direct use of renewable energy, direct use of renewable heat and biomass, indirect use of clean electricity via hydrogen and synthetic fuels, and use of CO₂ removal measures.

Adding to this, **Jari Kauppila**, Head of Quantitative Policy Analysis and Foresight at the International Transport Forum (ITF), presented the actions of the ITF to decarbonise the transport sector, including all modes of transport. The different sectors need to come together and find a common solution. For urban travel, the zero pathway is clear. For short-distance travel, innovative mobility solutions and electrification are key. For long-distance transport the picture is not so clear, with various solutions such as hydrogen, biofuels, etc. Finding the right balance is key. Innovation is indispensable in these hard-to-abate sub-sectors.

PANEL I: DECARBONISING SHIPPING WITH RENEWABLES

The diverse panel of experts discussed the most promising and innovative technological pathways, as well as regulatory and market solutions, to achieve zero emissions in the shipping sector, including electrification, biofuels, green hydrogen, synthetic fuels and others. The panel was moderated by **Roland Roesch**, Deputy Director, IRENA Innovation and Technology Centre, and the following panellists joined the discussion:

- » **Anne Sophie Vinther Hansen**, Investment Manager, Vækstfonden
- » **Dirk Kronemeijer**, Chief Executive Officer, GoodFuels
- » **Jakob Steffensen**, Head of Innovation and Technology, DFDS
- » **Tristan Smith**, Lecturer, University College London
- » **Tue Johannessen**, Senior Innovation Portfolio Manager, Maersk.

Highlights from the discussion:

- » **In shipping, we need a full technology disconnect from the past.** We cannot decarbonise shipping with a stepwise approach to increasing energy efficiency. We need net-zero-emission fuels that must come into play by 2030.
- » **Short-distance vessels are the big exception.** For these vessels, the way forward is clear with battery-electric ships. Pilot projects already exist. The next challenge is ensuring charging infrastructure and power sector integration at the ports.
- » **The lowest-hanging fruits in long-distance shipping are biofuels, but their problem is availability and cost.** Some speakers highlighted the importance of implementing biofuel solutions to show that there is a demand for green shipping and to achieve immediate results. Others stressed that investment in more scalable solutions is needed.
- » **Synthetic fuels are the solution to decarbonise shipping at scale in the long term.** Ammonia and methanol are especially promising. Ammonia demonstrations must still be made, but the cost projections for the far future look most promising. Synthetic methanol is the next cheapest option, possibly 20-30% more expensive than ammonia. Methanol is already in use, although it is not “green”.
- » **The main challenges are cost (especially related to the fuel infrastructure), scalability, and customer demand.** More than ever, political courage is needed to put a significant price on carbon – for example, USD 20-30 per tonne rather than the proposed USD 0.6 per tonne – although this is difficult due to the international nature of shipping. Policy incentives must especially tackle the supply side of fuels. The cost of green shipping cannot be borne by export-dependent developing nations. Overall, the most essential prerequisite to decarbonise shipping might be growing customer demand for green shipping.

PANEL II: DECARBONISING AVIATION WITH RENEWABLES

A diverse panel of experts discussed the most promising and innovative technological pathways, as well as regulatory and market solutions, to achieve zero emissions in the aviation sector, including electrification, biofuels, green hydrogen, synthetic fuels and others. Panellists evaluated the decarbonisation potential of different options, identified their deployment challenges, weighed their pros and cons, and closed with their vision on which solutions are most likely to succeed. The panel was moderated by **Jagoda Egeland**, Advisor to the Secretary-General, International Transport Forum, and the following panellists joined the discussion:

- » **Glenn Llewellyn**, Vice President – Zero Emission Technologies, Airbus
- » **Hassan El-Houjeri**, Climate and Sustainability Technology Strategist, Aramco
- » **Jack Saddler**, Professor, University of British Columbia
- » **Oskar Meijerink**, Project Lead – Future Fuels, SkyNRG
- » **Valentin Batteiger**, Lead Alternative Fuels, Bauhaus Luftfahrt.

Highlights from the discussion:

- » **No silver bullet exists for eliminating the climate impact of aviation.** A series of solutions is needed. Fuel cell propulsion technology needs to be further developed. Hydrogen combustion is promising for short-distance aircraft. For long-distance aircraft (*i.e.*, flying over 2 000 to 3 000 nautical miles), synthetic fuels are most promising. New aircraft development is needed.
- » **The lowest-hanging fruits are drop-in biofuels, similar to shipping.** These can be used today; however, they are not scalable and will play only a marginal role in decarbonising aviation.
- » **In the short term, the most important policy measures to decrease the emissions of aviation is to switch from short-distance flights to land transport.** Other measures revolve around efficiency gains.
- » **Policy making should be cross-sectoral. As aviation is the hardest sector to decarbonise, other sectors should be decarbonised first.** Policies must be technologically agnostic and build on diversity and optionality. The high cost is a huge barrier that will be difficult to overcome in times of low oil prices. Broad societal action is needed. An interesting approach is to oblige airlines to grow only sustainably.
- » **The impact of COVID on aviation has been tremendous.** COVID should be seen as a caesura and an opportunity to rethink and fundamentally change aviation.

