

IRENA INNOVATION WEEK

Renewable solutions to decarbonise end-use sectors



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IRENA INNOVATION WEEK

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Summary report 2023

Table of Contents

| | |
|------------------------------------------------------------------------------------------------------|-----------|
| List of abbreviations | 6 |
| Innovation Week 2023: Overview | 8 |
| Key actions for policy makers | 9 |
| Opening high level session: Innovation for the energy transition | 15 |
| Key actions for policy makers | 16 |
| Highlights of the session | 17 |
| Power systems of the future: Infrastructure requirements for widespread electrification | 23 |
| Key actions for policy makers | 24 |
| Highlights of the session | 25 |
| Electrifying road transport | 30 |
| Key actions for policy makers | 31 |
| Highlights of the session | 32 |
| Electrifying heating and cooling in buildings | 38 |
| Key actions for policy makers | 39 |
| Highlights of the session | 40 |
| Walking the last mile of the energy transition with hydrogen: A systemic approach | 48 |
| Key actions for policy makers | 49 |
| Highlights of the session | 50 |
| Solutions for decarbonising the iron and steel sector | 58 |
| Key actions for policy makers | 59 |
| Highlights of the session | 60 |
| Solutions for decarbonising the chemical and petrochemical sector | 64 |
| Key actions for policy makers | 65 |
| Highlights of the session | 66 |
| Solutions for decarbonising the shipping and aviation sectors | 70 |
| Key actions..... | 71 |
| Highlights of the session | 72 |
| Future materials for EV batteries | 77 |
| Key actions for policy makers | 78 |
| Highlights of the session | 79 |
| Grid evolution: Transforming energy landscapes in developing countries and SIDS | 84 |
| Key actions for policy makers | 85 |
| Highlights of the session | 86 |

| | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Geopolitics of the energy transition: Innovation in critical materials | 92 |
| Key actions for policy makers | 93 |
| Highlights of the session | 94 |
| Closing remarks and takeaways | 98 |
| Highlights of the session | 99 |
| Demand-side management and storage: Case studies | 102 |
| Key actions for policy makers | 103 |
| Highlights of the session | 104 |
| Enabling data driven decision making: Mission Innovation’s Energy Innovation Metrics Hub | 116 |
| Key actions for policy makers | 117 |
| Highlights of the session | 118 |
| Collaborative framework for high shares of renewables | 123 |
| Key actions for policy makers | 124 |
| Highlights of the session | 125 |
| Strategic considerations for sector coupling in long-term energy scenarios | 130 |
| Key actions for policy makers | 131 |
| Highlights of the session | 132 |
| Innovations and technological pathways to decarbonise hard-to-abate sectors | 139 |
| Key actions for policy makers | 140 |
| Highlights of the session | 141 |
| Symposium on the green hydrogen economy: The necessity of quality infrastructure (standards, certification, testing and metrology) | 146 |
| Key actions for policy makers | 148 |
| Highlights of the session | 150 |
| Youth and innovators hub | 154 |

List of abbreviations

| | |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| AI | artificial intelligence |
| BESS | battery energy storage system |
| CEC | California Energy Commission |
| CEER | Council of European Energy Regulators |
| CEM-Hubs | Clean Energy Marine Hubs |
| CEPRI | China Electric Power Research Institute |
| CFCM | Collaborative Framework on Critical Materials |
| CO ₂ | carbon dioxide |
| CO ₂ eq | carbon dioxide equivalent |
| CMP | Continental Power Systems Masterplan |
| CRIEPI | Central Research Institute of Electric Power Industry |
| CSP | concentrated solar power |
| DSO | distribution system operator |
| EC JRC | European Commission Joint Research Centre |
| EHPA | European Heat Pump Association |
| EIB | European Investment Bank |
| EPRI | Electric Power Research Institute |
| ERI | Energy Research Institute |
| ESMAP | Energy Sector Management Assistance Programme |
| ESS | energy storage system |
| ETS | emissions trading system |
| EU | European Union |
| EU DSO Entity | European Union Distribution System Operators Entity |
| EU ETS | European Union Emissions Trading System |
| EV | electric vehicle |
| GHG | greenhouse gas |
| Gt | gigaton |
| GW | gigawatt |
| GWh | gigawatt hour |
| HVDC | high voltage direct current |
| ICAO | International Civil Aviation Organisation |
| ICT | Information and Communication Technology |
| IEA | International Energy Agency |
| IEC | International Electrotechnical Commission |
| IECEX | International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres |
| IMO | International Maritime Organisation |

| | |
|------------------|-----------------------------------------------------------------------------|
| IoT | internet of things |
| ISGF | India Smart Grid Forum |
| ISO | International Organisation for Standardisation |
| KPI | key performance indicator |
| kWh | kilowatt hour |
| LCOE | levelised cost of electricity |
| LTES Network | Long-term Energy Scenarios Network |
| LT-LEDS | long-term low greenhouse gas emission development strategies |
| MDB | multilateral development bank |
| METI | Ministry of Economy, Trade and Industry |
| MI | Mission Innovation |
| MSDG | medium-scale distributed generation |
| MWh | megawatt hour |
| NDC | Nationally Determined Contribution |
| PV | photovoltaic |
| P2P | peer-to-peer |
| PTB | German Metrology Institute (<i>Physikalisch-Technische Bundesanstalt</i>) |
| Pth | power-to-heat |
| PtH ₂ | power-to-hydrogen |
| PtM | power-to-methanol |
| R&D | research and development |
| RD&D | research, development and demonstration |
| REMC | renewable energy monitoring centre |
| RPO | renewable energy purchase obligation |
| SAF | sustainable aviation fuel |
| SIDS | small island developing state |
| SGCC | State Grid Corporation of China |
| SSDG | small-scale distributed generation |
| SPIC | State Power Investment Corporation |
| TEPCO | Tokyo Electric Power Company |
| TOU | time-of-use |
| TSO | transmission system operator |
| TWh | terawatt hour |
| UHV | ultra-high voltage |
| UNCRA | United Nations Common Regulatory Arrangement |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VRE | variable renewable energy |
| VSC | voltage source converter |
| V2G | vehicle-to-grid |
| WSA | World Steel Association |
| ZEV | zero emissions vehicle |

Innovation Week 2023: Overview

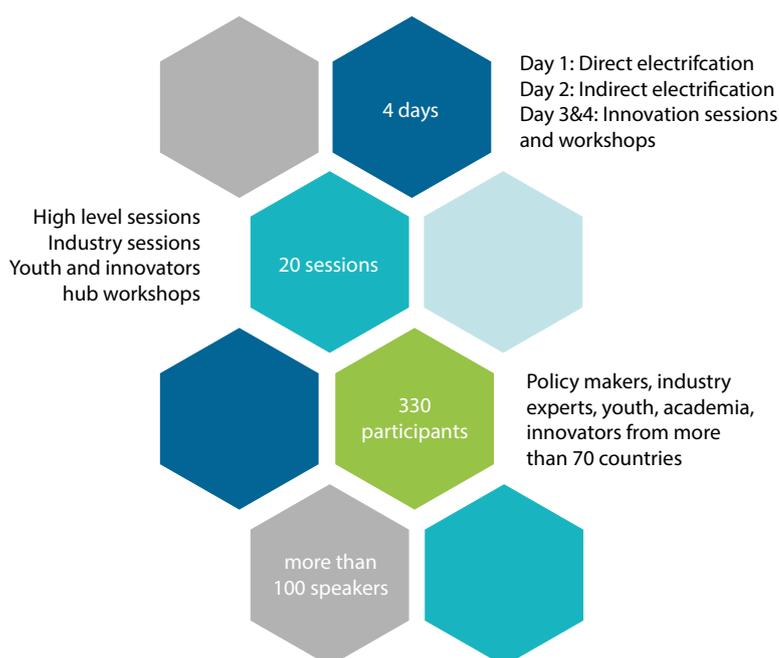
On 25-28 September 2023, the International Renewable Energy Agency (IRENA) Innovation Week 2023 took place in Bonn.

Bringing together leading policy makers, innovators and industry experts from across IRENA's diverse global membership, the gathering had the theme, 'Renewable solutions to decarbonise end-use sectors'.

The week aimed to both inspire and inform decision makers by showcasing emerging renewable-based solutions from around the world, while also exploring what action was necessary to fully unlock the potential of renewables in end-use sectors. Recordings of the sessions can be viewed [here](#).

The event was built on previous weeks held in [2016](#), [2018](#) and [2020](#). The first two editions had focused on the energy supply side, exploring zero-carbon power systems based on integrating high shares of renewables. In particular, those editions had examined the decarbonisation of power systems and the integration of variable renewable energy (VRE).

A further foundation was then provided by the [2020](#) edition, which was held virtually and discussed prospects for decarbonising transport and industry. The 2023 edition broadened this discussion on decarbonising end-use sectors and was informed by IRENA's recent flagship report, [Innovation landscape for smart electrification](#). The digital, interactive version of this report was launched at Innovation Week 2023, as the [Innovation toolbox](#) for smart electrification.



Key actions for policy makers

The Innovation Week's four days of discussion gave rise to six main actions for policy makers:



1. De-risk investments in innovation

- **Design clear long-term policies with short-term targets.** The establishment of long-term goals sets the direction for decarbonising energy sectors. Short-term mandates and targets, however, help size market gaps and send the right signals to financiers and developers.
- **Establish policies that de-risk first-movers and level the competitive playing field.** This can be done, for example, through financial incentives aimed at kickstarting and accelerating the transition.
- **Ensure that all financial decisions are in line with the goal of achieving sustainability.** Such decisions should align with the objectives of the Paris Agreement and mobilise private capital through innovative financing instruments, such as risk-sharing and grants via blended finance for scaling up low-carbon production routes.
- **Establish mechanisms to scale up financing for green solution project development.** Create policies that identify the right financing and market solutions to unlock investments. Such policies should also address offtake risks and promote the use of innovative financing instruments to reduce the cost of capital, making green projects financially viable.
- **Develop incentives, both financial and non-financial, that can support the growth of capital-intensive, low-carbon steel initiatives.**
- **Strike a balance between maintaining competitiveness and profitability in the chemical industry.** This needs to be done while still moving ahead with deploying low-emission solutions. Technologies to aid transition in the chemical industry are widely available and there should be a focus on innovation in business models and regulatory frameworks in the sector.
- **Deploy a comprehensive suite of measures to commercialise low-carbon technologies in hard-to-abate sectors.** These measures should include sector-specific emission reduction targets, harmonised standards and certification, as well as supportive policy tools and regulations.
- **Prioritise solutions that are the most efficient and make the most economic sense.** This should be done while also looking at technology maturity and feedstock availability when considering fuel-options for decarbonisation.
- **De-risk flexibility asset investments.** This is essential for progress towards a more flexible energy system. While in many cases technology risk has plummeted due to technology cost reductions, focus should still be given to enabling certainty in revenue. The technology to provide flexibility services is available, but is underused and undervalued.
- Decarbonising hard-to-abate sectors is no easy task. The technology is there, but a lot of this is at an early stage of readiness and still not widely disseminated or mass produced. Moreover, technologies are capital intensive and have long development cycles. 'Valley of death' occurs all along the innovation journey. **Along with smart policy tools, it takes smart public funding – and private – to support the development and deployment of the necessary technology.**

2. Address infrastructure challenges

- **Prioritise grid strengthening and modernisation, digitalisation and storage.** This should be done while incentivising demand-side management.
- **Increase homegrown development of renewable energy sources and the production of green hydrogen.**
- **Align infrastructure development with investments in renewable generation and increasing electricity demand from end-use sectors.** This can prevent congestion or curtailments that result in increased costs for consumers.
- **Develop renewable generation close to demand.** This enables a larger share of demand to be met locally, without impacting the grid.
- **Consider regional grid interconnections.** These can strengthen the grid and integrate higher shares of renewables.
- **Approach innovation in a systemic way.** This should encompass technology, infrastructure, market design and business models, along with system planning and operation.

3. Prioritise demand-side management strategies

- **Demand side management is a great source of untapped flexibility.** Demand should not only guide generation. It should also strive for increased flexibility in order to better accommodate the variable patterns of renewable energy generation, particularly during peak load periods. Both residential and industrial demand should be considered when designing the strategy for demand-side management.
- **Adapt regulations to facilitate timely innovation and the development of associated business models for smart electrification strategies.** The growing electrification of transport, heating, cooling and the emergence of green hydrogen present both challenges and significant flexibility potential.
- **Compensate services provided to the electricity network fairly.** This supports electrification and ensures that services evolve in line with actual needs, actively involving consumers and allowing them to benefit from the energy transition.
- **Involve consumers in the process.** This should be done to meet their needs and make it easy for consumers to participate in providing flexibility services to the grid. Through tariff design, price signalling mechanisms should be created and a local market established so that consumers can actively or passively provide services to the grid. Inform consumers of the benefits of demand-side management.
- **Prioritise smart grids and smart meter roll-out, foster digitalisation, improve demand and supply forecast.** Promote the sharing of data and information among stakeholders to improve charging predictability in energy consumption patterns.

- **Unlock flexibility in as many demand sectors as possible.** This should include industries, district heating and cooling, e-mobility, regional microgrids and others. The benefits from vehicle-to-grid (V2G) charging should be unlocked by enabling access to market flexibility and removing double taxation. When managed correctly, V2G does not affect battery lifespan.
- **Ensure that the renovation rates of building stocks increase in parallel with the roll-out of power-to-heat/cooling solutions.** This should ensure increased energy efficiency and decreased demand.

4. Ensure equity and inclusivity

- **Design effective policies by assessing and understanding the local context.** This context includes the climate, energy sources available, regulations in place and socio-cultural aspects, as well as economic development and industry involvement.
- **Consider the unique needs and resources of different regions and communities.** This is particularly the case in Africa and small island developing states (SIDS) where small-scale, decentralised solutions are needed.
- **Increase the adoption of decentralised solutions.** These include solar rooftop photovoltaic (PV) systems, electric vehicles (EVs) and heat pumps. These should be available across society's different segments, not just among those with high purchasing power.
- **Ensure careful consideration is given to the socio-economic impact and to specific needs of local communities** when designing the optimal policy framework for green hydrogen development.
- **Establish responsible sourcing regulations.** These should guarantee supply chain traceability and thereby enable responsible and sustainable sourcing of minerals. This entails imposing rigorous environmental standards and conducting comprehensive social impact assessments at every stage of extraction, processing and refining.
- **Adjust regulations and develop capacity development** programmes to enhance job attractiveness in hard-to-abate sectors.

We are all on a learning journey, but innovation in all aspects is needed for a fair, just, efficient and equitable transition for all.

5. Co-operate for robust supply chains and technology and knowledge transfer

- **Increase international co-operation in innovation between governments.** No single country possesses all the knowledge or resources required. International collaboration should harness regional strengths and shared objectives, with the aim of mitigating geopolitical divisions and increasing the resilience of the supply chain.
- **Collaboration between countries is crucial for investment opportunities, sustainable development and well-functioning, robust supply chains.** Transparent supply chains and material traceability throughout resource life cycles are drivers for investment and better governance. The potential for co-operation over conflict in the critical materials supply chain was emphasised.
- **Invest in international and cross-sectoral collaboration for technology and knowledge transfer.** This is vital to developing and implementing innovative solutions effectively. At the same time, the creation of local supply chains is also key.
- **Incentivise collaboration among all stakeholders.** These include utilities, regulators, the private sector and financial institutions. Multi stakeholder partnerships involving businesses and local communities should be actively fostered. These partnerships should focus on addressing governance gaps, promoting sustainability, and ensuring responsible mineral resourcing throughout the entire value chain. Simultaneously, they should seek to build trust and secure the consent of local communities, while generating local value.
- **Collaborate with multiple stakeholders throughout the entire value chain to understand industry barriers and financing challenges.** Develop policy frameworks that mitigate risks and support the development of green solutions.
- **Strengthen co-operation between government and industries.** This is especially crucial in large scale projects that demand faster permitting procedures.
- **Incentivise strong partnerships between the utility and the industry.** This should help avoid overburdening the grids.
- **Transparency and international collaboration are priority areas.** This was highlighted by the speakers. The need for transparency across the entire EV battery supply chain, including raw materials, was emphasised. This is to ensure resilient and responsible sourcing. Simultaneously, collaboration between continents, countries and other stakeholders leverages regional strengths for innovation.
- **Foster new ways for collaboration between countries, the private and public sector, and between different sectors.** Innovation is more than technology – it is also bringing different elements together. Often, when decarbonising a sector, actors from outside the industry can change the status quo of the sector and bring innovation by bringing fresh perspectives.
- **Share best practices, communication, education and ways of reducing complexity.** These are key in advancing the energy transition.

6. Create demand for green products

- **Create early demand for green products.** This can be done through mandates, subsidies for first-of-its-kind projects, public procurement and sectoral agreements on carbon footprints, for example.
- **Recognise and support industries such as chemicals, cement, refineries, ammonia and steel.** These will be key drivers of hydrogen consumption up to 2030.
- **Implement policies aimed at streamlining hydrogen certification and permit processes.** This will help promote the development of local hydrogen markets. To support low-carbon industries, the infrastructure – including the development of hydrogen transport and storage networks must be improved.
- **Use green public procurement practices.** This can boost demand for low-carbon steel products and other green products.
- **Establish a carbon pricing mechanism.** This is regarded as crucial for the decarbonisation of the shipping and aviation sectors. It would also encourage the adoption of sustainable fuels by penalising the use of polluting fuels and increasing the cost-competitiveness of the upcoming e-fuels.
- **Establish standardised carbon accounting guidance and regulations.** These should be in line with globally recognised methodologies to measure and reduce emissions effectively.
- **Increase resources for research and development (R&D) across the energy supply chain.** Innovation has the potential to reduce or even eliminate the demand for specific materials, enhancing sustainability and concurrently diminishing risks and vulnerabilities in the supply chain.

Opening high level session

Innovation for the energy transition



Innovation is the engine powering the global energy transformation towards a carbon-neutral future.

The share of electricity in total final energy consumption must increase from its 2019 level of 21% to 30% by 2030.

According to IRENA's 1.5°C Scenario, the share of electricity in total final energy consumption must increase from its 2019 level of 21% to 30% by 2030. It must then reach 51% by 2050. This can be achieved with tremendous growth in technologies that run on electricity. Yet, although many of these technologies are available, systemic innovation in system operation, business models and market design is also crucial in powering the global energy transformation towards a carbon-neutral future.

This transformation will highlight not only how we produce energy, but also on how we consume it. Both supply and demand must be transformed together and in co-ordination for a faster and more effective decarbonisation of the entire system.

This session brought together policy makers to discuss how innovation can accelerate the energy transition in different regions.



Key actions

for policy makers

1. **Enable the energy transition.** This can be done by addressing physical infrastructure challenges, digitalisation, the incentivisation of flexibility in storage and demand side management, an increase in homegrown development of renewable energy sources, and the production of green hydrogen.
2. **Ensure equity and inclusivity in the energy transition.** The unique needs and resources of different regions and communities should be considered, particularly in Africa and SIDS, where small-scale, decentralised solutions are needed.
3. **Invest in collaboration and technology and knowledge transfer.** This should go beyond national boundaries in order to develop and implement innovative solutions more effectively. At the same time, creation of local supply chains is key.
4. **Innovate and change the status quo.** We must change the way we live and the way we think. We are all on a learning journey, but innovation in all aspects is needed for a fair, just, efficient and equitable transition for all.

Highlights of the session

Setting the scene

Roland Roesch, Director of the IRENA Innovation and Technology Centre, opened the event stressing the imperative of tripling installed renewable power capacity by 2030, if climate goals are to be met.