PANEL III: DECARBONISING ROAD FREIGHT TRANSPORT WITH RENEWABLES

A diverse panel of experts discussed the most promising and innovative technological pathways, as well as regulatory and market solutions, to achieve zero emissions in the road freight transport sector, including electrification, biofuels, green hydrogen, synthetic fuels and others. Panellists evaluated the decarbonisation potential of different options, identified their deployment challenges, weighed their pros and cons, and closed with their vision on which solution is most likely to succeed. The panel was moderated by **Francisco Boshell**, Analyst, IRENA Innovation and Technology Centre, and the following panellists joined the discussion:

- » **Angie Farrag-Thibault**, Project Lead for Clean Trucking, World Economic Forum
- » **Elisabeth Fretheim**, Head of Business Development, Nikola Motor
- » **Henrik Engdahl**, Chief Engineer Charging, Volvo
- » **Steven Nadel**, Executive Director, American Council for an Energy Efficient Economy.

Highlights from the discussion:

- » **For trucks, the technology options are not clear yet, and all options are needed and must co-exist.** Regulation and policy measures must trigger demand for green freight traffic.
- » **Two of the options for green freight vehicles are batteries with renewable energy – including charging via electric road system (ERS) – and green hydrogen.** Depending on the application case, the three distinctions are range, off-time and efficiency. Short-distance freight vehicles will likely use batteries, unless their use case does not allow for enough off-time for charging. For example, the refuelling of a fuel cell truck takes between 10 and 20 minutes, while the charging of a battery-electric truck can last between 8 hours (overnight charging) and 1 hour (fast-charging opportunity). Long-distance freight will likely be based on hydrogen. Uptake of hydrogen will occur especially after we have 100% renewable energy in the power sector – then efficiency of renewable energy will no longer be a crucial advantage of battery technology.
- » **Those technologies could co-exist for a long time, with different markets favouring different solutions.** Battery solutions for freight transport, including plug-in hybrid trucks and charging via ERS, could dominate in Europe, while hydrogen solutions could dominate in North America. Road electrification could be the decisive distinction.
- » **Policy makers should commit to lighthouse emission goals that enable all stakeholders – not just vehicle producers but also utilities and drivers – to plan and prepare.**
- » **The expansion of the power sector and smart charging play a crucial role.** The bottleneck is not primarily peak generation, as most vehicles will charge during off-peak times at night and there is plenty of generation capacity. The bottleneck will be the distribution system. Industry needs to understand that if a company needs to charge around 20 vehicles simultaneously (as a common example), they will need to co-ordinate this with the utility. Such an expansion of charging stations infrastructure may take between 5 to 10 years for development.
- » **Policy makers must engage in a collaborative effort to harmonise policies to help the market take off.** The private sector cannot solve the remaining problems alone. This is especially true for providing the charging infrastructure.

PANEL IV: IDENTIFYING CROSS-SECTORIAL SYNERGIES IN SHIPPING, AVIATION AND ROAD FREIGHT TRANSPORT

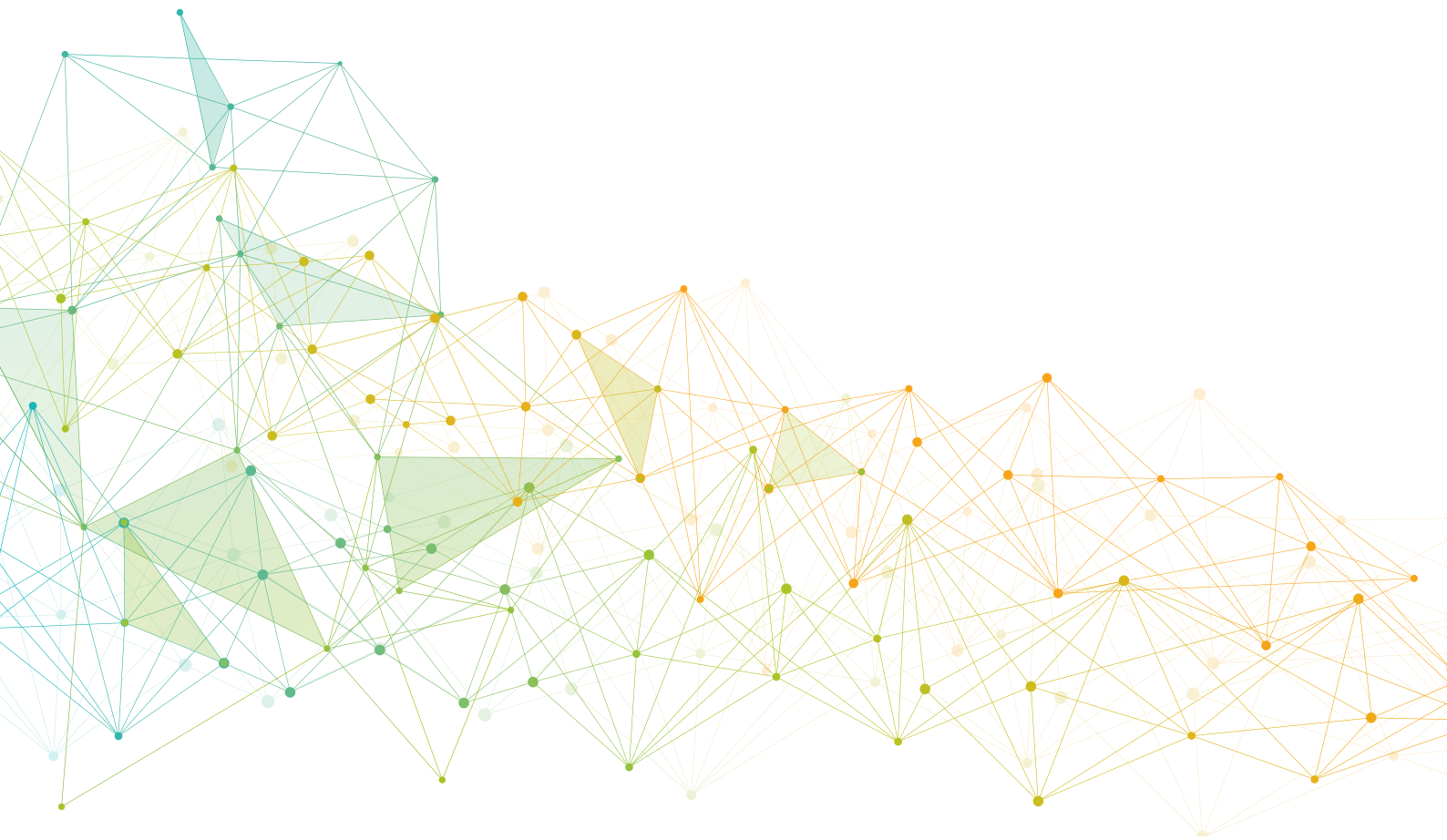
A panel of experts from different transport sub-sectors brought their own perspectives to discuss the necessary actions to enable the deployment of key renewable-based solutions in road freight, aviation and shipping, and to reach zero carbon emissions by mid-century. Among others, speakers from these sub-sectors explored and discussed options including innovative policy, technology, regulatory and market measures, as well as the potential of cross-sectoral co-operation as a means to build synergies, economies of scale and enable the complete decarbonisation of transport. **Pierpaolo Cazzola**, Advisor on Energy, Technology and Environmental Sustainability, International Transport Forum, moderated this panel with the following panellists:

- » **Christoph Wolff**, Head of Mobility, World Economic Forum
- » **Jane Hupe**, Deputy Director, Environment, Air Transport Bureau, International Civil Aviation Organization (pre-recorded)
- » **Mariette van Empel**, Director Sustainable Mobility, Ministry of Infrastructure and Water Management, the Netherlands
- » **Randall Krantz**, Senior Project Advisor, Getting to Zero Coalition, Global Maritime Forum.

Highlights from the discussion:

- » **Decarbonising transport requires improvements in three areas: legislation, regulation and markets. In these areas, we need action, co-operation and innovation.**
- » **A systemic view is key. Policy interventions must recognise the different sector preconditions for decarbonisation.** Policies must limit cannibalisation effects among sectors and use resources where they exert the greatest impact.
- » **The COVID pandemic may trigger a lasting behavioural change and has reinforced the joint understanding that system resilience is important.** COVID impacted aviation strongly but had less of an effect on heavy-duty trucks and shipping.
- » **There must be a policy mix of measures at the demand and supply side.**

SESSION 7 SUMMARY: IRENA YOUTH TALK - ENTREPRENEURSHIP AND INNOVATION FOR THE GREEN ENERGY AGENDA

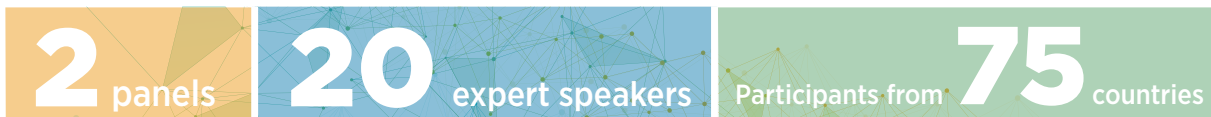


CO-ORGANISED BY INITIATE AND SDG 7 YOUTH CONSTITUENCY



SESSION OVERVIEW

The IRENA Youth Talk brought together young entrepreneurs and innovators in the renewable energy sector to share their ideas and to discuss the role of their solutions in the energy transition, including the challenges they are facing and how to overcome them. The session was divided between renewable solutions for the transport sector and renewable solutions for the industry and buildings sectors.