Introducing the recently launched IRENA report, [Innovation landscape for smart electrification](#), a collaborative effort involving insights from over 200 experts, he emphasised that smart electrification strategies not only present economic opportunities, but also potential savings in public spending.

In his welcoming speech, IRENA Director-General Francesco La Camera then highlighted the importance of innovative solutions in achieving IRENA's call to triple global renewable energy capacity to 11 000 gigawatts (GW) by 2030 to meet climate targets. He noted that the G20 leaders had recently endorsed IRENA's recommendations, aligning with the goal of 11 terawatts (TW) of renewable power capacity and significant new investments. He stressed that innovation is the key to achieving these goals, with systemic innovation required. This means innovation is needed in technology, business models, regulations and financing. The director-general then highlighted the importance of addressing the challenge of hard-to-abate sectors, such as heavy industry, shipping and aviation, with early-stage technologies.

Nawal Al-Hosany, Permanent Representative of the United Arab Emirates to IRENA, then recalled that seven years had passed since the global community, both north and south, committed to limit global warming. A goal of greenhouse gas (GHG) emissions peaking by 2025 and declining by 2030 had been set. Acknowledging the collective failure to meet these targets, she stressed the urgency of action and innovation.

Al-Hosany then highlighted that the viability of most carbon dioxide (CO₂) abatement solutions had been commercially demonstrated, but called for the acceleration of early-stage technology commercialisation. She then pointed out the importance of a tailored, national approach, recognising that one solution does not fit all, with decisions needing to consider individual resources and needs. COP28, she said, would serve as a catalyst for leveraging technology and innovation to get the world back on track for a 1.5°C trajectory, a transformation more significant than the industrial revolution. Technology innovation, she noted, would be a central theme throughout COP28, as it focused on addressing pressing global challenges.

Panel discussion

Featuring the distinguished guests listed below, participants in the opening panel underlined their unwavering commitment to the energy transition. They then presented the challenges and innovation priorities specific to different regions.

Moderator: Elizabeth Press, Director, IRENA Planning and Programme Support

Panelists:

- Amani Abou-Zeid, Commissioner for Infrastructure and Energy of the African Union Commission
- Kadri Simson, Commissioner for Energy of the European Commission
- Philippe Henry, Vice President and Minister of Climate, Energy, Mobility and Infrastructure, Wallonia region, Belgium
- Kaleb Udui Jr., Minister of Finance, Republic of Palau
- Siva Gunda, Vice Chair, California Energy Commission
- Francesco La Camera, IRENA Director-General

Speaking on Africa's potential for innovation in energy and infrastructure, Amani Abou-Zeid, Commissioner for Infrastructure and Energy of the African Union Commission, stressed the importance of identifying key enablers that will empower African countries to harness these opportunities. She emphasised that no single solution would suit all and explained how Africa is innovating in decentralisation. This included distributed generation technologies, off-grid solutions, pay-as-you-go business models for mini-solar kits and other examples.

The main challenge, Abou-Zeid said, is the lack of innovation in finance, shown by the fact that Africa received only 2% of global investments in renewables in the last two decades. She underscored the need for political strategies that focused on skills development and creating local value chains, resource mobilisation, and technology and infrastructure development.

Abou-Zeid also highlighted how critical it is that emerging innovations in energy transition, renewable-based power systems and digitalisation be embraced, while ensuring affordable and resilient energy. Furthermore, she stressed the significance of the Continental Power Systems Masterplan (CMP) as a ground breaking framework for co-ordinating energy planning at the continental level, promoting cross-border interconnectors, and fostering collaboration with international partners.

Finally, Abou-Zeid reiterated that different regions had different needs, with heating – for example – of great importance in Europe, while cooling for Africa. She pointed out that cooling needs as much attention as heating in terms of innovation and technological breakthrough. Similarly, while Europe prioritises the use of large-scale storage, for Africa, small-scale storage for decentralised solutions is key.

The remarks of Kadri Simson, Commissioner for Energy of the European Commission, centred on the European context. She explained that the European Green Deal strategy includes three main workstreams: (1) accelerate the homegrown development of renewable energy sources; (2) decarbonise transport and industry, increasing the demand for green hydrogen; and (3) incentivise the use of large storage and demand side management as flexibility providers.

For all three, she said, clear signalling and digitalisation are central. Clear signals to project developers are important to allow additional power generation to come online. Digitalisation is a key enabler for smart electrification projects, such as smart charging of EVs or smart operation of heat pumps.

Simson then highlighted the importance of interconnected markets in the European Union (EU). She mentioned plans to further invest in infrastructure to enhance the interconnectivity of the power system within and beyond EU, with this including investment in undersea cables. Moreover, she introduced the Net Zero Industry Act as a noteworthy initiative in support of Europe's decarbonisation efforts.

Kaleb Udui Jr., Minister of Finance, Republic of Palau, then presented his country's journey towards energy independence. This included Palau's successful efforts to secure independent contracts with private companies, including PV installers. He said that the Pacific is one of the first regions to experience the impact of climate change and that Palau's energy challenge was complex because of its smallness and remoteness.

The minister explained that Palau aims to reach 100% renewable energy by 2032. Palau is seeking to transform the power sector with a more reliable grid, while also transforming the country's second largest fossil fuel consumer – the transport sector. He also mentioned Palau's collaboration with Japan to install renewable energy capacity, while further emphasising the need for adaptability and flexibility in the face of inflation. In addition, he highlighted the pivotal role of innovation in shaping Palau's energy future and the significance of adaptation in the face of climate change.

Philippe Henry, Vice President and Minister of Climate, Energy, Mobility and Infrastructure, Wallonia region, Belgium, then focused on his country's unique challenges and opportunities in the energy sector. He stressed the importance of innovation in areas from energy generation to transmission and efficiency. He explained how Belgium is focusing on the decarbonisation of the mobility and heating sectors, as well as the shipping sector, with green hydrogen. Henry also underlined the need for cross-border technical collaboration and shared experiences in addressing common energy challenges. He noted that the innovative approaches seen during the COVID-19 pandemic should also extend to the energy and climate sectors, as collaboration across borders is essential in finding sustainable solutions.

Siva Gunda, Vice Chair of the California Energy Commission, then delved into California's energy policy and the complex issues related to rapid electrification, grid reliability and climate change.

Gunda said that California is aiming for a rapid electrification of its transport, buildings and commercial sectors, and to boost production of green hydrogen. This would increase electricity demand by a factor of 2.5, he said, which posed grid reliability challenges. In addition, climate change is making it difficult to fight climate change as more frequent fires, droughts, and floods pose extra challenges to the power system.

Gunda then concluded that a shift in thinking is needed, with supply forecasting needing to be matched with demand. He pointed out the necessity of demand flexibility, complemented by transmission upgrades, in planning for extreme weather events. He also emphasised the importance of creating a strategic reserve.

California is trying to address the 'duck curve' challenge, caused by increased electricity demand

in the evening – a period coinciding with less solar energy production. The options are to import wind electricity from neighbouring states (for which new transmission lines were needed), and to incentivise the use of behind-the-meter storage. Gunda further highlighted the importance of equity and the need for communities to feel involved and supported in the transition to cleaner and more reliable energy sources.

IRENA Director-General Francesco La Camera then emphasised the moral and ethical aspects of decision making in the energy sector. He underscored the need for just and equitable solutions that benefit all people, regardless of their economic status. He also highlighted the importance of technological innovations that are both efficient and environmentally sustainable, particularly in energy storage solutions.

In conclusion, the speakers offered valuable insights into various aspects of energy transition, innovation, and sustainability. They addressed the unique challenges and opportunities of their respective regions and emphasised the importance of collaboration and justice in the global energy landscape.

Photographs from the opening high level session 'Innovation for the energy transition'



Power systems of the future



Infrastructure requirements for widespread electrification



Session organised in partnership with China Electric Power Research Institute (CEPRI)

Investment will need to be carefully planned to avoid potentially serious operational problems

Building the right power sector infrastructure – one capable of sustaining and fostering massive electrification – is a critical challenge in the short, medium and long-term.

Indeed, investment will need to be carefully planned to avoid potentially serious operational problems related to uncontrolled future electrification. Knowing how electricity will be used in buildings, transport and industry – and how much will be transformed into hydrogen and e-fuels – will make it possible to plan for the power sector's key future infrastructure and innovation needs. This applies across the full landscape of generation, transmission, distribution, storage, digitalisation, efficiency and flexibility.



Key actions

for policy makers

1. **Approach innovation in a systemic way.** This should encompass technology, infrastructure, market design and business models. Innovation is the key enabler of a smart electrification strategy.
2. **Align infrastructure development with investments in renewable generation.** This will prevent bottlenecks or curtailments that result in increased costs for consumers.
3. **Prioritise strategies for demand side management.** This is an untapped source of flexibility, and should be considered in terms of both residential and industrial demand. Demand should not only guide generation, but also strive for increased flexibility to better accommodate the variable patterns of renewable energy generation, particularly during peak load periods.
4. **Adapt regulations to facilitate timely innovation and the development of associated business models.** The growing electrification of transport, heating, cooling and the emergence of green hydrogen present both challenges and significant potential for flexibility.
5. **Compensate fairly the services provided to the electricity network.** This will support electrification and ensure services evolve in line with actual needs. Consumers must be actively involved, allowing them to benefit from the energy transition.

Highlights of the session

Setting the scene

In his opening remarks, Dr Huafeng Yan, Chairman and President of CEPRI, State Grid Corporation of China (SGCC), highlighted that there is a global consensus that clean electricity would be the main carrier for a sustainable energy system. To that end, the Chinese government had proposed building a new type of power system that is low-carbon, safe, affordable, flexible and intelligent. This is being done with a view to achieving peak carbon by 2030 and carbon neutrality by 2060. Building a new type of power system and widespread electrification were important pathways for energy transition, he said. He then called for a further fostering of international co-operation to promote innovation and harmonise technical standards and protocols.

Asami Miketa, Head of Energy Transition Planning and Power Sector Transformation, IRENA, then introduced the recently published IRENA flagship report, [Innovation landscape for smart electrification](#). According to IRENA's 1.5°C scenario, 51% of global total final energy consumption will be met by direct electrification and 14% by indirect electrification by 2050. The investments in infrastructure assets to transport, convert and store energy will be as significant as the investments in generation assets, she said, and need to be planned within a smart electrification strategy. She then added that innovation would be the main driver of smart electrification and must be considered in a holistic way, not only for technology and infrastructure, but also for market design and regulation, system planning and operation and business models. This is what IRENA calls 'systemic innovation'. By enabling the synergies between the different innovation dimensions, the true potential of a smart electrification strategy can be unlocked.

Bo Li, Director of International Affairs at CEPRI (SGCC), then presented China's experience with integrating a high share of variable renewables in the power system.

China's new type of power system is meant to support energy transition and the achievement of climate goals and brings profound changes to the generation mix, load characteristics, grid structure, and its operation. It entails three challenges: (1) balancing demand and production with the fluctuation of wind and solar; (2) maintaining system security and stability with regards to system frequency and voltage; and (3) deeply decarbonising the energy and electricity in particular industries.

The CEPRI director then gave some concrete examples of key technologies and practices in China. These included advanced weather prediction, voltage source converter (VSC)-high voltage direct current (HVDC) and flexible low-frequency transmission, and ultra-high voltage (UHV) transmission across regions and provinces. They also included the development of large solar and wind power bases in the Gobi Desert and other sandy areas, with an objective of generating 455 GW by 2030. A further example was the development of a platform to smartly manage China's 11 million EVs.

Norela Constantinescu, Head of Innovation at the European Network of Transmission System Operators for Electricity (ENTSO-E), then gave an overview of the ambitious outlook in Europe regarding widespread electrification of energy demand.

Europe's solar and wind capacities are expected to increase tenfold by 2050, she said. Over the same period, consumption is expected to double due to the electrification of transport, heating and cooling, and the use of electrolyzers for hydrogen. She then added that electrification also has to be considered from the system's perspective, as it needs vast volumes of flexibility and grid reinforcement. This calls for increasing co-operation between countries and greater integration between sectors, supported by digitalisation. Only a suitable regulatory framework, she said, could allow for timely development and encourage innovation. She then emphasised that electrification requires more alignment between transmission and distribution system operators, and that market design is a key enabler, allocating value where and when it is needed.

Panel discussion

Moderator: Kristian Ruby, Secretary General, Eurelectric

Panelists:

- Dr Wenpeng Luan, Advisory Expert, CEPRI
- Dr Ninghong Sun, Team Lead of System Planning, TransnetBW
- Sylvie Tarnai, Chief Strategy Officer, Energy Pool
- Luís Cunha, Board Member, EU Distribution System Operators (EU DSO) Entity and Director, EDP Distribuição
- Dr Annegret Groebel, President, Council of European Energy Regulators (CEER)

With infrastructure the backbone of the energy transition, smart electrification strategies should encompass not only infrastructure development, but also efficient uses of the existing grid. Dr Ninghong Sun, Team Lead of System Planning, TransnetBW, suggested that alternative possibilities that can reduce investment costs, such as digitalisation or demand-side response, should be examined.

Sylvie Tarnai, Chief Strategy Officer, Energy Pool, highlighted that Europe's recent negative prices underscored the need for greater elasticity on the demand side. Indeed, massive electrification accompanied by variable renewable generation necessitates a shift in the paradigm of the articulation between supply and demand. To ensure the energy transition remains affordable, consumption should not fully drive production, as has been the case until recently. Instead, it should also be able to adapt more to production patterns.

Luís Cunha, Board Member, EU DSO Entity and Director, EDP Distribuição, then explained that designing our system from the bottom up could reduce the need for infrastructure development. Citizens need to be empowered, with local community involvement potentially able to limit the need for network expansion. Investing in solar panels and electric cars, citizens can better comprehend their consumption and make the most of their own supply.

The surplus of energy can be shared within the community, and only after that should the surplus be sent to the network. Such a local approach for balancing supply and demand could naturally reduce network investment costs. Dr Wenpeng Luan, Advisory Expert, CEPRI, gave the example of China, where development of rooftop solar led to 30% electricity feedback in the network, causing major challenges and calling for greater demand-side response and storage.

In addition, the industrial sector holds potentially significant untapped flexibility. However, the realisation of this is being impeded by a lack of visibility and long-term incentives. To embark consumers on the energy transition, they need to get the fair value of their contribution to flexibility.

CEER President Dr Annegret Groebel then raised the point that regulation should allow innovation to develop, for instance by means of regulatory sandboxes. Digital tools and technological innovations, she said, would not be a bottleneck in smart electrification, even if they require certain preconditions such as smart meters. Instead, the hindrance may lie in unfit market design and a lack of business models.

Dynamic retail tariffs and grid tariffs could help send the right signals to consumers. Nonetheless, dynamic tariffs imply that consumers have a level of trust in the market, which may not be the case, especially after the recent energy crisis. Luís Cunha then said that in addition, in an unbundled system, the portion of transmission costs in the total price may not be significant enough to drive a behavioural change. Dr Wenpeng Luan then pointed out that China already uses dynamic tariffs to shift peak load and optimise V2G dispatch.

Smart electrification will be supported by the development of national or international standards and protocols for the different technologies.

POWER SYSTEMS OF THE FUTURE INFRASTRUCTURE REQUIREMENTS FOR WIDESPREAD ELECTRIFICATION

ORGANISED IN PARTNERSHIP WITH STATE GRID



GROWING CONCERNS:
AROUND THE WORLD
THE FUTURE IS RENEWABLE
JUST &

THE FOCUS MUST BE ON
*** COLLABORATION**
& WE MUST
*** DEMONSTRATE SOLUTIONS**

CLEAN - EFFICIENT - CARBON-NEUTRAL - ECONOMIC
TO SPEED UP THE GLOBAL ENERGY TRANSITION

HOW TO
UNRAVEL WE
REACH CLIMATE
GOALS!



SMART ELECTRIFICATION
OUR LATEST
INNOVATIONS

THE TRANSITION IS
PUSHED BY:
• ECONOMIC IMPACTS
• DECARBONISATION
• DIGITALISATION
• ENERGY INTERDEPENDENCY

URGENT!
SCALE UP!
10X CURRENT
DEMAND.

DRIVERS
STRATEGY

WE HAVE A TOOLBOX
TO CATER TO EACH
NEED.
BEYOND ENERGY
INNOVATIONS
→ WHAT OTHER IMPLICATIONS?

IMPLICATIONS?
• INFRASTRUCTURE
PLANNING
• CREATE FLEXIBILITY
• SMART DEMAND
• STRATEGIC SISING

SYSTEMIC INNOVATION

SEPTEMBER
25

CHALLENGES OF THE NEW TYPE OF POWER SYSTEM =

- NTPS**
- BALANCING PRODUCTION
- SYSTEM SECURITY & STABILITY
- DEEP CARBONIZATION OF ENERGY & ELECTRICITY

KEYNOTE:
NOROLA CONSTANTINESCU
HEAD OF INNOVATION
ENTS-O



WHY RENOUVERATION
STILL SO LOW?
• DYNAMIC PRICING NEEDED
• FLEXIBLE CONTRACTS
• CAN WE??

GRID
• NEED NEW STANDARDS
• PARTICIPATORY
• RENEWABLE FLEXIBILITY!

CHARACTERISTICS NTPS

- CLEAN LOW CARBON
- SAFE
- SMART & FRIENDLY
- CONTROLLED
- OPEN & INTERACTIVE

KEYNOTE:
BO LI
DIRECTOR OF INTERNATIONAL
AFFAIRS CEC

CARBON NEUTRAL EUROPE

RENEWABLES MUST BE COMBINED!



MOBILITY
• ELECTRIC MOBILITY
• GROWS HEAVILY
• SYSTEM NEEDS TO KEEP UP
• SMART CHARGING NEEDED
• PEAK CHARGING LOADS
• WITH NEW HYPER-CAROLING
POSSIBLE

HYDROGEN
• INVESTMENTS
• FLEXIBLE
• AS A STORAGE OPTION?

FOCUS ON 3 SECTORS
• DIGITALISATION & KEY
• HOUSING: HEATING & COOLING
• RETROFITTING
• INCREASED DEMAND TO COME
• FLEXIBILITY IS KEY (AGAIN)



LONG-DURATION FLEXIBILITY
• INVESTMENTS
• FLEXIBLE
• ON-DEMAND WHERE & WHEN NEEDED

T.R.U.S.T.
MUST BE A KEY PART OF THE TRANSITION!