KEY INSIGHTS

- » **Youth can play an important role in transforming the energy sector** including transport, industry and buildings.
- » **Transport electrification makes a very good business case for investment.** The capital required is relatively low, whereas the utilisation is very high.
- » **E-mobility innovation is key in low- and middle-income countries, where the transport sector is the main polluting and the fastest growing sector.**
- » **Thinking and innovation are needed on how to make products accessible to everyone.**
- » **Young entrepreneurs can face many challenges** in making their ideas a reality – particularly a lack of access to financing. At the same time, young people possess many important assets that set them apart including the potential for creativity and going beyond existing paradigms, excellent digital know-how and large global networks.
- » **The experts advised young innovators on several key points:** the need to build their skills; to think big, while also looking for a business case; to be innovative, not just in terms of technologies but also financing; to collaborate and support one another; and most importantly, to not be afraid to fail, and to never give up.

PANEL I: RENEWABLE SOLUTIONS FOR TRANSPORT

The panel brought together young entrepreneurs and established experts in the transport sector. It provided a platform for entrepreneurs to showcase their innovation, which was then followed by a panel discussion on the role of youth in the transition and the challenges and opportunities to decarbonise the transport sector.

SCENE SETTING

Arina Anisie, Associate Programme Officer at IRENA, introduced the agency's work on innovation, emphasising the need for systemic innovation – meaning innovations in technologies – combined with innovations in business models, market design and system operation. IRENA mapped emerging innovations for wind and solar power integration in its [Innovation landscape report for a renewable powered future](#) and the [Innovation Toolbox](#).

As the cost of renewables-based electricity generation is falling, electrification is emerging as a key solution to decarbonising end-use energy sectors, including industry, buildings and transport. IRENA's analysis anticipates that the share of electricity in the transport sector would increase from just 1% at present to more than 40% in 2050. However, smart charging strategies are key for successful electrification of the transport sector.

INNOVATION SHOWCASE

Five innovation pitches were presented:

- » **Jedlix (Netherlands):** Jorg van Heebeen, Co-founder, presented Jedlix, which develops and operates a vehicle-to-grid integration (“VGI”) platform to optimise the charging and discharging of EVs and to facilitate their insertion into the power grid at scale.
- » **Ecobodaa (Kenya):** Kimosop Chepkoi founded Ecobodaa in order to build a zero emission, connected, reliable and efficient last-mile transport experience in Africa’s cities. Ecobodaa designs and assembles electric motorcycle taxis (commonly known as bodabodas in East Africa) which are then leased out to riders.
- » **Electric Tuk Tuk (Sri Lanka):** Sasiranga De Silva introduced his electric tuk tuks that can reduce CO₂ emissions 65% per unit compared to a combustion-fuelled tuk tuk. The electric tuk tuks have a 100-kilometre range.
- » **Trekk Scooters (Nigeria):** Isaac Oyedokun, Chief Executive Officer and Co-Founder, and Esther Ehindero, Chief Operating Officer, introduced Trekk Scooters, a pioneer of e-scooter sharing services in Nigeria, paving the way for micro-mobility in Africa. This eco-friendly technology redefines the traditional and arduous means of people movement within closed communities, such as university campuses and residential estates.
- » **eDRV (Netherlands):** Bhaskar Deol, Chief Executive Officer and Co-Founder, introduced eDRV, a company that provides software that makes it easy to manage EV charging as a commercial, residential or fleet business. Founded in 2019, eDRV is part of the Rockstart Technology Startup Accelerator.

PANEL DISCUSSION: SUPPORTING YOUTH INNOVATION IN DECARBONISING TRANSPORT

The panel discussion was aimed at reflecting on the innovations presented and creating a dialogue between young entrepreneurs and established experts in the sector. The panel was moderated by **Noortje van Heijst**, Investment Associate of the Unknown Group, and the following panellists joined:

- » **Philippe Vangeel**, Secretary General, The European Association for Electromobility (AVERE)
- » **Alexander Körner**, Programme Officer, Sustainable Mobility Unit, Economic Division, United Nations Environment Programme
- » **Bhaskar Deol**, Chief Executive Officer and Co-Founder, eDRV
- » **Sasiranga De Silva**, Founder and Lecturer, Electric Tuk Tuk.

Highlights from the discussions:

- » **Transport electrification makes a very good business case for investment.** The capital required is relatively low, while the utilisation is very high, creating an exciting opportunity for both entrepreneurs and investors.
- » **E-mobility innovation offers a unique opportunity in low- and middle-income countries.** Globally, transport is responsible for around 25% of emissions, in contrast to low- and middle-income countries where it exceeds 30% and 40%. Notably, transport is one of the fastest growing sectors in such countries. Connecting microfinance, sharing mobility, mobile payments, rural electrification and decreasing costs of solar panels create unique opportunities for transforming the transport sector entirely.

- » **Transport should not be considered in isolation and requires a truly holistic integrated approach.** Its decarbonisation needs to be approached within the wider energy transition.
- » **Thinking and innovation are needed on how to make products accessible to everyone.** Projects are needed that serve the greater share of different populations and that meet all different demands – that is, diversification of e-mobility services to include shared transport (public transport) rather than focusing on single-use cars (Tesla).
- » **E-mobility and education go hand in hand.** Entrepreneurs and young people are vital to shifting transport away from fossil fuels and towards electrification, which requires that e-mobility is treated as a subject in its own right and taught in schools and universities.
- » **In emerging economies, such as India, and for last-mile connectivity, the return on investment for investors looks positive (low capital expenditure, high demand) and represents an attractive investment market.** However, investors, such as venture capitalists and corporate venture capitalists, need to take a longer-term view – by 2024-2025, the market will be a very exciting one.

PANEL II: RENEWABLE SOLUTIONS FOR INDUSTRY AND BUILDINGS

The panel brought together young entrepreneurs and established experts in the industry. It provided a platform for entrepreneurs to showcase their innovation, which was then followed by a panel discussion on the role of youth in the energy transition and the challenges and opportunities to decarbonise the industry and buildings sectors. Experts also provided valuable advice for young entrepreneurs.

SCENE SETTING

Elena Ocenic, Associate Programme Officer at IRENA, highlighted that while the electrification of transport is showing early signs of disruptive acceleration, renewables are growing too slowly in major energy-consuming sectors such as buildings and industry.

In the buildings sector, high-efficiency, building-integrated renewables and thorough retrofitting, refurbishment and renovation of buildings are key ingredients for the success of the energy transition. At the same time, implementing stricter standards for domestic appliances and emissions from new buildings can reduce CO₂ emissions.

In the industry sector, through direct use of renewable electricity, direct use of renewable heat and biomass, and indirect use of renewable electricity via synthetic fuels and feedstocks, renewables could account for 46% of the economic emission abatement potential in four high CO₂-emitting industry sectors: iron and steel, chemicals and petrochemicals, cement and lime, and aluminium (per IRENA's [Reaching Zero with Renewables](#) report).

INNOVATION SHOWCASE

Five innovation pitches were presented:

- » **Enapter (Germany):** Vaitea Cowan, Co-Founder, presented Enapter, a company that manufactures highly efficient, modular hydrogen generators using anion exchange membrane (AEM) electrolysis. The electrolyser is already deployed globally, delivering energy independence to a broad range of sectors. It is used for transport, fuel for heating, energy storage, mobility and power-to-gas. Enapter has offices in Germany, Italy, the Russian Federation and Thailand.

- » **Okham (Indonesia):** Dwi Rizky Rachmadhani and Ilham Gucci, Founders, presented Okham, a platform provider for an Internet of Things data aggregator that can help to integrate renewable energy resources by providing both demand- and supply-side flexibility services to grids.
- » **Energy 4 Impact (Kenya):** Esther Wanza, Energy Business Mentor, introduced Energy 4 Impact, a non-governmental organisation that provides energy access through off-grid technologies and business development for women entrepreneurs in sub-Saharan Africa.
- » **Skoon Energy (Netherlands):** Peter Paul van Voorst, Co-Founder, introduced the world's first online battery sharing platform. With the two-sided marketplace, anyone can book clean energy and have it delivered anywhere.
- » **Optim Energy (Rwanda/Sierra Leone):** Jeremiah Thoronka aims at solving energy access and environmental challenges. The Optim Energy prototype is an innovative piezoelectric device that harnesses energy from heat and vibrations, all of which naturally occur in the environment, to create affordable, accessible and clean power.