PANEL DISCUSSION

WE NEED A LONG-TERM
R_i + P_i "DEFER"

- DIGITALIZE
- FLEXIBILITY
- ENHANCE
- EXPAND
- RENOVATE

WE NEED A HOLISTIC APPROACH
• SYNCHRONISATION IN ROLLOUT / STORAGE & DEVELOPMENT:
• CHANGE BASIS FOR INVESTMENT
• EFFICIENTLY USE CURRENT GRID

CONSUMER SHOULD PARTICIPATE & BENEFIT FROM TRANSITION

FAIR REMUNERATION DESIGN SYSTEM FROM BOTTOM-UP ALSO FOR COMPANIES, SO WHY NOT FOR INDIVIDUALS
• BUILD ENERGY COMMUNITIES
• LOWER COSTS

ANTICIPATORY INVESTMENTS
MUST BE THE FOCUS

STORAGE
AS MAIN TECHNOLOGY
• DEMAND & CUSTOMER RESOURCES; BRINGS FOCUS & CHALLENGES



CHANGE THE PARADIGM
• CONTINUE TO EMPOWER CONSUMERS
• GROW THE DEMAND - RESPONSE
• GRID TARIFFS MUST ADJUST

UNLOCK ENERGY PRODUCTION
FOR INDIVIDUAL / CONSUMER



2 SCENARIOS CONSIDERED IN REACHING GLOBAL TARGETS: KEY FINDINGS
• ENERGY INDEPENDENCE IS A BIG WIN (WIND & SOLAR)
• FLEXIBILITY STAYS KEY
• SYSTEM SECURITY & STABILITY

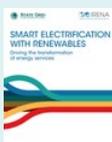
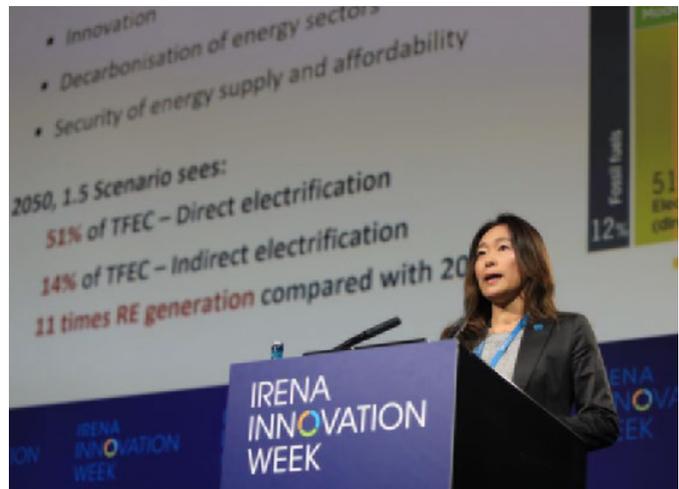
DR. WENPENG LIAN
• PEAK-SHEDDING IN FRANCE MADE POSSIBLE & WORKS WELL DUE TO GOVERNMENT POLICIES
• HEAVILY DEPENDENT TO MONITOR GRID

SYLVIE TARNAL
• PRODUCTION & CONSUMPTION PATTERNS MUST CHANGE

FOCUS!



Photographs from the session 'Power systems of the future: Infrastructure requirements for widespread electrification'



Further reading

https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Feb/IRENA_Smart-Electrification_Renewables_2022.pdf?rev=f4add985f6284a7cb811977c65b281b1

Electrifying road transport



Session organised in partnership with the Electric Power Research Institute (EPRI)

A major challenge to widespread EV adoption is ensuring that the power grid can supply increased demand with renewable-based electricity.

The adoption of EVs is accelerating globally. IRENA estimates that there will be 380 million of these vehicles in operation by 2030 and almost 1.8 billion by 2050. This massive deployment of EVs poses a challenge for the electricity system, however: can it cope with the additional demand? IRENA estimates that electricity's share of transport sector energy consumption will grow to 10% by 2030 and almost 50% by 2050.

Therefore, a major challenge to widespread EV adoption is ensuring that the power grid can supply increased demand with renewable-based electricity. EV smart charging strategies can increase renewable integration and reduce peak loads, thus decreasing grid congestion.

This session brought together different stakeholders to discuss the challenges and actions needed for smart electrifying the mobility sector. The discussion included the view of electricity regulators, city municipalities, distribution system operators (DSOs), EV manufacturers (particularly e-trucks) and innovators who are implementing smart charging projects on the ground.



Key actions

for policy makers

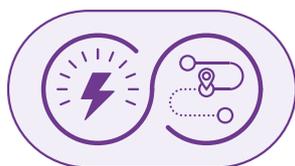
1. **Unlock demand flexibility.** For this, smart grids must be prioritised, digitalisation fostered, and demand and supply forecasts improved. The sharing of data and information among stakeholders to improve charging predictability in energy consumption patterns must be promoted.
2. **Involve customers in the process.** Their needs must be met and it must be made easy for them to participate in providing flexibility services to the grid. Smart charging technologies are already available, now price signals, through tariff design, must be created and a V2G market established so that the customers can actively or passively provide services to the grid by smartly charging their EVs.
3. **Unlock benefits from V2G charging.** This should be done by enabling access to the flexibility market, removing double taxation. Electrified fleets can offer substantial flexibility, while when managed correctly, V2G does not affect battery lifespan.
4. **Increase the adoption of EVs across society.** This should not be a mode of transport just for those with high purchasing power.
5. **Develop renewable generation close to the charging points.** This should be done so that a larger share of demand is produced locally, without impacting the grid.

Highlights of the session

Setting the scene

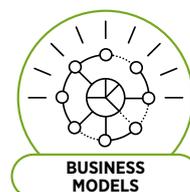
IRENA analyst Arina Anisie opened the session by introducing the power-to-mobility toolbox from [Innovation Landscape for Smart Electrification report](#). This is a collection of 35 key innovations in business models, technology and infrastructure, market design and regulation, system planning and operation. The innovation toolbox aims to offer policy makers a framework to build their own smart electrification strategies for road transport. This can be tailored to their own context and to the specifications of their power system and transport sectors.

Smart electrification strategies harness synergies between renewable electricity in the power system and the batteries of grid-connected EVs. Smart charging of EVs can integrate VRE into the grid, reducing congestion, minimising the required grid investment and decreasing peak load.



POWER TO MOBILITY

35 INNOVATIONS



- **1** EV model evolution
- **2** EV battery
- **3** Battery recycling technology
- **4** Diversity and ubiquity of charging points
- **5** Wireless charging
- **6** Overhead charging
- **7** Portable charging stations
- **8** V2G systems
- **9** Digitalisation for energy management and smart charging
- **10** Blockchain-enabled transactions
- **11** Smart distribution transformers
- **12** Smart meters and submeters
- **13** Dynamic tariffs
- **14** Smart charging: local flexibility provision
- **15** Smart charging: system flexibility provision
- **16** “Right to plug” regulation
- **17** Streamlining permitting procedures for charging infrastructure
- **18** Standardisation and interoperability
- **19** V2G grid connection code
- **20** Cross-sectoral co-operation and integrated planning
- **21** Including EV load in power system planning
- **22** Grid data transparency
- **23** Clean highway corridors
- **24** Operational flexibility in power systems to integrate EVs
- **25** Management of flexible EV load to integrate VRE
- **26** Management of flexible EV load to defer grid upgrades
- **27** EV as a resilience solution
- **28** EV aggregators
- **29** EV load peak shaving using DERs
- **30** Battery second life
- **31** EV charging as a service
- **32** Electric mobility as a service
- **33** Ownership and operation of public charging stations
- **35** A single bill for EV charging at home and on the go
- **35** Battery swapping

Siva Gunda, Vice-Chair of the California Energy Commission (CEC), then presented California's efforts to electrify transport while supporting grid reliability. California aims to be carbon neutral and use 100% clean electricity by 2045, while all new cars and trucks sold will have to be Zero Emissions Vehicles (ZEV) by 2035. In addition, over the last decade solar generation has surged 20 times in California (both utility scale and rooftop solar) and wind generation has expanded 63%. California also expects new capacity from battery storage and long duration energy storage, energy efficiency, and demand response.

Gunda pointed out that the increased frequency of extreme weather events caused by climate change, such as droughts, extreme heat and fires, also makes it difficult to fight climate change. In this context, he said, grid planning is becoming even more relevant, while demand flexibility is absolutely critical. Charging millions of EVs will introduce significant new load onto the electricity grid. CEC models project that electricity consumption in 2030 from light-duty vehicle charging will reach around 5 500 megawatts (MW) around midnight and 4 600 MW around 10 a.m. on a typical weekday. This will increase electricity demand by up to 25% and 20% at those times, respectively.

While current results indicate that non-residential charging demand will generally align with daytime solar generation, more than 60% of total charging energy will still be demanded when sunshine is not abundantly available, Gunda added. Further, a projected surge of charging demand around midnight when off-peak electricity rates take effect may strain local distribution infrastructure. To fully realise the economic, air quality and climate benefits of electrification, California must pursue greater vehicle-grid integration, he said, with the co-ordination of charging with grid needs, in order to ensure that charging is better aligned with clean, renewable electricity without sacrificing driver convenience.

Panel discussion

Moderator: Daniel Bowermaster, Senior Programme Manager, EPRI

Panelists

- Gilles Dillen, Senior Manager Foreign Investments, Renewable Energy and Cleantech at the City of Amsterdam
- Henrik Engdahl, Director - Electromobility Business Development, Volvo Trucks
- Michael Mohnhaupt, Board of Directors, The Mobility House
- Gregory Poilasne, CEO Nuvve
- Jan-Peter Sasse, Regulator, e-mobility and distribution grid, Bundesnetzagentur Germany
- Luís Cunha, Board Member, EU DSO Entity and Director, EDP Distribuição

With demand flexibility absolutely critical, there is a need to better forecast demand and supply and to digitalise the grid in order to be able to provide flexibility services. Gilles Dillen, Senior Manager Foreign Investments, Renewable Energy and Cleantech at the City of Amsterdam, explained Amsterdam's successful experience to date with deploying EVs. Now, he said, it is important to look into smart charging in order to benefit the grid and minimise the grid congestions that had started to show up in the city's grid. Dillen said that Amsterdam aims to increase the adoption of EVs across society, not just among those with high purchasing power.

Smart charging technologies are currently available, he added. However it is important to involve customers in the process, firstly to meet their needs and also to make it easy for them to participate in providing flexibility services to the grid.

The characteristics of different vehicle types (two-three wheelers, cars, buses, small and large trucks) and their use pattern also need to be considered when designing charging strategies and the flexibility services those vehicles could provide to the grid. Factors like battery size, range, and charging frequency affect the business case for these vehicles. Some trucks operate daily, while others are idle during parts of the day or for several days, which presents important considerations. Henrik Engdahl, Director - Electromobility Business Development, Volvo Trucks, made the point that trucks were typically designed for either driving or charging, offering limited flexibility. However, he added, they can offer predictability, and this is equally important because it can be planned for. The predictability of larger vehicles is indeed crucial, Engdahl added, and sharing data on their consumption and plans is essential. Decisions regarding utility investments can be informed by these plans and their predictability.

Luís Cunha, Board Member, EU DSO Entity and Director, EDP Distribuição, then explained that potential solutions to support the integration of EVs into the grid involved shifting the timing of charging from peak hours to off-peak hours. For that, he added, the tariff design is key. Tariffs need to be linked to the market price, as in Sweden. However, the market does not consider the state of the grid.

The panel discussion also delved into the roles of DSOs grid operators and V2G companies in creating price signals and establishing a V2G market.

It was emphasised that consumers should have the option to choose dynamic tariffs or not, with a better understanding of consumer preferences needed over time. It is also important to avoid both overestimating and underestimating the role and willingness of consumers. While DSOs bear significant responsibility, they are not meant to be market makers. DSOs believe that a specialised tariff is necessary, but cannot impose these tariffs, as they operate in a regulated market.

Jan-Peter Sasse, Regulator, e-mobility and distribution grid, Bundesnetzagentur Germany, then brought the view of the regulator into the discussion. He pointed out that in Germany electricity retailers are obliged to offer a tariff to the customers that is based on the spot price. He then added that together with tariff design, smart meters are crucial to support demand-side management. A new start with smart meter deployment has therefore been initiated in Germany. Sasse then emphasised that the primary challenge is to make the grid smarter, with much work needed to be done on this with distribution system operators (DSOs) and transmission system operators (TSOs).

Gregory Poilasne from Nuvve and Michael Mohnhaupt from The Mobility House then shared their successful business models.

Poilasne explained that the regulatory framework is key to enabling innovations. He added that regulation in the Nordic countries has enabled Nuvve to operate V2G charging for the last seven years and provide various grid services. In the United States, Nuvve focuses on clean school buses, which are parked most of the time and can represent a great asset to the grid. He also stressed the importance of artificial intelligence (AI) in understanding and predicting charging patterns in order to ensure smooth integration of EVs.

Mohnhaupt then presented the smart charging projects that are being carried out by Mobility House. These range from behind-the-meter optimisation to full flexibility provided by V2G integration. Some of these projects are already at the commercial stage, he said. Michael argued that an electrified fleet could offer substantial flexibility, which might even remove the need for other types of energy storage in the system. Regulators, however, need to create a level playing field, he said, so that V2G can access the flexibility market, with double taxation removed.

The panel also re-assured the audience that in the case of V2G charging, battery degradation was a concern of the past. Poilasne explained that batteries are influenced by factors such as temperature, time and depth of discharge. When managed properly, they could have a significantly extended lifespan and in Nuvve no impact of V2G charging on batteries had been observed. Engdahl then confirmed that proper management could ensure that the impact on batteries due to V2G is not a concern.

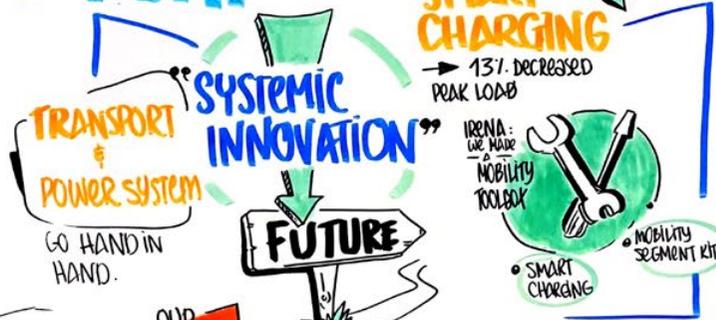
One important innovation for smart charging mentioned by the panellists was the development of renewable generation close to the charging points. This can ensure that a larger share of demand is produced locally, without impacting the grid.

ELECTRIFYING ROAD TRANSPORT



POTENTIAL: **SMART CHARGING**
 → 13% DECREASED PEAK LOAD

KEYNOTE **ARINA ANISIE**



KEYNOTE **SIVA GUNDA**



APPROACH?

- FLEXIBILITY
- OPTIMIZE LOAD
- CLEAN RESOURCES: VOLUME & DIVERSITY TO MEET RELIABILITY
- DEMAND FLEXIBILITY

RISKS?

- WILDFIRES (IN NEIGHBORING AREAS)
- DROUGHTS → LESS & ERATIC WATER
- TEMPERATURE HOTSPOTS EXTENDED

HOLISTIC

- TRANSITION OF FOSSIL FUELS
- EQUITY
- ELECTRIFY END USES
- CLEAN FUELS FOR HARD TO ELECTRIFY END USES

V2G

V2H/B

NOW AT COMMERCIAL STAGE

PANEL DISCUSSION

WHAT IS GOING ON IN AMSTERDAM?

- MORE SMART CHARGING NEEDED
- RISKY TO GRID CHARGING AS FOCUS
- MUST BE ABLE TO PAUSE CHARGING
- EASIER REGULATIONS

DSO PERSPECTIVE?

- MOVING TO OFF-PEAK HOUR FOCUS
- SMART METERS & BETTER UNDERSTANDING OF USE

MOBILITY HOUSE?

- FULL-FLEET ROLL-OUT
- WE WILL BE ABLE TO MANAGE RENAULT ROLL-OUT NEXT YEAR
- B2G IS IMPORTANT → FLEXIBILITY THAT IS CHEAP WILL BE KEY.

NIVE IN DENMARK

- PRICE IS PRETTY GOOD IN NORDIC COUNTRIES
- SCHOOL BUS PROJECT IS SUCCESSFUL



HUGE POTENTIAL

LONG-HAUL TRUCKS

- DEPENDABLE SERVICES



BIG LOAD & FLEXIBILITY IN CHARGING DURING THE NIGHT

WHERE TO INVEST FIRST?

WHERE TO INVEST FIRST?



DOUBLE TAXATION MUST BE REMOVED

CONGESTION MANAGEMENT IS NOT CLEAR YET! WHICH MECHANISMS?

WHO DECIDES TARIFFS?

EV CHARGES APPEARING IN PLACES WITH NO REVENUE → TREASURY PLAN NEEDED

IN GERMANY DELAY IN SMART METERS, BUT REGULATION CAN MAKE DIFFERENCE

SOLUTIONS SHOULD BE SIMPLE FOR CONSUMERS

- BE IN CONTACT WITH CONSUMER PROTECTION AGENCIES & REALLY LISTEN TO THEM.

SITUATION DIFFERS IN THE EU: WHEN PEOPLE CAN CHARGE THEIR EV. FOR EX

WE MUST ORGANISE FROM THE BOTTOM UP!

TIME-SHIFTING?

IN AMSTERDAM? → SMART CHARGING WITH DSO → BLOCKCHAIN

CHALLENGES:

BATTERY 2ND USE: → CONFLICT OF COMPETENCE? → DEPENDS ON SITUATION

IMPACTS ON: BATTERY LIFE

TEMPERATURES

HUMAN CHALLENGES: HOW TO PREDICT...

COST OF ENERGY?

Photographs from the session 'Electrifying road transport'



Electrifying heating and cooling in buildings



Session organised in partnership with the European Heat Pump Association (EHPA)

The heating and cooling sector represents roughly half of global energy consumption.

This session brought insights into how to decarbonise the heating and cooling sector, which represents roughly half of global energy consumption.

The session brought together experts from different contexts who shared their expertise and contributed to a discussion which evolved around the need to combine energy efficiency measures with electricity-based solutions. It also focused on mechanisms for mobilising investment that would ensure the transformation of the sector without compromising the power system.

The discussion also emphasised the need for the smart operation of heat pumps and for the adoption of flexibility sources that allowed grid operators to manage grids better. It also looked at the possible role of aggregators and energy communities in sectoral electrification.



Key actions

for policy makers

1. **Revise energy carrier taxation** to provide the right incentive for the electrification of heat, meaning large-scale deployment of heat pumps.
2. **Ensure that renovation rates** of building stocks increase in parallel with the roll-out of power-to-heat/cooling solutions, to ensure increased energy efficiency and decrease demand.
3. **Design effective policies by assessing and understanding the local context.** This includes the local climate, the energy sources available, the regulations in place and socio-cultural aspects, as well as industry involvement.
4. **Change the social perception of heat pumps** as burdensome and expensive solutions.
5. **Strengthen co-operation between government and industry.** This is especially important for large scale projects that demand faster permitting procedures.
6. **Improve urban planning.** This should enable successful district cooling and heating projects.

Highlights of the session

Setting the scene

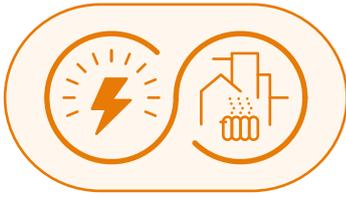
IRENA analyst Juan Pablo Jiménez provided an overview of how electrification is expected to take place in the lead up to the 2050 energy goals.

Based on IRENA's 1.5°C Scenario, the share of electricity taken by buildings is expected to reach 73% of total final energy consumption by 2050. This implies moving from 58 million heat pumps in 2020 to 793 million in less than 30 years.

Jiménez then presented Italy as an example where heat pump costs have declined – a trend in many countries. In Italy's case, the cost of small-scale air-to-air heat pumps – those up to 5 kilowatt thermal capacity (kWth) – has fallen by almost 50% between 2016 and 2019. Driven by these reduced costs, markets have shown significant increases in sales. Since 2021, high natural gas prices in Europe have also added to the appeal of heat pumps there. Yet, in other markets such as Japan, where 86% of households have at least one air-conditioner unit, China or the United States, heat pumps are also rapidly gaining market share.

The technology to decarbonise the heating and cooling sector for buildings (low-temperature heating) is available at high efficiencies and at more competitive prices. However, smart electrification strategies are also key, so that the operation of an increasing number of heat pumps is done in a smart way. This would be a way in which peak demand is minimised, grid congestion is reduced and flexibility is provided to the power system.