PANEL DISCUSSION: SUPPORTING YOUTH INNOVATION IN DECARBONISING INDUSTRY AND BUILDINGS

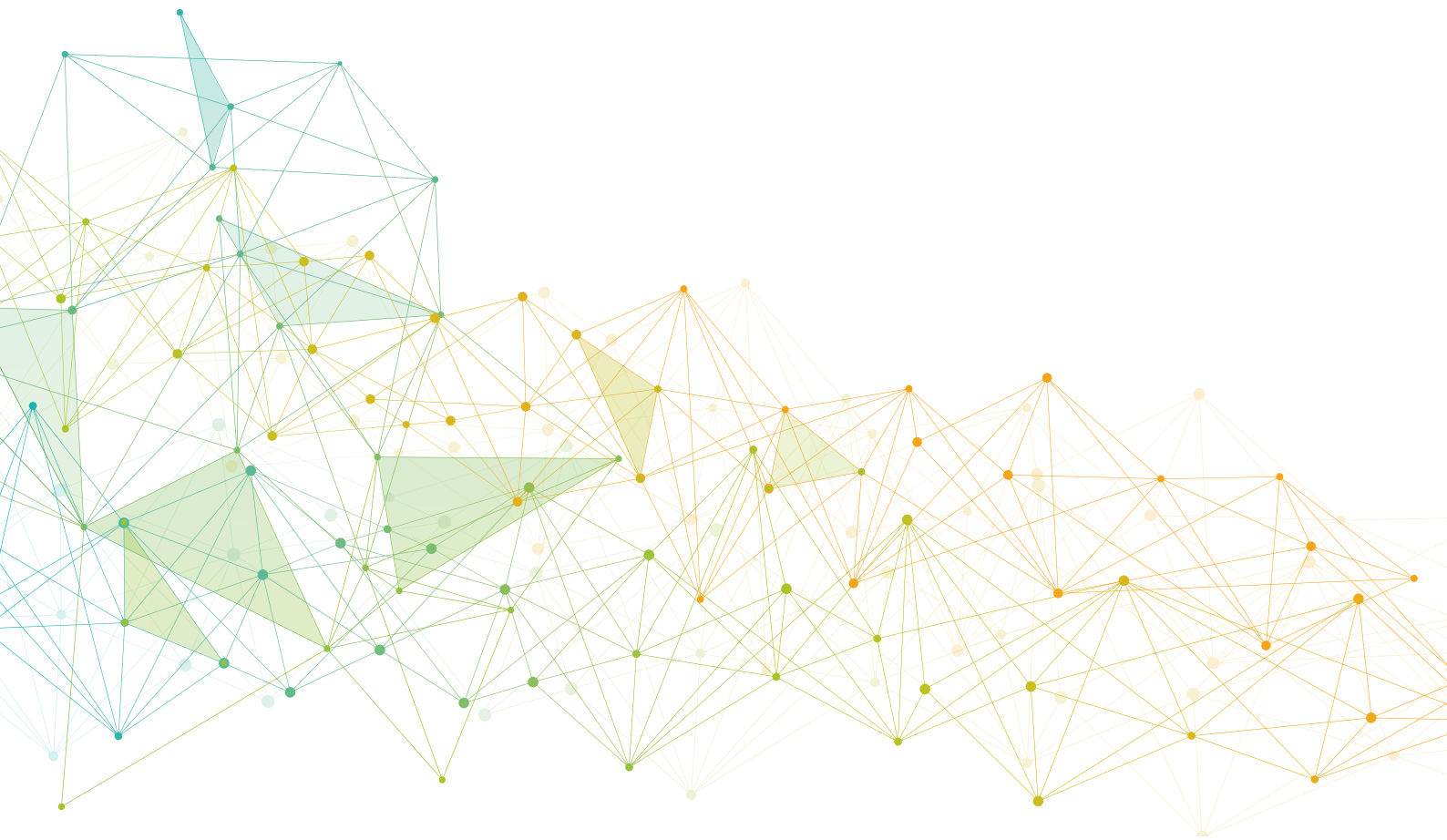
The panel discussion was aimed at reflecting on the innovations presented and creating a dialogue between the young entrepreneurs and established experts in the sector. The panel was moderated by **Joyce Mendez**, Co-Founder of the Latin American Observatory of Geopolitics of Energy, and the following panellists joined:

- » **Ernesto Ciorra**, Chief Innovability Officer, Enel
- » **Thaddeus Anim-Somuah**, Engineering Manager Projects, Croda
- » **Esther Wanza**, Energy Business Mentor, Energy 4 Impact.

Highlights from the discussions:

- » **Youth can play an important role in transforming the energy sector** including industry and buildings. Incentives are needed on both the consumer and industry sides (if customers demand sustainable products, then industry will follow and provide). Most importantly, raising awareness is the first step.
- » **There is a need for the industry to switch from economic-based values to environmental-based values.**
- » **Young entrepreneurs can face many challenges** in making their ideas a reality – particularly a lack of access to financing. At the same time, they possess many important assets that set them apart including the potential for creativity and going beyond existing paradigms, excellent digital know-how and large global networks.
- » **The panellists shared core pieces of advice with young innovators** including the need to build their skills, to think big while also looking for a business case, to be innovative not just in terms of technology but also financing, to collaborate and support one another, and most importantly to not be afraid to fail, and to never give up.

CLOSING SESSION SUMMARY: WAY FORWARD



SESSION OVERVIEW

The last session of the 3rd IRENA Innovation Week summarised and reflected on key insights from all sessions, discussed what it means for the Paris Agreement and brought the previous technical discussions into a broader context by exploring how policies, regulatory frameworks and finance can help to scale up decarbonisation of the energy-intensive industry and transport sectors.

2 discussions

8 expert speakers

Participants from 64 countries

SUMMARY OF KEY INSIGHTS

High-level speakers shared perspectives on deep decarbonisation in the context of policy, regulation, and finance, reiterating the need for cross-pollination and collaboration across different stakeholders:

- » **There is growing momentum towards post-pandemic net-zero recovery plans.** Long-term strategies need to lay foundations for an irreversible shift to a resilient, net-zero and inclusive world economy.
- » **A cross-sectoral collaborative approach across the value chain** is key to decarbonise the industry and transport sectors. Solutions should activate the ambition loop, create jobs and reduce the economic crisis.
- » **Political ambition and a systems approach across technology, policy and socio-economic structures are instrumental for the energy transition.** Only fully integrated policies across sectors should be promoted, taking advantage of the synergies with direct and indirect electrification, bioenergy and synthetic e-fuels.

KEY TAKEAWAYS AND REFLECTIONS ON THIS WEEK'S DISCUSSIONS

Dolf Gielen, Director of the IRENA Innovation and Technology Centre, summarised his key insights from the week's sessions, which involved more than 100 experts from over 35 countries.

Key takeaways from this week's discussions:

- » **Affordable and scalable renewable solutions for the industry and transport sectors are on the horizon.** The energy transition discourse is shifting rapidly, as deep decarbonisation is now a priority for more and more decision makers.
- » Renewable solutions based on **electrification with renewable power or by using green hydrogen** produced from renewable power are **gaining prominence as important decarbonisation solutions.**
- » **A significant potential role exists for bioenergy and biomass feedstocks** within the industry and transport sectors.
- » **A massive upscaling effort is urgent.** For example, in the field of electrolyzers, the required increase is four orders of magnitude, which equals a growth rate of 135% per year sustained over 30 years.

Key reflections from this week's discussions on topics that require further analysis and mapping:

- » Agreeing on **standards and certification procedures** for green energy carriers.
- » Establishing **enabling infrastructure** such as hydrogen and renewable fuels distribution networks.
- » Improving the **economic viability** further through technological learnings and upscaling.
- » Expanding **enabling policies** for the accelerated energy transition.
- » Utilising **digitalisation** as an enabler and a driving force for the energy transition.

FIRESIDE CHAT ON CLIMATE ACTION IN THE INDUSTRY AND TRANSPORT SECTORS

Elizabeth Press, IRENA's Director of Planning and Programme Support, discussed the ambitions and implications of industry and transport decarbonisation in the context of climate negotiations with:

- » **Gonzalo Muñoz**, High-Level Climate Champion, Chile
- » **Catherine Bremner**, Director of International Climate and Energy, Department for Business, Energy and Industrial Strategy, UK

Highlights of climate action in industry and transport through the lens of initiatives from the COP25 and COP26 presidencies:

- » **There is a need to maintain momentum and get a critical mass to decarbonise all sectors of the economy:**
 - › **Commitments** to reach net-zero are **on the right track and are expanding in an unprecedented manner** among decision makers even in COVID times, including in China and California.
 - › **Calls are being made to scale up** renewable solutions **faster** and to implement the most **appropriate mix of renewable solutions** for each challenge.
 - › **There is a need to accelerate innovation through various approaches** in support of the priorities of the COP26 UK presidency. The UK highlighted new political forums, campaigns to double the pace of transition, the creation of green hydrogen transport hubs, a low-carbon hydrogen development programme, a hydrogen strategy and a new CCUS infrastructure fund with a dedicated GBP 800 million to establish at least two CCUS clusters in the UK.
 - › **The 4Ps are needed as a pathway to reach net-zero: pledge** to net-zero, **plan** actions, **proceed** to deliver and **publish** activities and deliverables.

- » **Concrete public-public and public-private activities to accelerate climate action can feed into more ambitious Nationally Determined Contributions (NDCs) under the Paris Agreement and into long-term strategies to reach net-zero:**
 - › **Non-Party stakeholders** have a fundamental role to play in climate action to reduce carbon emissions and should come together under the Race to Zero campaign and commit. The **Race to Zero campaign** mobilises actors outside of national governments to join the [Climate Ambition Alliance](#). The campaign has seen collaborations among many stakeholders, creating an ambition loop that will lead to enhanced and more ambitious NDCs.
 - › **Launched in September 2020, the [COP26 Energy Transition Council](#) brings together global political, financial and technical leadership (including IRENA) in the power sector to collaborate in the run-up to COP26 to accelerate the transition from coal power to clean power as part of a green economic recovery from the COVID-19 pandemic.** Additionally, the [Transport Decarbonisation Alliance](#) brings together the 3Cs (countries, cities/regions and companies) to accelerate the global transformation of the transport sector towards a net-zero emission mobility system by 2050.
- » A post-pandemic recovery that is green and sustainable could help accelerate the energy transition:
 - › Governments are called on to adopt **recovery plans that lay the foundations for an irreversible shift to a resilient, net-zero and inclusive world economy.** Governments should embrace and build plans **around cost-competitive renewables**, electric batteries and storage systems. This in turn brings benefits including the creation of new industries, jobs, and clean and sustainable livelihoods and environments.
 - › To unlock public and private finance, such **recovery plans require financial system transformation.** In an effort to provide a replicable framework to do so, the **Task Force on Climate-Related Financial Disclosures** was established and provides a framework for companies to calculate their exposure to climate risk and to disclose it to investors.