Jiménez then briefly introduced IRENA's [Innovation landscape for smart electrification](#) report stressing the idea that there is no 'one-size-fits-all' solution for smart electrification. He also said that IRENA's in-house toolbox is available for policy makers to help them design their local, regional, or national strategies for the decarbonisation of the building sector, adding that the toolbox took a systemic innovation approach.



POWER TO HEAT AND COOLING

35 INNOVATIONS



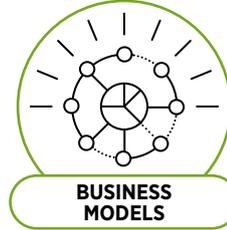
TECHNOLOGY AND INFRASTRUCTURE



MARKET DESIGN AND REGULATION



SYSTEM PLANNING AND OPERATION



BUSINESS MODELS

- **1** Low-temperature heat pumps
- **2** Hybrid heat pumps
- **3** High-temperature heat pumps
- **4** Waste heat-to-power technologies
- **5** Medium- and high-temperature electricity-based applications for industry
- **6** Low-temperature TES
- **7** High-temperature TES
- **8** Fourth-generation DHC
- **9** Fifth-generation DHC
- **10** IoT for smart electrification
- **11** AI for forecasting heating and cooling demand
- **12** Blockchain-enabled transactions
- **13** Digitalisation as a flexibility enabler
- **14** Dynamic tariffs
- **15** Thermal load flexibility
- **16** Flexible PPAs
- **17** Standards and certifications for improved predictability of heat pump operation
- **18** Energy efficiency programmes for buildings and industries
- **19** Building codes for power-to-heat solutions
- **20** Streamlining permitting procedures and regulations for thermal infrastructure
- **21** Holistic planning for cities
- **22** Heat and cold mapping
- **23** Coupling cooling loads with solar generation
- **24** Smart operation with thermal inertia
- **25** Smart operation with seasonal thermal storage
- **26** Smart operation of industrial heating
- **27** Combining heating and cooling demand in district systems
- **28** Aggregators
- **29** DERs for heating and cooling demands
- **30** Heating and cooling as a service
- **31** Waste heat recovery from data centres
- **32** Eco-industrial parks and waste heat recovery from industrial processes
- **33** Circular energy flows in cities – booster heat pumps
- **34** Community-owned district heating and cooling
- **35** Community-owned power-to-heat assets

Notes: AEM = anion exchange membrane; AI = artificial intelligence; ALK = alkaline; DER = distributed energy resources; DHC = district heating and cooling; EV = electric vehicle; IoT = Internet of Things; PEM = polymer electrolyte membrane; PPA = power purchase agreement; P2P = power-to-power; SOEC = solid oxide electrolyser cell; TES = thermal energy storage; TSO = transmission system operator; VRE = variable renewable energy; V2G = vehicle to grid.

Mr. Yoichi Fujita, Technical Researcher at Japan's New Energy and Industrial Technology Development Organisation (NEDO) then shared Japan's plans for accelerating the deployment of heat pumps from a policy, market and R&D perspective.

In Japan, he said, there is a plan for global warming countermeasures. The 6th edition of the country's strategic energy plan also sets goals for the deployment of heat pumps in the residential, commercial and industrial sectors.

So far, Japan seems to be on track to achieve its 2030 goals. These are: 1 673 MW of industrial heat pumps; 90 000 heat pumps in the commercial sector and 15.9 million heat pumps in the residential. Mr. Fujita then introduced Japan's Top Runner Programme. This aims to increase the efficiency of air conditioners, electric heat pumps and water heaters, amongst other appliances. In addition, heat pumps are also subject to energy efficiency labelling.

Japan has also made subsidies available for investment in energy conservation projects and in equipment such as heat pumps and refrigerators. There are also subsidies for residential, high-efficiency domestic hot water (DHW) heaters and for net-zero energy buildings, the construction of which also benefits heat pump demand.

Mr. Fujita then gave an idea of the size of the Japanese market for heat pumps by saying that 9 million units had been sold in 2022, after sales had peaked in 2020.

All market segments in Japan – including residential room air conditioners, commercially packaged air conditioners, and residential and commercial heat pumps for water heating – show positive or stable sales trends, Mr. Fujita said.

He then added that Japan is also investigating the use of waste heat. The country is developing some flagship projects in this that aim to reduce, recover and reuse untapped thermal energy. On top of this, Japan is allocating resources to deploy high-temperature heat pumps and heat recycling absorption chillers under this waste heat initiative.

Heat pumps should be a commodity: They should be everywhere, yet visible to no one

Thomas Nowak, Secretary-General of the EHPA

Before moving on to the panel discussion, Thomas Nowak, Secretary-General of the EHPA, gave some insight into the potential role of heat pumps in the grid of the future.

He highlighted the fact that in just four years – from 2018 to 2022 – the number of heat pumps in Europe has doubled. He then said, however, that regulators should provide the right signals to activate end-user interest and investment. This meant that policy makers should correct, to whatever extent was possible, the high cost of electricity versus natural gas. Today, the cost of electricity is roughly twice that of natural gas, he said. The secretary-general concluded by mentioning the EU Heat Pump Accelerator initiative, which aims to further accelerate the roll-out of heat pumps.

Panel discussion

Moderator: Thomas Nowak, Secretary-General, EHPA

Panellists:

- Stefan Moser, Head of Unit for Buildings and Products, European Commission
- Kazuyoshi Nakano, Senior Research Scientist, Central Research Institute of Electric Power Industry (CRIEPI)
- Matthias Grapow, Vice-President Business Development and Digitalisation, MAN Energy Solutions (MAN ES)
- Ezzeddine Jradi, Chief Transformation and Business Excellence Officer, Emicool District Cooling Company, Dubai

The panel discussion began by asking a key question: what are the innovations missing from the market that would result in a faster deployment of heat pumps? According to Stefan Moser, Head of Unit for Buildings and Products, European Commission, we need to go beyond simple technological acquisition to a full systemic integration of heat pumps. Society's perceptions of heat pumps must be changed, he said, because for many people they are currently considered burdensome and expensive.

We need to make heat pumps the standard, the normal

Stefan Moser, Head of Unit for Buildings and Products, European Commission

Kazuyoshi Nakano, Senior Research Scientist for CRIEPI, then stressed the importance to Japan of coupling heat pumps with solar PV, as well as the need for manufacturers to implement pricing strategies. Matthias Grapow, Vice-President Business Development and Digitalisation, MAN Energy Solutions (MAN ES), then raised the need for project size to be scaled up. He said that the Scandinavian market offered a great opportunity for large-scale heat pumps because of cheap electricity. Large-scale heat pumps could replace coal-based generation plants, he added. Some of the projects developed by MAS ES had switched off coal-fired power plants, replacing them with heat pumps that take heat from seawater and electricity from wind energy.

Promoting large scale heat pump projects means switching off coal-fired power plants and using seawater heat and green electricity instead

Matthias Grapow, Vice-President Business Development and Digitalisation, MAN Energy Solutions

Next, Ezzeddine Jradi, Chief Transformation and Business Excellence Officer, Emicool District Cooling Company, Dubai, gave an insight into what elements are necessary for success in a district cooling project. Some of these elements relate to the creation of cooling as a service, he said, which means users can be metered and thus better understand their own energy consumption. The aggregation of demand via district cooling also helps reduce the peak loads, he added.

The concept of district cooling harnesses innovations across all dimensions, including technology, the market, regulation and business models

Ezzeddine Jradi, Chief Transformation and Business Excellence Officer, Emicool District Cooling Company, Dubai

Concerning district cooling and the amount of heat released into the environment, the EHPA secretary-general pointed out the need for waste heat legislation that would force users to recover waste heat whenever possible. On that front, Moser indicated that such legislation is key for systemic efficiency. This, he said, included industrial symbiosis with other energy users, meaning that synergies should be created among a network of different companies. Cities should also be built with their entire system thought through, in order to maximise integration.

Digging deeper into the policy dimension, the European Commission buildings unit head then indicated that service markets were better reflected in new policies that tried to follow a systemic approach, establishing heating and cooling as commodities.

Another key aspect of the discussion was the resilience of the electricity grid in incorporating the number of heat pumps needed. In this sense, heat pumps could potentially operate as grid stabilisers, it was suggested.

On this issue, Grapow said that large-scale projects could be much more effective in unbundling supply and demand. This is because large-scale projects could operate in a more co-ordinated way with the grid and take advantage of thermal storage. These factors helped reduce peak demand periods. Similarly, district cooling could offer similar opportunities in decoupling supply and demand by taking advantage of large-scale thermal storage. In the Middle East, cooling storage is a way to achieve resilience and efficiency, he said.

Another important issue tackled in the discussion was the issue of permitting for a faster deployment of heat pumps.

In the case of the Middle East, in particular the United Arab Emirates, the focus of regulation has been on the protection of consumers. There, district cooling is a new utility and many consumers do not understand tariffs, the obligations of providers, liabilities and other factors. District cooling is a complex ecosystem and involves many stakeholders. Therefore, regulation should focus on understanding how to operate and on government permitting. Regulation also guarantees the quality of service.

From the MAN ES perspective, Grapow said, the technical aspect of permitting is crucial for the execution of large-scale projects. In some cases, a long delay in permitting makes the initially-planned technology outdated. According to CRIEPI's Nakano, it is essential to combine permitting and regulation with effective incentives. Moser then added that permitting could be accelerated without compromising legitimacy and should be done in an efficient manner.

To accelerate electrification, we need to accelerate permitting

Matthias Grapow, Vice-President Business Development and Digitalisation, MAN Energy Solutions

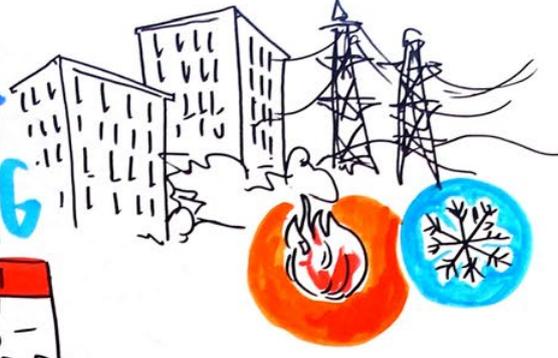
When talking about the biggest challenge in the adoption of heat pumps, Jradi then explained that in the Middle East context, cooling should start with urban planning. It is important to understand the role of cooling, he said. Getting funding is also a challenge. A lot of investment is going into green projects, but the investment climate should have duration in order to bring a proper return on investment.

Cooling should start with urban planning

Ezzeddine Jradi, Chief Transformation and Business Excellence Officer, Emicool District Cooling Company, Dubai

Grapow then said that there is a need to integrate heating and cooling, as well as have a full assessment of the different challenges requiring communication, while working together with citizens. In Japan, the integration of EV and electric houses is more relevant than the integration of heating and cooling pumps, for example, because the thermal sector is already largely electrified. The challenge ahead in the residential sector then related to e-mobility.

ELECTRICIFYING HEATING & COOLING OF BUILDINGS



DAY 1
SESSION
- 3 -

MATIAS CRAPANZANO (MAN ES)

We need **LARGE-SCALE PROJECTS** ESSENTIAL FOR **UNBUNDLING** HEAT SUPPLY & DEMAND

JUAN PABLO JIMENEZ IRENA

INNOVATIONS ACROSS ENTIRE ENERGY VALUE CHAIN NEEDED

FRANCO NUNO (E.H.P.L.)

HEAT PUMPS SHOULD BE A COMMODITY: THEY SHOULD BE EVERYWHERE & VISIBLE TO NO ONE.

ALIGN FINANCES & CLEAR INFO

DEPLOYMENT NEEDS TO INCREASE: 58 MI TO 793 MI ACCORDING TO NETO2023

RENOVATIONS! MUST BE SUPPORTED & SUBSIDIZED

ELIZABETH STRAIN (SINTECOP)

RIGHT COMMUNITIES & PROFITERS IS VITAL FOR ADOPTION
COOLING STARTS WITH URBAN PLANNING

END USERS MUST BE PART OF THE SOLUTION

COST OF ELECTRICITY TO COST OF GAS RATIO MUST BE AROUND 2. → FOR CONSUMER SAVINGS

UNDERSTAND LOCAL CONCEPTS

STEPH MORRE (EU COMMISSION)

SOCIETY THINKS HEAT PUMPS ARE BURDENSOME & EXPENSIVE, WE MUST CHANGE THIS PERCEPTION!

KAZUYOSHI NAKANO (C)

ENERGY LABELLING DESIGNS FOR AIR-CONDITIONERS & HP/HS

POLICY MUST BE CLEAR

EMPHASIZE **LONG-TERM BENEFITS**

MANAGING THERMAL WASTE

→ CIRCULAR ECONOMY
→ EFW FACILITIES

PERMITS MUST ENABLE FAST ADOPTION

GOVT. SUPPORT & CONSUMER EDUCATION

Photographs from the session 'Electrifying heating and cooling in buildings'



Walking the last mile of the energy transition with hydrogen

A systemic approach



Session organised in partnership with the Organisation for Economic Co-operation and Development (OECD)

Green hydrogen represents a key, last-mile solution for the achievement of net-zero emissions by mid-century.

While energy efficiency and renewable energy sources can reduce most emissions, green hydrogen is necessary in challenging scenarios where direct renewable electricity use is impractical or costly. For this reason, green hydrogen represents a key, last-mile solution for the achievement of net-zero emissions by mid-century.

To turn ambitious green hydrogen plans into action, however, systemic innovation is essential. This includes regulatory improvement, policy enhancement and the addressing of finance, infrastructure, and scalability issues throughout the value chain.

The session detailed below convened a number of experts in order to enhance our understanding of how innovation in green hydrogen can help decarbonise hard-to-abate sectors with renewable electricity, while maintaining reliable and affordable energy system infrastructure. The session covered key innovation aspects, such as enabling technologies, market design, financing solutions and regulations, with a focus on identifying and enabling deployment pathways for green hydrogen projects.



Key actions

for policy makers

- 1. Prioritise systemic innovation in the development and implementation of long-term policies that encourage and facilitate financing for green hydrogen projects.**

This prioritisation should focus on enhancing efficiency and competitiveness, allocating resources for research and innovation in green hydrogen technology and infrastructure. It can thus form a foundation for national policy roadmaps.
- 2. Establish mechanisms to scale up financing for green hydrogen project development.** Policies should be created that identify finance and market solutions that unlock investments. They should also address offtake risks and promote the use of innovative financing instruments to reduce the cost of capital, making green hydrogen projects financially viable.
- 3. Recognise and support industries as key drivers of hydrogen consumption up to 2030.** These industries include chemicals, cement, refineries, ammonia and steel. Policies should encourage innovation and business models for long-duration flexibility.
- 4. Implement policies aimed at streamlining hydrogen certification and permit processes.** This should enable the more rapid development of local hydrogen markets.
- 5. Collaborate with multiple stakeholders throughout the hydrogen value chain.** This will assist in understanding industry barriers and financing challenges. Policy frameworks should be developed that mitigate risk and support the development of green hydrogen.
- 6. Give careful consideration to the socio-economic impact and the specific needs of local communities** when designing the optimal policy framework for hydrogen development.

Highlights of the session

Setting the scene

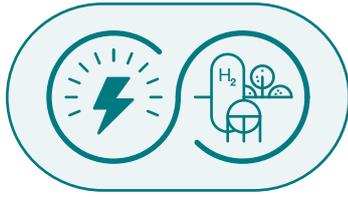
Francisco Boshell, Head of Innovation and End-Use Sector Applications at IRENA, began the session by underscoring the importance of innovation in accelerating the production of renewables-based hydrogen.

His presentation showed that under IRENA's 1.5°C Scenario, global hydrogen supply needs to increase six-fold by 2050. IRENA projects that, by then, 94% of the hydrogen supply would consist of green hydrogen, while the remaining 6% of blue hydrogen.

To integrate hydrogen electrolyzers into power systems effectively, a smart approach is also required, he said. This approach involves capitalising on synergies with renewable energy generation and utilising electrolyzers as providers of flexibility.

Boshell's presentation further highlighted that in order to achieve these objectives and address the challenges of scaling up hydrogen production, substantial innovation is needed across a variety of areas. These include green hydrogen technology, infrastructure, market design, regulation, system planning and operation, and business models.

In addition, IRENA then presented its latest publication, [Innovation landscape for smart electrification](#), which outlines 30 systemic innovations aimed at overcoming these challenges in a section dedicated to power-to-hydrogen.



POWER TO HYDROGEN

30 INNOVATIONS



TECHNOLOGY AND INFRASTRUCTURE

- **1** Pressurised ALK electrolyser
- **2** PEM electrolyser
- **3** SOEC electrolyser
- **4** AEM electrolyser
- **5** Compressed hydrogen storage
- **6** Liquefied hydrogen storage
- **7** Hydrogen-ready equipment
- **8** Digital backbone for green hydrogen production
- **9** Hydrogen leakage detection



MARKET DESIGN AND REGULATION

- **10** Additionality principle
- **11** Renewable PPAs for green hydrogen
- **12** Cost-effective electricity tariffs
- **13** Electrolysers as grid service providers
- **14** Certificates
- **15** Hydrogen purchase agreements
- **16** Carbon contracts for difference
- **17** Regulatory framework for hydrogen network
- **18** Streamlining permitting for electrolyser projects
- **19** Quality infrastructure for green hydrogen
- **20** Regulatory sandboxes



SYSTEM PLANNING AND OPERATION

- **21** Electricity TSOs including hydrogen facilities in their planning
- **22** Co-locating electrolysers with renewable generators (onshore and offshore)
- **23** Smart hydrogen storage operation and P2P routes
- **24** Long-term hydrogen storage
- **25** Co-operation between electricity and gas network operators



BUSINESS MODELS

- **26** Local hydrogen demand
- **27** Hydrogen trade
- **28** Hydrogen industrial hub
- **29** Revenues from flexibility provided to the power system
- **30** Sale of electrolysis by-products (oxygen and heat)

Notes: AEM = anion exchange membrane; AI = artificial intelligence; ALK = alkaline; DER = distributed energy resources; DHC = district heating and cooling; EV = electric vehicle; IoT = Internet of Things; PEM = polymer electrolyte membrane; PPA = power purchase agreement; P2P = power-to-power; SOEC = solid oxide electrolyser cell; TES = thermal energy storage; TSO = transmission system operator; VRE = variable renewable energy; V2G = vehicle to grid.

Deger Saygin, Industry Programme Lead of the Environment Directorate at the OECD, then highlighted the importance of scaling up financing to expedite the development of green hydrogen. This included the Clean Energy Finance and Investment Mobilisation (CEFIM) mechanism, he said. The CEFIM assists emerging and developing economies in reaping benefits across the entire hydrogen value chain. His presentation then elaborated on the necessity of identifying the right financing and market solutions to unlock investments in capital-intensive technologies, such as green hydrogen. This process involved mitigating offtake risks and utilising innovative financing instruments to reduce the cost of capital, making green hydrogen projects financially viable.

Alicia Eastman, President and Co-founder of InterContinental Energy, then discussed the delivery of green hydrogen and ammonia projects at national and local scales by showcasing four different projects supported by InterContinental Energy. Her presentation highlighted the role of InterContinental Energy in using foreign direct investment (FDI) to support ammonia projects. She further emphasised the significant potential role of ammonia as a shipping and air fuel.

Panel discussion

Moderator: Gokce Mete, Global Lead Hydrogen and Industry Transition, South Pole

Panellists:

- Ulf Bäumer, Head of Innovation Centre and Service and Digitalisation, Thyssenkrupp Nucera
- Donal Cannon, Head of Regional Representation for South Asia, European Investment Bank (EIB)
- Norela Constantinescu, Head of Section Innovation, Entso-e
- María Jaén, European Hydrogen Research Leader, EPRI
- Francisco Maza, Hydrogen Director, REPSOL
- Mark van Stiphout, Deputy Head of Unit – Research, Innovation, Digitalisation, Competitiveness at DG Energy – European Commission

The demand for green hydrogen is expected to grow rapidly, said Mark van Stiphout, Deputy Head of Unit – Research, Innovation, Digitalisation, Competitiveness at DG Energy – European Commission. He then shared the information that the EU has revised the green hydrogen consumption forecast for its member states from 5 million tonnes (Mt) to 20 Mt by 2030, with 10 Mt to be imported and 10 Mt to be produced in Europe. Globally, this would equate to between 160 GW and 200 GW of electrolyser capacity and approximately 400 GW of renewables required by 2030. He then highlighted that achieving this requires an enormous ramp-up within the next seven years.

Francisco Maza, Hydrogen Director, REPSOL, then said that the primary focus up to 2030 would not only be on technological innovation, but also on improving efficiency. He highlighted the need to accelerate the learning process and secure financing, all while drawing from industry experiences and working within a stable regulatory context.

Ulf Bäumer, Head of Innovation Centre and Service and Digitalisation, Thyssenkrupp Nucera, then added that enhancing the efficiency of electrolyzers is the most pressing action, as this could reduce both the required installation capacity and the cost of hydrogen production. Electrolyzers needed to become more efficient, cost-effective and larger in scale, he said, to ensure the availability and affordability of hydrogen, while preparing for the next generation of electrolyzers to enter production in 2030.

To meet our targets, he then added, we needed to concentrate on technologies that could be scaled up immediately. He said that considering the challenges – which include reaching 1 terawatt hour (TWh) of electrolysis capacity by 2050 just to replace grey hydrogen, plus an additional 5 TWh to meet total hydrogen demand – innovation should prioritise the actions required in the near future.

Norela Constantinescu, Head of Section Innovation, Entso-e, then said that up to 2030, the major drivers of hydrogen consumption will be industries such as chemicals, cement, refineries, ammonia and steel. She added that beyond this, green hydrogen could play a crucial role in providing long-duration flexibility, which requires substantial investments and innovation in business models.

She then said that optimising human, material and financial resources to accelerate green hydrogen development is crucial. This involved implementing long-term and sustainable regulations, as well as finding the right financing solutions to secure capital for mid- and long-term needs, particularly for projects in emerging markets and developing economies.

Constantinescu then highlighted that green hydrogen could play a pivotal role in the integration of renewable energies for the energy transition. She added that to enable the integration of renewables and green hydrogen, the electricity grid needed to be digitalised. This digitalisation would need to enable decision support and optimisation in operating the various assets of the energy system, while also ensuring cybersecurity.

Providing the right type of finance during the pre-commercial development phase is a key innovation required to accelerate the deployment of hydrogen projects, she said. Multilateral development banks (MDBs), such as the EIB, could overcome these challenges by using blended finance to provide grants and technical assistance.

Donal Cannon, Head of Regional Representation for South Asia, European Investment Bank (EIB), then pointed out that in the green hydrogen sector, economies of scale are less pronounced than in wind and solar energy. As a result, the focus had shifted to electricity costs, underscoring the significance of engaging solar-rich countries. He then said that in order to ensure fairness and sustainability, it is essential to establish frameworks that encompass environmental and social benchmarks, impartial assessments and criteria for enhanced access to electricity and water resources.

María Jaén, European Hydrogen Research Leader, EPRI, agreed that innovation and the rapid expansion of infrastructure for green hydrogen are essential. She then emphasised the importance of considering hydrogen compatibility with existing pipeline materials, especially with transmission pipelines, when innovating pipeline infrastructure. In addition, she pointed out that compression stations may need replacement when hydrogen blending exceeds 20%. Furthermore, in the design of pipelines, it is crucial to take into account the higher velocity of hydrogen due to its lower energy density. This consideration may lead to the need to place compression stations closer to each other, especially when repurposing natural gas pipelines for hydrogen.

The discussion then highlighted that partnerships are also needed to support multiple industries, including chemicals, refineries, ammonia production and steel, as they explore the replacement of natural gas with green hydrogen for emissions reduction. Similarly, sectors like heavy-duty transportation, maritime, shipping and aviation are considering hydrogen fuel cells for cleaner operations. Collaborations involving governments, research institutions, hydrogen producers and industries are essential, the participants felt, in understanding specific needs and facilitating the integration of green hydrogen.

Cannon then drew attention to the fact that governments require technical assistance to facilitate their engagement with private companies developing green hydrogen projects. This assistance encompasses critical areas such as procurement, standard setting and certification, he said. He then emphasised that in these respects, the public sector requires substantial technical support.

WALKING THE LAST MILE OF THE ENERGY TRANSITION with GREEN HYDROGEN

• IN PARTNERSHIP WITH OECD •



WILL BE **ESSENTIAL** FOR CERTAIN SECTORS
 NEEDS TO GROW
 * 6x
 * 94% GREEN
 * 6% BLUE
 * NOW MORE FLEXIBLE

SUPPLY

TRADE

130 MILLION TONNES PIPELINES 70MT SHIPPING 60MT HARMONISATION: EU, JAP, S-KOREAN MARKETS

DEMAND

KEY ELEMENTS?
 • INNOVATION NEEDED FOR MECHANISMS HOW TO ENSURE LOW CARBON?
 • INFRASTRUCTURE IN IMPORT AREAS
 WE MUST **INNOVATE TO PLAN!**

FINANCING



EMERGING & DEVELOPING ECONOMIES WITH KEY ROLES IN PRODUCTION & IMPORT.
 ENDURING CONDITIONS?
 BARRIERS? FINANCIAL RISKS?

RIGHT ENABLING CONDITIONS IS ESSENTIAL

HOW TO CLOSE THIS GAP?
 SURVEY: OECD'S H2 GREEN STEEL EXPANSE: CAPITAL (HEAVY!)
 OFFTAKER: TRY AREA TO LOOK AT
 CURRENCY: FINANCING MODEL ALSO PLAY BIG ROLE

PUBLIC SECTOR INTERVENTION NEEDED



LOOKING FOR PERFECT LOCATIONS WITH SUN & WIND TO GET TO **75% CAPACITY FACTOR**

4 PROJECTS

WITH VARIOUS PARTNERS WITH CIG (ICE AS STRATEGIC PARTNER)
 • GEO - 25 GW
 • SAUDI - 10 GW
 • U.A.E - 50+ GW
 • AREH - 2.6 GW

LARGE PROJECTS!

WE NEED BEST EXECUTION OF PROJECTS FOR LOCAL COMMUNITIES
 AMMONIA IS MOST EFFICIENT & MAKES MOST SENSE AS 0-EMISSION FUEL IN SHIPPING: 1-2 YEARS FOR NEW SHIPS! (15-20 YEARS NEEDED FOR PLANES)



MOST IMPORTANT INNOVATION?
 HOW TO AVOID ENERGY-COLONIALISM?

INFRASTRUCTURE LOCATIONS?

HOW TO KEEP THE HUB IN THE EU?
 ELECTRICITY GRID CONNECTED & STORAGE MORE FEASIBLE
 MANY DIFFERENT USES: SHIPPING, BIG VEHICLES, PLANS
 LARGE SCALE STORAGE WILL BE UNDERGROUND



EFFICIENCY

CHALLENGES IN MATERIALS: HYDROGEN, NATURAL GAS BLEND
 ELECTROLYZERS: HOW WILL THEY WORK?
 TECHNOLOGY & DECISIONS WITH NEED TO SCALE & POTENTIAL FOR EXPORT - BY UNDERSTANDING MARKET: IMPORTS MAY BE POSSIBLE FOR SPAIN AS WELL - SPAIN HAS BIG POTENTIAL FOR EXPORT

INTERNATIONAL COLLABORATION = KEY!



UP TO 2030: MAIN DRIVER IS INDUSTRY
 • OFFSHORE FIELDS
 • STOCKING INVESTMENT
 • MORE INNOVATION NEEDED

FEASIBLE?

BETTER UNDERSTAND RISKS & MITIGATE

INDUSTRIAL PARTNERS ARE ESSENTIAL



LOCATION & TRANSPORTATION MUST BE BLAZED UP FAST
 ALKALINE H2O IS THE TECHNOLOGY FOR THIS SCALE
 PUBLIC FINANCE IS SCARCE!
 TO MITIGATE RISKS

FINANCING

PRICING IS A CONCERN FOR THE EU
 BUT OUR INVESTMENTS IN ENERGY EFFICIENCY & ENERGY AUTONOMY ARE KEY WAYS TO CONTINUE TO BE A HUB



ELECTROLYZERS CAPACITY IS MAIN INNOVATION
 • BIGGER
 • CHEAPER
 • MORE EFFICIENT

LESS RELIANCE ON ENERGY IMPORTS
 IN THE EU WE WANT 20GW CAPACITY!
 PREP TO SCALE UP WITH INCREASED INVESTMENT & AMBITION

FAIR?

CHALLENGE: FINDING RIGHT FINANCING
 PROJECTS MUST BE SPREAD UP WITH REGULATION

SHORT VALUE-CHAIN: 1-STR - 1-SECTOR
 • AMMONIA -> FOCUS
 • STEEL EXPORT -> DUE TO DRIVE FOR SUSTAINABILITY



SIGNIFICANT UPTAKE IN INTEREST FOR THE EU
 JUMP IN SCALE!

50-400MM CAPACITY!

INDIA IS DOING WELL
 SUB-SAHARAN REGIONS ARE AT RISK OF ENERGY COLONIALISM
 SOLAR RICH COUNTRIES IN POOR REGIONS AT RISK - BUT
 ACCESS TO GRID & TO LABOUR
 WATER HAS HUGE POTENTIAL FOR GREEN H2
 WE MUST ALSO DO SOCIO-ECONOMIC INVESTMENT

Photographs from the session 'Walking the last mile of the energy transition with hydrogen'





Solutions for decarbonising the iron and steel sector



Session organised in partnership with the World Steel Association (WSA)

How IRENA and WSA can support the iron and steel sector in the transition.

The session focussed on the pressing challenges and the innovations needed to decarbonise the iron and steel industry. The panellists shared their insights into innovations required in policy, technology, infrastructure, and skill requirements that can support the sector's transition. The session also discussed how IRENA and WSA can support the iron and steel sector in the transition.



Key actions

for policy makers

1. **Revise electricity market designs to adopt low-cost renewables and simplify permitting processes.** This would accelerate renewables deployment in steel production.
2. **Establish standardised carbon accounting guidance and regulations.** This should be done in line with globally recognised methodologies in order to measure and reduce emissions effectively.
3. **Improve infrastructure to support a low-carbon steel industry.** This includes developing hydrogen and CO₂ transport and storage networks.
4. **Use green public procurement practices to boost demand for low-carbon steel products.**
5. **Develop both financial and non-financial incentives.** These can support the growth of capital-intensive, low-carbon steel initiatives.
6. **Promote skills development and knowledge exchange.** This should be done in collaboration with the private sector and universities. This can address the need for a skilled labour force with expertise in renewable energy and green steel production processes.

Highlights of the session

Setting the scene

Luis Janeiro, Team Lead, End-Use Sectors at IRENA, opened the session by discussing the steel industry's vital role in human development and the metal's widespread use in various sectors. The production processes in use by the industry, however, are significant sources of CO₂ emissions. In order to address this, the transformation of the steel sector is imperative, he said, particularly given increasing demand for steel, worldwide.

To achieve this transformation, optimising steel use, maximising recycling and enhancing process efficiency is necessary, while also transitioning to clean energy sources such as renewables and low-carbon hydrogen. This transformation requires systemic innovations in policy and regulation, technology, business models, and workforce skills.

Panel discussion

Moderator: Andrew Purvis, Director, Sustainable Manufacturing, WSA

Panellists:

- Christopher Gusek, Head of Steel Technology, H2 Green Steel
- Robert Jan Jeekel, Head of EU Institutional Affairs, ArcelorMittal Europe
- José Noldin, Chief Executive Officer, GravitHy
- Samuel Flückiger, Head of EU Climate Policy, thyssenkrupp Steel Europe

Beginning the discussion, Robert Jan Jeekel, Head of EU Institutional Affairs, ArcelorMittal Europe, said that steel producers have difficulties in accessing sufficient volumes of low-cost renewable electricity. A decarbonised steel industry would rely to a significant extent on the use of renewable power to produce green hydrogen, substituting coal as a source of energy and as a reducing agent. However, he then noted, if steel producers faced challenges accessing sufficient volumes of low-cost renewable electricity, that would hinder their transition to emissions reduction. To address this issue, revising market designs and streamlining permitting processes to boost the deployment of renewable energy sources is critical.

Samuel Flückiger, Head of EU Climate Policy, thyssenkrupp Steel Europe, then said that efforts are needed to establish a robust policy and regulatory environment. He emphasised that there is a need to develop clear standards and certification schemes to ensure a common measurement system for CO₂ emissions. Jan Jeekel then added that providing the correct type of incentives to encourage businesses to adopt environmentally friendly practices is also essential. Additionally, green public procurement could play a significant role in driving demand for low-carbon steel.

Christopher Gusek, Head of Steel Technology, H2 Green Steel, then pointed out that while green steel technology is already available, there are still technical barriers to its adoption. As an example, he said that raw material supply could be a challenge. This includes the supply of sufficient high-grade iron ore needed for direct reduction furnaces. However, he then said that technology is always improving and we could potentially address this concern. Flückiger then mentioned the Thyssenkrupp Steel strategy. In this, a direct reduced iron (DRI) smelter was using low-grade iron ore.

Flückiger also noted that insufficient infrastructure is hindering the transition to a low-carbon iron and steel sector. He said that developing hydrogen networks is critical to support the industry's transition.

Mr. José Noldin, Chief Executive Officer, Gravithy, then said that low-carbon steel initiatives face challenges in securing finance. This is affecting the whole supply chain, he said, as the bankability of power supply investments often relies on the bankability of the green steel project itself and vice-versa. Having an anticipated sales pipeline could provide financial stability and instil confidence in investors and stakeholders. This could facilitate the growth and success of initiatives for a low-carbon steel sector.

Noldin continued by saying that labour with a new set of skills is needed to support the industry's transition. He said that the steel industry requires a skilled labour force with new expertise. The industry must shift towards renewable energy and green steel production technologies in order to adapt. It is important to foster the exchange of knowledge between different regions and sectors to meet these evolving demands. He also noted the role of digitalisation in this transition. Collaborative efforts involving universities, the private sector and governments are, he added, crucial to supporting the industry's evolution.

Further reading



[Towards a Circular Steel Sector](#), IRENA (2023)



[Breakthrough Agenda Report 2023](#), IEA, IRENA, UN HLC (2023)

Photographs from the session 'Solutions for decarbonising the iron and steel sector'



Solutions for decarbonising the chemical and petrochemical sector



Session organised in partnership with DECHEMA¹

IRENA and DECHEMA identified technological and policy interventions that could support the transition towards a low-carbon future.

The session focused on the innovations needed to decarbonise the petrochemical and chemical industry and explored the challenges and opportunities presented by the transition to a low-carbon sector.

The session was also a platform for the panellists to exchange ideas, share experiences, enabling IRENA and DECHEMA to identify the technological innovations and policy interventions that could support the transition towards a low-carbon future in the sector.

¹ The German Society for Chemical Apparatus (*Deutsche Gesellschaft für chemisches Apparatewesen*)



Key actions

for policy makers

1. **Focus on innovations in business models and regulatory frameworks.** The technologies to aid transition in the chemical industry are largely available.
2. **Strike a balance between maintaining competitiveness and profitability.** The chemical industry needs to do this while still moving ahead with deploying low-emission solutions.
3. **Boost the incentive to recycle by strengthening demand for recycled products.** In this, **unambiguous regulations** can help. To an extent, solutions like recycling help with the feedstock problem, but cannot solve it completely.
4. **Scale up newer technologies using fossil-free feedstock, in the mid- to long term.** Biomass and biotechnologies are great low-energy options compared to synthetic feedstock. Innovations in the feedstock value chain are necessary to source renewable CO₂.
5. **Incentivise strong partnerships between the utility providers and the industry.** This can help avoid overburdening the grids. Electrification is a viable pathway to decarbonise the sector, mainly by replacing fossil fuel-produced heat with electricity. Solutions like hybrid electrification, where strategically chosen parts of the process are electrified, can provide flexibility while helping integrate renewable energy.

Highlights of the session

Setting the scene

Francisco Boshell, Head of Innovation and End-Use Applications at IRENA, opened the session by introducing the vital role of chemicals in modern societies and how decarbonisation of this sector is one of the most complex challenges in the end-use industry.

In IRENA's Planned Energy Scenario, demand for chemicals is expected to grow by 70% by 2050, with emissions increasing to 2.5 gigatonnes (Gt) of CO₂ by the same date. Boshell then highlighted three key renewable-based pathways for CO₂ emission reduction: (1) use of biomass; (2) direct electrification of processes; and (3) indirect electrification via synthetic fuels and feedstock. Key challenges in these pathways were also underlined. He then opened the floor to the panellists for a discussion on how systemic innovations in policy and regulations, technology, business models, skills and capacity development could help in the transition to a low-carbon future.

Panel discussion

Moderator: Florian Ausfelder, Head of Energy and Climate, DECHEMA

Panellists:

- Martijn de Graaff, Programme Director, Power-2-Chemicals, Voltachem
- Rossella Di Virgilio, Head of Opportunity Analysis and Strategy Support, Versalis-ENI
- Jörg Unger, Senior Vice-President, Low Carbon Emissions and Projects, BASF
- Dharik Mallapragada, Principal Research Scientist, DC-Muse/MIT Energy Initiative
- Lars Börger, Vice-President Strategy and Long-Term Development for Renewable Polymers and Chemicals, Neste

Rossella Di Virgilio, Head of Opportunity Analysis and Strategy Support, Versalis-ENI, began the discussion by saying that while recycling is an important solution, it is not the only one. Recycling would not be able to match the complete demand for feedstock, especially with demand growing overall and technologies using renewable feedstock being key. However, recycling is necessary, she said, reaffirming that the technology to scale up does exist. The industry needs to bring itself to capacity and develop large-scale recycling plants. Simultaneously, strengthening demand for recycled products is also necessary and regulations are needed to support this.

New costs, such as those entailed by energy storage and emission trading systems (ETS), also need to be accounted for. Alternative technologies also implied higher costs, making them less competitive.

Jörg Unger, Senior Vice-President, Low Carbon Emissions and Projects, BASF, said he believed it is important to avoid first mover's disadvantage. He recommended that the chemical industry, together with support from the government and the finance industry, strategise different revenue models and encourage first movers to show that the market could function and revenue could be generated.

De-fossilised green end-products would probably result in an overall single-figure percentage cost increase, Lars Börger, Vice-President Strategy and Long-Term Development for Renewable Polymers and Chemicals, Neste, noted. But along the value chain, some companies might see a significantly higher cost increase. He then offered insights into how collaboration across the value chain is essential to make companies competitive and enable cost and benefit sharing.

Martijn de Graaff, Programme Director, Power-2-Chemicals, Voltachem, then noted that the industry still needs to make the same products, albeit in a different way. To make them, newer technologies need to be deployed and these also need to be competitive with the old, robust technologies that had had years of optimisation and efficiency improvements. He then called for a systemic approach in business models and regulatory frameworks that support the new technologies in rapidly becoming competitive.