PUBLIC-PRIVATE DISCUSSIONS

Rabia Ferroukhi, IRENA's Director of Knowledge, Policy and Finance, opened the session by briefly introducing policies to support the energy transition in industry and transport:

- » **Global efforts in heating, cooling and transport are significantly lagging due to institutional, technical and financial barriers.** Addressing those barriers requires an integrated, systems approach. Enabling the transition pathways for the heating and cooling sector requires both cross-cutting policies – such as target setting, the removal of fossil fuel subsidies and the mobilisation of private investment – and pathway-specific policies.
- » **A systems approach across technology, policy and socio-economic structures is instrumental for the energy transition.** This approach requires appropriate deployment policies as well as fundamental systemic changes to the socio-economic structures on which this transition relies. Only then can we ensure the millions of renewable energy jobs, economic development and health benefits that the transition can generate for societies around the world.

Rabia Ferroukhi then moderated the discussion on how to scale up deep decarbonisation technological solutions for industry and transport from the policy, regulatory and finance perspectives, with the following panellists:

- » **Young Tae Kim**, Secretary General, International Transport Forum
- » **Amanda Wilson**, Director General, Office of Energy Research and Development, Natural Resources Canada
- » **Ola Göransson**, Senior Advisor in the Climate Division, Ministry of Environment, Sweden
- » **Michael Hackethal**, Head of Division – General issues of international energy co-operation, multilateral energy co-operation, Federal Ministry for Economic Affairs and Energy (BMWi), Germany
- » **Gregory Dolan**, Chief Executive Officer, Methanol Institute
- » **Soma Banerjee**, Executive Director, Confederation of Indian Industry.

Highlights from the discussion:

- » **Political ambition is key to support the energy transition.**
- » **Achieving governments' commitment to climate goals requires co-ordinated collaboration and joint efforts at the institutional level.** Various countries have established climate cabinets encompassing different ministries working together and sharing responsibilities to implement climate action plans. The monitoring mechanism is important to ensure that implementation is on track. The regulatory framework and standards – such as on biofuel blending mandates and EV charging infrastructure – need to incentivise companies and citizens to take additional actions to move forward.
- » **Engaging all stakeholders in the target-setting process could ensure better implementation and make these targets more achievable.** Bringing together various stakeholders (different relevant ministries, industries and civil society) around the shared vision requires their alignment around shared objectives and a good understanding of their roles. For example, Sweden's industries developed more than 20 voluntary roadmaps on a fossil fuel-free economy to support climate goals.
- » **A cross-sectoral integrated approach along the value chain is essential and should be approached on a step-by-step basis.** Building consensus and knowledge on the decarbonisation of transport and industry is challenging for achieving the targets. Different means of engagement are needed.
- » **The full range of tools should be used** to accelerate the transition and to make renewable-based solutions affordable. **Technologies are mature, but scalability is their key barrier.** Smart grids and storage systems, bio-methanol and e-methanol, hydrogen, and other technologies and fuels all play an equally important role in decarbonising industry and transport.
- » **Affordability and accessibility** of renewable energy are **big issues to consider for developing countries to deploy renewables. This directly affects the way** that renewables are integrated into the existing system, and challenges related to the power grid and to transmission and distribution facilities need to be addressed.
- » **Publicly funded long-term and co-ordinated research and innovation programmes are key.** The programmes need to be geared towards current and future needs including the needs in the energy-intensive industry and transport sectors and aim to achieve technological and non-technological progress.

CLOSING REMARKS

Francesco La Camera, IRENA's Director General, concluded the week of discussions with public and private sector experts from across IRENA's global membership by offering encouraging and inspiring messages:

- » Partnering with organisations around the world and bringing more than 100 speakers from over 35 countries allowed for truly **global perspectives and a broad view of emerging solutions in industry and transport coupled with systemic innovations and financial and policy needs.**
- » Getting to the 1.5 °C pathway is challenging, and **commitments from all sectors, especially transport and industry, are key.**
- » **The current COVID-19 pandemic can show us what it is possible to achieve by encouraging innovation and co-operation.** We hope to recover better and to build a sustainable future.
- » **IRENA continues to be fully focused on helping countries realise their renewable transition pathway.**