Dharik Mallapragada, Principal Research Scientist, DC-Muse/MIT Energy Initiative, then said how the chemical industry is an energy intensive industry, with a large proportion of its processes working at high temperatures. Steam crackers need a temperature between 800°C and 870°C and fossil fuels are burned to reach such high temperatures. Electrifying the steam crackers is currently under trial. Large crackers have about 15 furnaces, while only around 2-3 of them could be electrified, if the power grid is not to be overwhelmed.

SOLUTIONS TO DECARBONIZE THE CHEMICAL & PETROCHEMICAL SECTORS

DAY 2
SESSION 2

MARTIN DE GRAAF VORACHEM
THE CHEMICAL INDUSTRY - NOT JUST PART OF THE PROBLEM, BUT A BIG PART OF THE SOLUTION

TECHNOLOGY

it's ABOUT INVENTING NEW BUSINESS MODELS
it's ABOUT INNOVATIVE WAYS TO GENERATE REVENUE
JOERG UNGER (BASF)

is there TO A GREAT EXTENT BUT WE NEED A REGULATORY FRAMEWORK

VARIETY OF SOLUTIONS is Needed

TRANSITION TO RENEWABLES

will play role!
→ MUST FIND SOURCES OF RENEWABLE CARBON TO ALIGN WITH AVAILABILITY OF RENEWABLE ENERGIES



THE INDUSTRY WILL NEED A LEVEL PLAYING FIELD INTERNATIONALLY TO ENABLE INVESTMENTS

IF THERE IS AN ADDITIONAL COST...

PROFITABILITY

WHO WILL PAY?

WHAT IS THE BUSINESS MODEL FOR THIS?

CIRCULARITY

WITH IMPACTS ON
○ FEED STOCK
○ BUSINESS MODELS
○ DEMAND FOR PRODUCTS

Photographs from the session 'Solutions for decarbonising the chemical and petrochemical sector'



Solutions for decarbonising the shipping and aviation sectors



ITS UC DAVIS
Institute of Transportation Studies

Session organised in partnership with the Institute of Transportation Studies at UC Davis

Shipping and aviation currently account for over 5% of global energy-related emissions.

Shipping and aviation currently account for over 5% of global energy-related emissions. This figure is expected to double by 2050, if no action is taken. This makes decarbonisation of these sectors crucial to meet the targets set in the Paris Agreement.

Overall, the decarbonisation of the shipping and aviation sectors is, however, a complex and challenging task. This is due to several factors, including technological readiness, cost and infrastructure limitations.

This session gathered experts from the shipping and aviation sectors to identify key priority actions and to discuss how to accelerate the full decarbonisation of these sectors by mid-century.



Key actions

for policy makers

1. **Prioritise the solutions that are most efficient and make the most economic sense.** This should be done while also looking at technological maturity and feedstock availability when considering fuel-options for decarbonisation.
2. **Design clear long-term policies with short-term targets.** The establishment of long-term goals sets the direction for these sectors. Yet, short-term mandates and targets help size market gaps and send the right signals to financiers and developers.
3. **Establish policies that de-risk first-movers and level the competitive playing field.** Examples of such policies include financial incentives to kickstart and accelerate the transition.
4. **Focus on international and cross-sectoral collaboration.** This is a fundamental part of a fair and efficient transition.
5. **Establish a carbon pricing mechanism.** This is regarded as crucial for the decarbonisation of the shipping and aviation sectors. It would encourage the adoption of sustainable fuels by penalising the use of polluting fuels and increasing the cost-competitiveness of upcoming e-fuels.

Highlights of the session

Setting the scene

Pierpaolo Cazzola, Director – European Transport and Energy Research Centre, ITS-Davis, opened the session by introducing the current energy and emissions landscape for shipping and aviation. He then highlighted certain aspects of this, such as the importance of considering technological readiness and availability when weighing fuel-options. He also highlighted the need to focus on the solutions that make the most economic sense, along with the importance of carbon pricing mechanisms to send the right market signals and help fund innovation.

Carlos Ruiz, Programme Officer from IRENA, then provided a brief overview of the decarbonisation pathways of the shipping and aviation sectors, as seen by IRENA. He highlighted the implications these pathways have for the power sector, with renewables being the basis for the e-fuels needed to decarbonise these sectors.

Finally, Zhang Tianfu from the State Power Investment Corporation (SPIC) of China offered some insights regarding SPIC's plans to deploy large amounts of production capacity for green methanol, green ammonia and sustainable aviation fuels.

Panel discussion

Moderator: Pierpaolo Cazzola, Director - European Transport and Energy Research Centre, Institute of Transportation Studies at UC Davis

Panellists:

- Maisarah Abdul Kadir, Associate Programme Officer, IRENA
- Bernd Hackmann, Team Lead – Nationally Determined Contributions (NDCs), Long-Term Low Emission Development Strategies (LT-LEDS) and Sectoral Support Unit, United Nations Framework Convention on Climate Change (UNFCCC)
- Karl Hauptmeier, Managing Director, Norsk e-fuel
- Bruno James, Head of New Energy Business Development, Airbus
- Emile Herben, Director Product Management & Certification – Clean Ammonia, Yara
- Nelson Mojarro, Head of Innovation and Partnerships, International Chamber of Shipping

The discussion touched upon various aspects of decarbonisation in the aviation and shipping sectors, including:

A global change in mindset and increasing decarbonisation ambitions:

- Since the COP21 UN Climate Change Conference in Paris in 2015, governments and international organisations, such as the International Civil Aviation Organisation (ICAO) and International Maritime Organisation (IMO), have shown increased ambition in decarbonisation. The necessary technologies for decarbonisation exist, but policies need to catch up.
- This increased ambition is evident in countries from both the global north and south. It is extremely important that the transition is equally fair, with everyone involved and no country left behind. This applies to sectors beyond shipping and aviation.

Ongoing decarbonisation efforts in shipping:

- In 2023, there were substantial policy and regulatory changes in shipping. These included the inclusion of shipping in the EU Emissions Trading System (ETS) and the revision of the IMO GHG strategy, which added a net-zero target. These changes bring significant opportunities and challenges for ship owners and operators.
- Shipping is responsible for moving 90% of goods and 36% of energy products globally and it will not decarbonise alone. Collaboration with ports, energy providers, ministries and other sectors will be critical for an efficient decarbonisation. The creation of clean energy hubs close to ports will be necessary and initiatives like the Clean Energy Marine Hubs (CEM-Hubs) can help demonstrate the feasibility of such facilities and drive innovation and sustainability in the maritime industry.

Ongoing decarbonisation efforts in aviation:

- Sustainable aviation fuels (SAF), such as biofuels and e-kerosene, will be crucial for decarbonising aviation. This is especially so since the development of hydrogen aircraft is only expected to happen towards 2035 and after. The industry is already actively investing in, and building partnerships with, the e-SAF industry.
- The latest developments related to hydrogen-powered aircraft (for short- and medium-range flights) revolve around the choice of propulsion system, ensuring regulatory compliance and reliability, and preparing the ecosystem to ensure that airports are ready to accommodate hydrogen-based technologies.

Scaling-up of the e-fuel industry:

- Policies that include a combination of long-term targets with short-term mandates can help unlock the challenges faced by developers in securing much needed investment and financing. Examples of this include policies such as ReFuel EU, which has five-year targets, provides certainty to the market, sizes the gap and mobilises equity for the market.

- Ideally, the playing field should also be levelled for innovators and investors who are first-movers and who undoubtedly face increased challenges and risks. Policies such as the Inflation Reduction Act in the United States can help by establishing incentives. Collaborative efforts, such as partnerships between e-fuel producers and their buyers (airlines, ship owners, and others) could also prove helpful.
- There are still some challenges to overcome for e-fuels. For e-hydrocarbons, there is the need for a sufficient stream of sustainable carbon (from direct air capture or biogenic origin). For ammonia, there is the challenge of deploying ammonia-ready engines and the need for adequate procedures for the management of ammonia as a shipping fuel, given its toxicity.

SOLUTIONS TO DECARBONIZE SHIPPING & AVIATION SECTORS



1/4 OF GLOBAL EMISSIONS FROM TRANSPORT & SET TO INCREASE

FUEL OPTIONS?

- BIOFUELS → CHEAPER
- HYDROGEN → AS CARBON OR FEED STOCK
- E-AMMONIA
- FOSIL FUELS

CONNECT DIFFERENT ACTORS!



SHIPPING HAS CHANGED BEFORE

- ...BUT THIS CHANGE MUST:
- GO FAST
 - WITHOUT ONE DOMINANT FUEL
 - WE ARE JOINING NEED FOR ELECTRICITY



THE IMPORTANCE OF CERTIFICATION

SPIC SPECIALISED IN GREEN POWER CONVERSION



BY 2030 SIGNIFICANT EXPANSION

POLICIES

- MUST BE LONG-TERM
- CARBON-PRICING IS KEY
- COOPERATION NEEDED

WE ARE SEEING REAL CLIMATE ACTION!

BERND HACKMANN
NOC / LE-LEADS UNFCCC

SECTORS HAVE REALLY CAUGHT UP!

SHIPPING & AVIATION ARE THE BIG...



COUNTRIES ARE LOOKING INTO THEIR OWN RESOURCES & ENERGY OPTIONS



COOPERATION IS ESSENTIAL!



WE SEE NEW OPPORTUNITIES FOR AMMONIA PRODUCTION, TRANSPORT & USE

REGULATION

- HOW TO SAFELY TRANSPORT: ADVANCED MEASURES NEEDED

IMPLEMENTATION IS NEXT BIG POINT



FIRST MOVER ADVANTAGES & DISADVANTAGES



Certified

REFUEL AS IMPORTANT KICK-STARTER

- WE HAVE A STRONG PARTNERSHIP WITH NORWEGIAN AIRLINES
- ADDRESS MULTIPLE RISKS:
 - IS IT SAFE - RISK PERCEPTION
 - HOW MUCH WILL PEOPLE BE WILLING TO PAY
 - HOW TO OBTAIN RISKS FOR LENDERS?

EU & US APPROACH IS FIRST MOVER & DIFFERENT ESPECIALLY IN TERMS OF FINANCING

REFUELLING AVIATION IS AN ESSENTIAL MILESTONE

MOBILIZE PRIVATE EQUITY!

IT'S ABOUT PRIORITIZATION

GREEN HYDROGEN OPTIONS FOR SHORT & MID-RANGE FLIGHTS



HYDROGEN HAS POSITIVE TRENDS CO2 REDUCTIONS

TECHNICAL CHALLENGES: WHICH PROPELLERS WITH FUEL-CELL SOLAR & WIND/BIO ON SITE INTEGRATED IN AIRPORT

SAF

- BIO-SAF
- SAF AS A TRANSITION FUEL
- E-SAF INVESTMENT
- CLEAR TARGETS

DECENT FUEL EFFICIENCY TRAJECTORY & VANDING → HOW TO ADJUST FOR FUEL EFFICIENCY

EXAMPLE: USING FLIGHT PATTERNS OF GERSE REDUCES FUEL BY 10%

E-FUELS SHOULD BE 70% OF ENERGY DEMAND BY 2050 AT THE MOMENT IT IS LESS THAN 1%

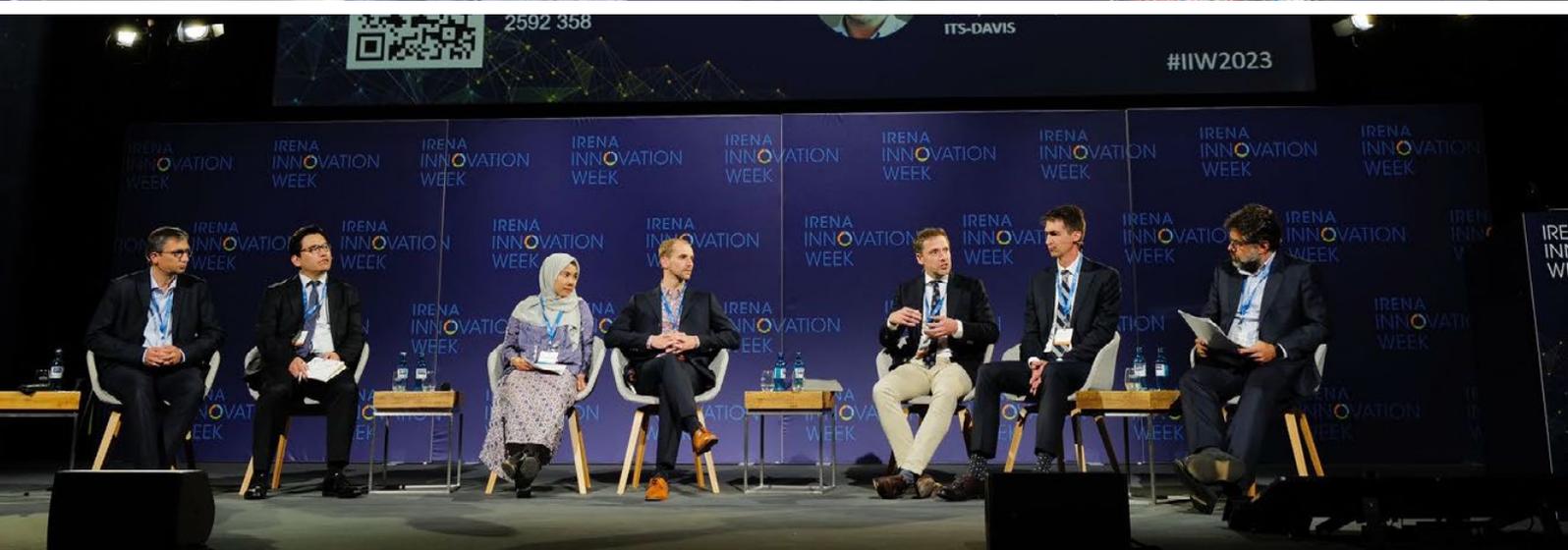
WE MUST...

ACKNOWLEDGE THE DIFFICULTY IN DECARBONIZING THESE SECTORS



IN PART ALSO BECAUSE OF BORDERS & DIFFERENT POLICIES

Photographs from the session 'Solutions for decarbonising the shipping and aviation sectors'



Future materials for EV batteries



Session organised in partnership with the European Commission Joint Research Centre (EC JRC)

Future EV demand projections are heavily dependent on government policies and uncertainties related to innovation in battery materials.

The ambitious global push for EVs in the context of the energy transition and decarbonisation is increasing pressure on the EV battery materials supply chain.

To understand potential supply-demand gaps for the critical materials used in EV batteries, it is crucial to analyse uncertainties stemming from projections of future EV demand. These are heavily dependent on government policies and uncertainties related to innovation in battery materials.

This session gathered experts to discuss commercial and emerging EV battery architecture and chemistries. It also provided a glimpse of how the market might look by 2030 and beyond, with the discussion centring on promising activities led by industry and researchers, as well as the challenges they face.



Key actions

for policy makers

- 1. Seek a middle ground between regulation and innovation.** An equilibrium between standardisation and the encouragement of innovation should be fostered and should aim to strike a balanced approach between sourcing materials locally and globally. Additionally, an equilibrium in investment should be maintained, focusing on select technologies while upholding a strong commitment to continuing R&D.
- 2. Approach policies aimed at promoting innovation in a systemic way.** This should encompass mining, material processing, battery manufacturing and end-of-life management.
- 3. Increase resources in R&D across the supply chain of EV batteries.** Innovation has the potential to reduce or even eliminate demand for specific materials, enhancing sustainability and concurrently diminishing risks and vulnerabilities in the supply chain.
- 4. Monitor market and technology developments closely.** This should be done while increasing and strengthening discussions with stakeholders across the industry to gain better understanding of the fast-evolving EV battery landscape. In addition, regulatory efforts and industry guidance should be improved.
- 5. Increase international co-operation in innovation between governments.** No single country possesses all the knowledge or resources required. International collaboration should harness regional strengths and shared objectives, with the aim of mitigating geopolitical divisions and increasing resilience in the supply chain.

Highlights of the session

Setting the scene

In his presentation, Luis Janeiro, Team Lead for End-Use Sectors at IRENA, outlined his organisation's current efforts and future plans regarding critical materials and the Collaborative Framework on Critical Materials (CFCM). His presentation stressed the necessity of electrifying road transport to meet the Paris Agreement goals, projecting 360 million EVs in circulation by 2030 – a significant increase from the 10 million on the road in 2021.

This surge would drive demand for EV batteries, which require materials such as graphite, lithium, cobalt, copper, manganese, phosphorus and nickel, he said. IRENA's research, he added, suggested material availability would not be a showstopper in the long term, but there might be short to medium-term supply challenges if mining and processing lagged. Technological progress and innovation were seen as potential solutions, reducing material demand or, in some cases, even eliminating it.

The second, scene-setting presentation was given by Michalis Christou, Project Leader at the European Commission JRC (EC JRC). Christou said that, "For the EU, the undisrupted supply of clean energy materials and components is not only an issue of sustainability, but also of competitiveness of the clean energy industry and of strategic autonomy." To bolster the supply and resilience of these materials, the Critical Raw Materials Act was created, he said.

His presentation also emphasised the importance of foresight, as presented in the recent EC JRC report. He also drew attention to the rapidly evolving innovation landscape for clean energy technologies, with substantial increases in EU investment and patenting activity now taking place. Furthermore, he emphasised the need to address uncertainties concerning the future of EV batteries, new materials, emerging chemistries, the pace of change and the potential impact on the supply chain.

Panel discussion

Moderator: Francisco Boshell, Head, Innovation and End-Use Applications, IRENA Innovation and Technology Centre

Panellists:

- Maximilian Fichtner, Executive Director, Helmholtz-Institute Ulm
- Srinivas Godavarthy, Chief Executive Officer (CEO), Li-Metal
- Rashmi Gupta, CEO, Vision Mechatronics
- Maroš Halama, Advisor, InoBat
- Marcos Ierides, Senior Innovation Consultant, Bax and Company

Marco Ierides, Senior Innovation Consultant, Bax and Company, highlighted the fact that innovation in the components of EV batteries is advancing rapidly. This evolution included transitioning from graphite-based anodes to silicon-graphite and the exploration of emerging and promising trends, such as lithium-metal. He also said that when evaluating the advantages and disadvantages of various battery chemistries, it is important to realise that challenges related to chemistry could often be addressed through non-material innovations, such as improvements in design or manufacturing processes.

Professor Maximilian Fichtner then stressed that uncertainties about which batteries will dominate in the future are likely to endure. He pointed to an assessment of roadmaps from the past 15 years, revealing that around 90% of the projections were inaccurate. Srinivas Godavarthy, Chief Executive Officer (CEO), Li-Metal, also underscored the uncertainties concerning the supply of low-cost materials, like lithium, and the potential ramifications of these uncertainties.

It is evident that the 'mega trend' in EV batteries revolved around sustainable raw materials, with the focus shifting from merely enhancing energy performance and safety in batteries to prioritising the sustainability of the materials themselves.

Rashmi Gupta, CEO, Vision Mechatronics, underscored the need to align the supply and value chains systematically to promote decarbonisation and to increase the share of EVs in the transport sector.

At the same time, the session concluded, innovation is not limited to chemistry alone; it extends significantly into battery engineering as well. Considerable progress has been made in enhancing the design of battery cells and packs, increasing the proportion of active materials within the batteries. Notably, technologies like blade design had effectively doubled the amount of active material used. The field of engineering had unlocked numerous possibilities, particularly in the development of higher-density LFP and sodium-ion batteries, and continues to drive innovation, holding the potential for transformative changes.

Investment in material science is essential, as Maroš Halama, Advisor, InoBat, highlighted. He pointed to the significant and untapped potential of nanotechnology in this sector. This had the capacity to triple the energy density of EV batteries while simultaneously reducing battery life cycle degradation, he said. Establishing small-scale R&D capacity is crucial for validating concepts and confirming their feasibility on a manufacturing scale. R&D centres could also facilitate the implementation of chemical adaptations which could support EV battery development.

In addition, the session emphasised that standardisation is paramount in mitigating the high risk associated with stranded investments due to misaligned technology choices.

Several key actions were then discussed. First, the session outlined how there is a need for support from international organisations such as IRENA in guiding the industry toward making informed investment decisions. Simultaneously, it is also vital for the industry to play a proactive role in educating policy makers and other relevant organisations about the latest developments.

The discussion then underlined the need for standardisation to improve sustainability throughout the value chain, from mining operations to battery manufacturing processes.

Transparency and international collaboration were also highlighted as priority areas by the speakers. The need for transparency across the entire EV battery supply chain, including raw materials, was emphasised, as this would ensure resilient and responsible sourcing. Simultaneously, collaboration between continents, countries and various stakeholders would leverage regional strengths for innovation.

FUTURE MATERIALS FOR EV BATTERIES

DAY 2
SESSION
3

INTRO:
 • IRINA HAS PUBLISHED REPORTS
 → IN CRMS 2020 - SCOPING PAPER & OTHER RARE EARTH MATERIALS
 • SIGNIFICANT ELECTRIFICATION NEEDED!

• PROJECTION DEMAND OF +5 TW OF JUST EV BATTERY CAPACITY

PLAN: STOCK IS TO REACH 360 MILLION EV'S BY 2030

MATERIALS AVAILABILITY
 "NOT A SHOWSTOPPER"
 DIFFERENT COUNTRIES HAVE DIFFERENT CHALLENGES
 → SCALE-UP NEEDED

• COLLABORATIVE FRAMEWORKS
 OUTREACH & STOCKHOLDER COOPERATION

PLANS FOR PRODUCTION CAPACITY IS INCREASING
 7.2 TW BY 2030

POTENTIAL FOR INNOVATION MAY ELIMINATE OR REDUCE NEED FOR MATERIALS → EX. LFP BATTERIES
 → NO Ni OR COBALT NEEDED

CRM PRODUCTION CAN BE REDUCED THROUGH INNOVATION

THIS IS MAINLY A **MATERIALS TRANSITION**

ACT. MARCH 2023: EU CRM ACT
 • EVIDENCE INTO 15 CRMS & THEIR VALUE CHAINS

PROMISING INNOVATIONS:
 • SODIUM-ION BATTERIES
 • NEW INNOVATIONS REDUCING NEED FOR GRAPHITE

CHALLENGES:
 • SCALING-UP MATERIAL PRODUCTION
 • CRM PRODUCTION
 • ADDRESSING MARKET UNCERTAINTIES
 • CONTINUING R&D SUPPORT.

RAPID INNOVATION IN EV BATTERIES

• NEW MATERIALS?
 → FAST PACED CHANGE
 → BRINGS RISK: MANAGING RISKS IN INVESTMENTS

SUBSTANTIAL RISE FOR EV MATERIALS BY 2030 & 2050

• STANDARDIZATION
 STRONG LEADERSHIP WITH REDUCE BUREAUCRACY.

PROPER END-OF-LIFE MANAGEMENT IS KEY FOCUS:
 • RE-USE
 • RECYCLING
 • REMANUFACTURING

SHIFT TO ECO-RESPONSIBILITIES

UNCERTAINTIES
 MANY STILL PLACE IN SECTOR

• LOCAL & GLOBAL APPROACH

GOVT & INVESTORS PLAY KEY COOPERATION ROLE IN REGIONS

• MANUFACTURING FACILITIES CAN ADAPT TO DIFFERENT BATTERY TYPES

• SODIUM-ION INNOVATION IS PROMISING

• ANODES
 CATHODES
 ELECTROLYTES
 SEPARATORS
 → HAVE POTENTIAL FOR BREAKTHROUGHS

KEY TAKEAWAYS

1 PREDICTING FUTURE IS DIFFICULT → DUE TO INNOVATION & CRMS

2 MORE COOPERATION & DIRECTION ON INVESTMENTS

3 NO SINGLE COUNTRY HAS ALL RESOURCES & KNOWLEDGE

Photographs from the session 'Future materials for EV batteries'



Grid evolution:

Transforming energy landscapes in developing countries and SIDS



giz

Session organised in partnership with GIZ²

Developing countries and SIDS have a range of different technical starting points and realities when it comes to renewable energy grid integration.

The aim of this session was to showcase and exchange innovations in technology, financial mechanisms, technical standards, best practices and strategic approaches to modernising electricity grids. The session also looked at innovations in increasing grid reliability while integrating variable renewables into the energy systems of developing countries and SIDS.

These countries have a range of different technical starting points and realities when it comes to renewable energy grid integration. Some, for example, have not yet reached full electrification, while others have island grids and some have poorly interconnected grids. Further, suitable frameworks and business models might not be in place to support transformation. These countries therefore need special attention when it comes to grid evolution.

² German Development Co-operation (*Deutsche Gesellschaft für Internationale Zusammenarbeit*)



Key actions

for policy makers

1. **Incentivise collaboration among all stakeholders.** These include utilities, regulators, the private sector and financing institutions. International organisations and donors can play a key role in facilitating this collaboration.
2. **Take into account the three critical points of grid modernisation:**
 - A long-term and holistic country vision, which includes a comprehensive planning and re-design of the grid, in line with energy transition goals.
 - A regulatory and legal framework in place to strengthen the power sector.
 - Utilities' readiness and willingness to deploy variable renewables – supported by capacity building.
3. **Develop a system/country-specific roadmap for the energy transition.** This should be centred on grid modernisation and based on best practices from, and exchange with, other countries.
4. **Strengthen regional grid interconnections.** This should be done in order to integrate higher shares of renewables.
5. **Focus on strengthening grids as one of the key aspects of climate resilience.** Grid strengthening and modernisation go hand in hand with power system resilience enhancement – further increasing the security and reliability of a power system.
6. **Incentivise investments in a timely manner.** This should be done while strengthening fundamental building blocks, such as the legal framework and pricing mechanisms, to ensure that grid upgrades will produce the intended results.

Highlights of the session

Setting the scene

Simon Benmarraze, Lead – Technology and Infrastructure Team, IRENA, introduced the session topic of grid modernisation as a crucial pillar of the energy transition. This modernisation, he said, also enhanced energy security and resiliency. He then emphasised that innovation is central to the energy transition, which would result in grids of the future that required adaptability, resilience and the capacity to accommodate diverse (renewable) energy sources.

He went on to demonstrate that renewable energy-based power is currently the most cost-effective option for new generation, and grid infrastructure modernisation is essential for the integration of renewables. The solution, according to IRENA, lay in developing a climate adaptation strategy for both transmission and distribution systems, as well as developing resilient enhancement measures for both short-term operational measures and long-term solutions.

He then gave some key messages for policy makers. First, they should adopt integrated planning to modernise grids. This planning should give an emphasis to local solutions, such as micro- and mini-grids, while improving energy access – particularly in off-grid communities in Africa and the SIDS.

Policy makers should also offer incentives for underfunded yet crucial grid projects, such as rural electrification through renewable mini-grids. This should be done in order to expand energy access in remote and off-grid regions. Policy makers should also streamline permits for key grid infrastructure projects, ensuring rigorous environmental and social assessments to maintain local socio-economic development and foster public acceptance.

A further key message was that policy makers should include climate resilience measures in all the stages of planning and development in order to better prepare for extreme weather and changing environmental conditions. They should also boost public funding for essential, climate-resilient infrastructure, focusing on areas with unique logistical and environmental challenges.

Reji Kumar Pillai, President, India Smart Grid Forum (ISGF), then presented several smart grid initiatives, pilot projects and success stories in solar and wind integration in India.

His country, he said, had the third largest power system in the world and a 99.9% electrification rate. In 2022, some 40% of India's power generation capacity also came from non-fossil fuel-based generation.

Various schemes and projects that promoted the uptake of renewables were in place, he said, including a real time market, green energy open access rules, green corridors and renewable energy monitoring centres (REMC). There were also round-the-clock renewable energy – energy storage systems (ESS) with solar and wind farms supplying renewable energy all day, every day. Smart grids and solarisation of irrigation pumps were also features, along with battery energy storage systems (BESS).

Of particular interest were the 11 REMCs. These help with system-wide visibility and improved operational co-ordination, as well as with visualisation and evaluation of renewable energy forecast performance. They use state-of-the-art modelling tools for accurate renewable generation forecasts, integrating weather forecasting inputs and renewable energy scheduling with secure interfaces for grid operators, regulators and generators. This maximised renewable energy utilisation and helped utilities meet renewable energy purchase obligations (RPOs), he said. Grid modernisation includes smart grid pilot projects, net metering/smart metering initiatives and energy storage system applications for grid support.

He then made some recommendations to energy ministries, regulators and utilities for renewable energy grid integration.

First, he said there should be a comprehensive planning and re-design of the electrical network – both its transmission and distribution grids. There should also be an implementation of smart inverters, the development of dynamic renewable energy markets and peer-to-peer (P2P) trading of green energy.

In addition, he recommended the deployment of grid interactive buildings, campuses and smart appliances, the adoption of the time-of-use (TOU) tariff and the establishment of a national rooftop solar registry. The latter was required, he said, for forecasting, scheduling and dispatch of rooftop solar generation. Finally, he further recommended the integration of EVs into the power grid.

Chavan Dabeedin, Head of Production, Central Electricity Board, Mauritius, then highlighted the progress that his country had been making with respect to the integration of renewables.

As of 2022, he said, 19.2% of generation capacity in Mauritius was renewable based, with a target of 60% by 2030.

To overcome the challenges posed by a higher share of VRE, several grid modernisation initiatives were underway, he added. These challenges include low inertia, high sensitivity to network disturbance (load and generation), and the high risk of frequency instability due to volatile power output of non-dispatchable renewable energy systems.

Modernisation efforts in Mauritius also included the use of indoor, gas-insulated switchgear substations. These offered higher reliability and safety, he said, increasing the responsiveness of the power system to frequency excursion using batteries, droop control and a smart grid. This included automatic generation control, a wide area monitoring system, advanced metering infrastructure with smart meters and an advanced distribution management system.

Regulatory measures included technical requirements for the interconnection of distributed generation to the low voltage and medium voltage network – small-scale distributed generation (SSDG) and medium-scale distributed generation (MSDG) grid codes. Mauritius aims to democratise access to the electricity grid and simplify the administrative procedures necessary to become a prosumer, he added.

Panel discussion

Moderator: Sofia Giljova, Policy Advisor for the Energy Transition, GIZ

Panellists:

- Kaleb Udui Jr, Minister of Finance, Palau
- Claire Nicolas, Senior Energy Economist – Energy Sector Management Assistance Programme (ESMAP), World Bank
- Chavan Dabeedin, Head of Production, Central Electricity Board, Mauritius
- Kader Diop, Conseiller Technique, ANER-Senegal
- Reji Kumar Pillai, President, India Smart Grid Forum
- Ambrosio Yobánolo del Real, Deputy Director of Planning and Management Control, Sustainability and Climate Change Agency (*Agencia de Sustentabilidad y Cambio Climático – ASCC*), Chile – Vice-Chair UNFCCC Technology Executive Committee (UNFCCC-TEC)

The discussion began with Kaleb Udui Jr, Minister of Finance, Palau, highlighting the pathway Palau is currently trying to follow to achieve its goal of 100% renewable energy. The aim, he said, was to do this through strategic co-ordination and collaboration among donors, the utility, regulators, the private sector and the political space.

Further critical points for the energy transition, he said, were utility management, energy efficiency and financing through innovative financing mechanisms. The latter included smart metering, which had been established for specific sectors in Palau and was viewed as important for certain parts of the population.

Claire Nicolas, Senior Energy Economist – Energy Sector Management Assistance Programme (ESMAP), World Bank, then spoke about the work that ESMAP is doing in this context. That work involved the provision of technical assistance and financing for grid-focused projects, as well as support in the identification of where the grid could accommodate VRE and how it could be reinforced to accommodate VRE safely and securely.

She then highlighted three critical points for grid modernisation: (1) have a country long-term vision; (2) strengthen the sector's fundamentals, such as the legal framework, as well as ensuring the readiness and willingness of the utilities to deploy VRE; and (3) support the sector with capacity building initiatives.

Chavan Dabeedin then provided another island perspective on the energy transition grid evolution. He cited the significant challenge posed by an inability to interconnect with other countries that could support the national grid.

He also drew attention to the significant technical challenges of VRE integration that are particularly pertinent to island systems. To maintain system security and stability in the face of a high penetration

of VRE, the current operational strategy in Mauritius was to keep conventional power plants operating at a low load factor to maintain a certain amount of energy as a spinning reserve, he said. This had allowed for a decrease in the production of energy from fossil fuels and an increase in the proportion of renewable energy on the Mauritian grid. He then emphasised further that strengthening grids was one of the most important factors for future climate resilience.

Kader Diop, Conseiller Technique, ANER-Senegal, then highlighted Senegal's target of 100% renewable energy by 2040. This, he said, was being undertaken via four major strategies: (1) reinforcement of the grid – both transmission and distribution – to safely and securely integrate VREs; (2) national grid extension and further integration with the West African Power Pool; (3) forecasting of oil and gas demand, which is important for GHG emissions quantification and reduction; and (4) retrofitting of oil-fired power plants as biofuel power plants.

Regarding the regulatory aspects, Senegal had implemented both a prosumer tariff and a new law for diversifying the electricity sector to include more renewables, he said. These efforts had been supported by international development partners, such as GIZ and IRENA, through initiatives in Senegal to build long-term planning capacity. A proposal had been made to IRENA for additional support in project development from a financial standpoint, as well as continued partnership with stakeholders, to reach this ambitious goal.

Reji Kumar Pillai, India Smart Grid Forum, then provided critical guidelines for other countries that wish to follow India's path for the energy transition.

He said that these countries must focus on their individual challenges and create a country- or utility-specific roadmap for the transition. He also further encouraged interconnection with other countries to strengthen grids under high VRE penetration levels. An example was the 4000 MW interconnector between Oman and India, which further stabilised the national grid.

Ambrosio Yobánolo del Real, Deputy Director of Planning and Management Control, ASCC, Chile - Vice-Chair UNFCCC Technology Executive Committee, then said that for the first time last year in Chile, wind and solar had won over fossil fuel generation. According to his experience, strengthening grids was a key aspect in future climate resilience.

He then added that economic and financial challenges are the most common issues identified by the UNFCCC-TEC, in addition to regulatory challenges. Even though electricity access in Chile had risen to 91%, he said, some people are still without access to electricity and off-grid solutions are needed for the targets to be met. Another priority in developed and developing countries which had been identified, he said, is energy storage.

GRID EVOLUTION

TRANSFORMING ENERGY LANDSCAPES IN DEVELOPING COUNTRIES & SIDS

DAY 2
SESSION
-2-

GRID MODERNIZATION

- ✓ UPDATING
- ✓ OPTIMISING USAGE
- ✓ IMPROVING THE EXISTING GRID

- HELPS SUPPORT END USE ELECTRIFICATION
- IMPROVES POWER SYSTEM RESILIENCE

GRID INTEGRATION

COORDINATED APPROACH WITH SMOOTH COLLABORATION BETWEEN



STRENGTHENING OF THE GRID

KEY FOR CLIMATE RESILIENCE

AMBROSIO YOBANOLO DEL REAL UNFCCC

DR. REJI KUMAR PILLAI

INDIA

WITH 424 GW IN 2023!

UNPRECEDENTED GROWTH!

INDIA OUTPACED PARIS AGREEMENT 8 YEARS EARLY!

INDIA IS A LEADER IN SMART GRIDS!

NEW GOAL IS 500 GW BY 2030

SENEGAL

GOAL OF 100% BY 2040

HOW?

- GRID REINFORCEMENT
- TRANSMISSION EXPANSION
- TRANSITIONING OIL PLANTS INTO BIOFUEL OPERATIONS
- REGULATORY INNOVATION LIKE PROSUMER TARIFFS

MAURITIUS

MR. CHAVAN DABEEDIN

100% ELECTRIFICATION ACHIEVED SINCE 1982

& RENEWABLE TARGET OF 60% BY 2030

- CHALLENGED BY LOW SYSTEM INERTIA
- GRID IS MODERNIZED
- SMART TECH IS BEING ADOPTED!

PALAU

H.E. MR. KALEB UDUI

WE MUST HAVE A STRATEGIC & MULTI-STAKEHOLDER APPROACH

- CHALLENGES & KEY FACTORS!
- UTILITY MANAGEMENT
 - FINANCING
 - BALANCING ENERGY EFFICIENCY

MR. AMBROSIO YOBANOLO DEL REAL

CHILE

WIND & SOLAR SURPASSED FOSSIL FUELS FOR 1ST TIME LAST YEAR

GRID MUST BE ROBUST TO ACCOMMODATE

Photographs from the session 'Grid evolution: Transforming energy landscapes in developing countries and SIDS'



Geopolitics of the energy transition:



Innovation in critical materials



Session organised in partnership with the Energy Transitions Commission (ETC)

Experts explored the geopolitical implications of the energy transition with a focus on innovation in critical materials.

In this session, experts explored the geopolitical implications of the energy transition with a focus on innovation in critical materials.

Partnering with the ETC, the panel examined global supply chain challenges in critical materials, highlighting the growing demand spurred by renewable energy technologies and EVs. Delving into disruptive innovations in battery technology, governance imperatives and the essential role of transparency and collaboration, the session underscored the imperative for international co-operation to tackle supply chain bottlenecks.

The session also discussed the role of recycling, reuse, end-of-life management and the development of a circular economy in the context of these critical materials, which are poised to play a pivotal role in the next couple of decades.



Key actions

for policy makers

- 1. Encourage disruptive innovation incentives.** Policy makers should proactively introduce incentives to foster the development and widespread adoption of disruptive innovations, which are pivotal in steering the course of future energy transition demands. In addition to spurring innovations that facilitate the shift away from cobalt-dependent battery technologies toward sustainable alternatives, innovation can also assume a crucial role in efficiently managing the demand for materials that have reached the end of their lifecycle, notably in the context of batteries and EVs.
- 2. Establish responsible sourcing regulations.** Policy makers should establish and enforce regulations that guarantee supply chain traceability, thereby enabling responsible and sustainable sourcing of minerals. This entails imposing rigorous environmental standards and conducting comprehensive social impact assessments at every stage of extraction, processing and refining.
- 3. Advocate for voluntary standards.** Policy makers should take the lead in championing clear and consistent voluntary standards for critical material extraction, processing and refining, all while safeguarding local economic development. The establishment of uniform practices will enhance transparency, accountability and the consistent application of responsible sourcing principles.
- 4. Allocate resources to support R&D.** This should focus on materials efficiency and recycling technologies. This investment is crucial for closing existing gaps in these areas, contributing to a more sustainable and circular approach to critical material use.
- 5. Promote cross-border collaboration.** Countries have diverse governance models and must work together proactively. To foster international collaboration, policy makers should create frameworks for sharing information and initiate joint efforts to tackle potential bottlenecks in the global supply chain of critical materials, while facilitating diversification.
- 6. Implement multi-stakeholder partnerships.** Policy makers need to actively foster multi stakeholder partnerships involving businesses and local communities. These partnerships should focus on addressing governance gaps, promoting sustainability and ensuring responsible mineral resourcing throughout the entire value chain. Simultaneously, they should seek to build trust and secure the consent of local communities, while generating local value.

Highlights of the session

Scene setting

In her scene-setting presentation, Elizabeth Press, Director – Planning and Programme Support, IRENA, explored the multitude of uncertainties surrounding critical materials. For the next decade, these uncertainties would hinder accurate supply-demand predictions, she said.

She then noted that supply challenges are currently pronounced for certain materials, with this exacerbated by geographical concentration and the extended lead times required to develop mining and refining capabilities. She stressed the vital role of international collaboration and vigilance in identifying potential bottlenecks, while highlighting the transformative influence of disruptive innovation on the evolution of material demand.

Panel discussion

Moderator: Elizabeth Press, Director – Planning and Programme Support, IRENA

Panellists:

- Leonardo Buizza, Lead - Supply Chains and Materials Analyst, Energy Transitions Commission
- Lucilla Crexell, National Senator, Argentina
- Indra Øverland, Research Professor, NUIP³
- Sjarah Soede, Deputy Director - Inclusive Green Growth Department, Deputy Director, Inclusive Green Growth, Ministry of Foreign Affairs (MFA), Netherlands

The panel discussion provided a deep dive into the intricacies of the global supply chain for critical materials. There was a focus on innovation and an offering of vital insights for policy makers and industry stake-holders.

Speakers first dispelled myths about material scarcity, highlighting the abundance of key resources such as lithium, copper and neodymium. They also emphasised the significance of responsible mineral sourcing practices, underlining that emissions from energy transition materials are considerably lower than those from fossil fuels. While material requirements are manageable, there is an urgent need to scale up clean energy supply chains, address environmental challenges in mining, and ensure sustainability.

³ Norwegian Institute of International Affairs (*Norsk utenrikspolitisk institutt* – NUIP)

A recurring theme in the discussion was the imperative for responsible extraction and refining practices. The environmental risks associated with these processes were a central concern, with the discussion emphasising the need for diversification in production and refining sources – especially in regions where concentration posed risks. Speakers also underscored the importance of achieving a just and inclusive transition, advocating for climate-conscious practices and breaking from past resource management approaches.

Creating an attractive investment environment in critical materials was deemed critical. This involves facilitating knowledge transfer, easing regulatory barriers and enhancing governance. Collaboration between countries is crucial for investment opportunities and sustainable development. The need to have clear rules and incentives for investors was acknowledged, encouraging innovation and environmentally responsible practices. Transparent supply chains and material traceability throughout their life cycles were seen as drivers for investment and better governance.

The potential for co-operation over conflict in the critical materials supply chain was emphasised, concluding that a focus on conflict is intellectually lazy. Shifting away from old fossil fuel-era narratives was underlined as necessary to fully embrace the challenges and opportunities presented by the transition to clean energy technologies.

The conversation also brought to light the significance of multilateral co-operation, with a focus on how governments, the private sector and local communities can address challenges and foster sustainability. In closing, speakers stressed that these insights offer a roadmap for policy makers to actively shape a sustainable, inclusive and environmentally responsible future for the energy transition.

GEOPOLITICS OF THE ENERGY TRANSITION

INNOVATION IN CRITICAL MATERIALS

• IN PARTNERSHIP WITH ENERGY TRANSITION COMMISSION •

KEYNOTE: ELIZABETH PRESS

BETWEEN NOW & 2030: MANY UNCERTAINTIES: → DIFFICULT TO PROJECT

MINING WILL STAY MUCH THE SAME & A FEW NEW AREAS



COLLABORATION & INNOVATION IS ESSENTIAL

NEW CONCEPT: V2G OR FREE BATTERIES

BATTERIES HAVE & WILL CHANGE!

PHYSICAL CONSTRAINTS

DISRUPTIVE INNOVATION

CIRCULAR ECONOMY



MYTHBUSTING

1. WE HAVE ENOUGH MATERIALS! → 2050+ BEYOND

2. EMISSIONS OF PRODUCTION OF THESE MATERIALS → IT WILL BE LOWER EMISSIONS

WE MUST FOCUS ON FUTURE:

• MINING: INVESTMENT & MORE SITES NEEDED.

• LOCAL & SOCIAL CHALLENGES MUST BE ADDRESSED

• INDUSTRIAL POLICIES NEEDED

3. SCALE OF MATERIAL: MOSTLY STEEL & COPPER. IS SHROUDED COMPARED TO COAL & GAS EXTRACTED EVERY YEAR

LITHIUM

10% IN ARGENTINA 50% IN CHINA

HAS MANY ENVIRONMENTAL RISKS

REFINING 70% IS DONE BY CHINA

COOPERATION IN THE REGION IS KEY & THIS IS VERY DIFFERENT FROM THE FOSSIL FUEL HISTORY

STOCKPILING ALTERNATIVES TO BE BUILT IN: TO DISCOVER THIS BEHAVIOR.

WUQE POTENTIAL FOR INNOVATION ... BE OPTIMISTIC!

WE MUST HELP WITH MYTHBUSTING

COPPER

• BIG MARKET, MORE ACTORS
• ENOUGH RESERVES
• MASSIVE NEED FOR ENERGY TRANSITION

... AND ACKNOWLEDGE TRADE-OFFS & TALK ABOUT THEM OPENLY

ENVIRONMENTAL RISKS

DUSH FOR MULTI-STAKEHOLDER PARTNERSHIPS → WORK AHEAD RISKS FOR INVESTORS



ETHICAL MINING

WHY? BECAUSE IT IS... THE RIGHT THING TO DO!



I AM FROM FRANCE, BUT MY CAR BATTERY IS FROM ARGENTINA

LOCAL DEVELOPMENT HELP COUNTRIES MOVE UP THE VALUE CHAIN



SHOWCASE CHAMPIONS

IN THE PRIVATE SECTOR, SHOWING THE WAY & PUT IN STRONG REGULATIONS FOR OTHER COMPANIES WHO ARE TO FOLLOW.

EV'S MAY BE THE FUTURE OF CARS... BUT NOT OF MOBILITY

WE MUST OVERCOME SILOS

MUST CHANGE TO COOPERATION

POTENTIAL CONFLICT



WE MUST NOT REPEAT A NARRATIVE FROM THE FOSSIL FUEL ERA



LIMIT THE HYDES, BUT GO FOR REAL SOLUTIONS

UNCERTAINTY DUE TO POSITIVE INNOVATION

WE MUST FACILITATE RESEARCH TO BRING CLARITY FOR INVESTORS

TRANSPARENCY

WILL BE CRITICAL FOR THE SMALL COMPANIES INVOLVED WITH CRM → WHICH ARE SET TO GROW HEAVILY!

WILL OUR RIGHTS & NEEDS BE CONSIDERED?



• JOBS?
• SOCIAL PROJECTS?
• EDUCATION?
• HEALTH & SAFETY?

Photographs from the session 'Geopolitics of the energy transition: Innovation in critical materials'



Closing remarks and takeaways



Highlights of the session

Panel discussion

Moderator: Felicia Jackson, Editor, Sustainable Growth Voice

Panellists:

- Roland Roesch, Director, IRENA Innovation and Technology Centre, IRENA
- Peter Schniering, Founder and CEO of Future Clean Architects
- Eleanor Webster, Head Secretariat Mission Innovation

The panel discussed how sharing best practices, communication, education and reducing complexity were key to advancing the energy transition.

That transition is a hard mission, however, with electrifying and decarbonising hard-to-abate sectors no easy task. The panel pointed out that while the technology is there, a lot of it is at early level of technological readiness and still not disseminated, nor mass produced. Moreover, technologies are capital intensive and have long development cycles. The 'valley of death' could be found along the innovation pathway everywhere, with it taking smart public funding (and to some extent, private) along with smart policy tools to support the development and deployment of the technology needed.

Prioritisation, the panel concluded, is very important. There is a limited amount of green hydrogen able to be produced and renewable electricity with unexplored potential, while resources and funding are limited. The panel emphasised that it is necessary to prioritise targeted spending; a smart plan is necessary to take out of the equation everything that is not necessary.

Reducing the complexity of the energy transition would be a first step, the panel decided. Reducing complexity is achieved by taking science-based advice. Currently, panellists felt, a lot of energy and resources are being wasted on myths.

The closing discussion also highlighted that electrification should be done as much as possible, as it is the most effective. The last mile, however, remained the hardest. Panellists pointed out the necessity of flexibility tools, as renewable electricity is variable, with long duration storage, demand-side management and other tools very necessary.

At the same time, the panel reiterated, there is no one-size-fits-all solution or innovation. Cultural context is a key element that needs to be considered. Decarbonisation and electrification pathways are different in different contexts. Countries are on different trajectories, socially and economically, yet we all need to be thinking about the next generation.

Innovation is more than technology, panellists affirmed, saying that it was also about bringing elements together and establishing new ways of collaboration between countries, the private and public sector and different sectors. Often, it would take outsiders to change the status quo and bring innovation. When decarbonising a sector, it is very helpful to have someone with a fresh perspective – sometimes one from outside the sector – and not only the incumbents' views.

CLOSING REMARKS & TAKEAWAYS

NEVER STOP LEARNING



PUBLIC & PRIVATE SECTOR COOPERATION & ALLOW FOR DIFFERENT TRAJECTORIES

INNOVATION
WE MUST THINK IF OUR TECH WILL WORK POST 2030.



BIGGEST CHALLENGES?
FINANCING?
 HOW TO SOLVE COMPLEXITY?
 FOCUS ON **SCIENCE-BASED RESULTS** & DO MYTH-BUSTING
 ENSURE FOR COOPERATION

ONE OF IRENA'S CORE JOBS!



SHIPPING & AVIATION:
 INTEGRAL CALCULATION OF SHIPPING INTO MIX

COLLABORATION:
 IN SECTORS & BETWEEN GOVERNMENTS

SMART POLICY FUNDING Needed!

IT'S A GEO-STRATEGIC RACE:
 EMBRACE THIS & SEE WHERE YOU CAN PUSH FOR MORE!

IT'S GOING TO BE HARD.

WE ARE ALL IN THIS TOGETHER

WE NEED FRESH PERSPECTIVES FOR REAL INNOVATION

SYSTEMIC CHANGES:
 RESULATOR & POLICIES MUST SUPPORT NEW TECH

CRM - WHAT IS NEEDED & CAN BE SUSTAINABLY SOURCED

DEMAND FLEXIBILITY:
 RECYCLE & USE EXISTING MATERIALS

STORAGE:
 DEMAND & ELECTROMOBILITY TO STABILISE GRID
 REGULATOR'S ROLE IS ESSENTIAL

DIGITALISATION:
 KEY FOR SUSTAINABILITY & GRID ENHANCEMENT

SOCIAL & JUST TRANSITION:
 LOW-TARIFFS

SMART INVESTMENT IN BUILDINGS

INFRASTRUCTURE:
 SMART ELECTRIFICATION & BENEFICIAL FOR PUBLIC
 USE WHAT IS ALREADY AVAILABLE BRING DOWN

STEEL:
 STANDARDIZATION & POLICY NEEDED

PETER SCHAEFFER
 DIRECTOR GENERAL

RODOLPH ROESCH
 DIRECTOR

Photographs from the session 'Closing remarks and takeaways'



Demand-side management and storage

Case studies



Session organised in partnership with the Ministry of Economy, Trade and Industry (METI), Japan

There needs to be a paradigm change from a centralised energy system to a decentralised one.

Increasing amounts of variable and non-dispatchable renewable generation are required to unlock flexibility options, such as demand-side management and storage. This means a changing paradigm from a centralised energy system to a decentralised one. It also means changing from a system that forecasts demand to match it with supply, to one that sees increasingly better forecasting of supply to match it with demand.

The session shared experiences on strategies for demand-side management and storage adopted in different countries and regions. Experts and innovators from Europe, Asia and the United States shared different national strategies in incentivising demand-side management and the use of storage while showcasing solutions that had been implemented and created value on the ground.



Key actions

for policy makers

1. **Incentivise flexibility and de-risk flexibility asset investments.** This is essential to progress towards a more flexible energy system. Even though technology risk has plummeted in many cases due to technology cost reductions, focus should now be given to certainty of revenues. The technology to provide flexibility services is available, but is underused and undervalued.
2. **Unlock flexibility in as many demand sectors as possible.** These should include industry, district heating and cooling, e-mobility, regional microgrids and others.
3. **Inform consumers of the benefits of demand-side management.** Dynamic tariff signals and other incentives for demand-side management bring benefits both to the system and to the consumer. This means that transparency and simplification of contracts, data access and roll-out of smart meters are also deemed necessary.
4. **Design adequate flexibility mechanisms for system resilience and reduce dependency on energy imports.**

Highlights of the session

Setting the scene

IRENA analysts Arina Anisie and Juan Pablo Jiménez provided an overview of the ongoing system transformation in terms of flexibility options. They also presented IRENA's ongoing work on the quantification of benefits from the flexible operation of distribution grids.

In this study, IRENA developed a power flow optimisation model to determine the optimal operation of the grid to reduce energy losses when heat pumps, EVs and decentralised solar PV systems were present. Results showed that a flexible operation could delay investments in the grid while increasing the electricity demand.

According to IRENA's analysis, enabling power-to-heat and power-to-mobility flexibility options as well as decentralised generation with solar PV can reduce peak demand by 50% and grid losses by 25%. This is especially so during the winter, when heat demand is dominant. Investments associated with grid reinforcement could be delayed or even avoided. Savings could be in the order of millions of euros for neighbourhoods of 25,000 people.

Case studies from Europe

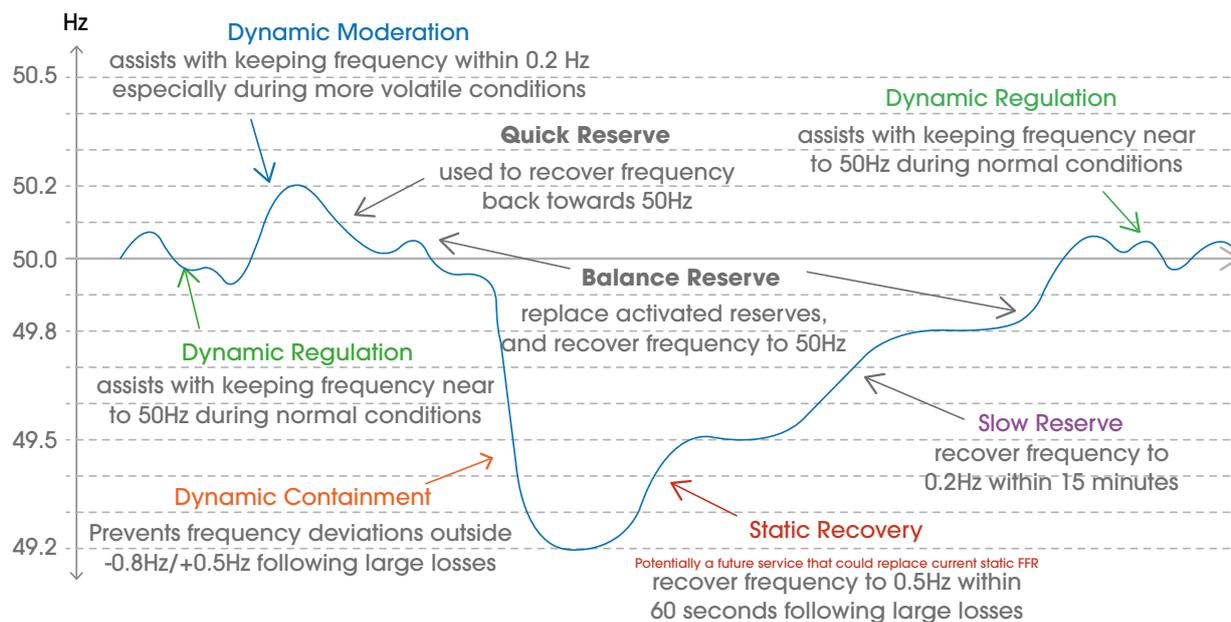
Panellists:

- Emanuele Taibi, General Manager, Italy, Field
- Sylvie Tarnai, Chief Strategy Officer, Energy Pool
- Michael Villa, CEO, SmartEn

Emanuele Taibi, General Manager, Italy, Field, gave an overview of progress in the policy arena in Italy and the United Kingdom and provided some policy recommendations on how to create a successful storage market.

Emanuele Taibi provided advice from an on-the-ground level. First, he indicated that the key services that offer revenue are in the ancillary services related to frequency, rather than in the wholesale market. In this regard, he then presented the variety of ancillary services available in the United Kingdom.

Ancillary services, the United Kingdom



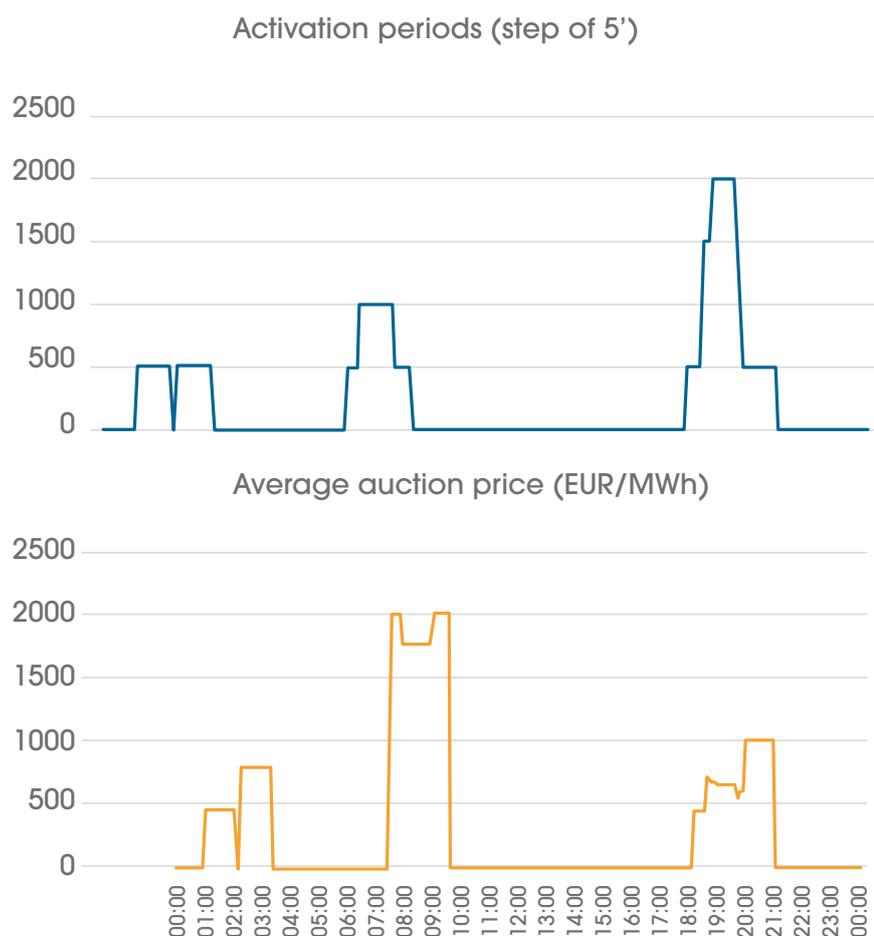
He also highlighted that so far, market interest (or priority) is in short-term storage, rather than long-term. Regarding prioritisation, water heating storage (sensible heating storage) is low hanging fruit for storage that needs priority in the expansion of storage options. Lastly, he pointed out that energy communities could help drive investment needs and offer investment certainty.

Sylvie Tarnai, Chief Strategy Officer, Energy Pool, presented the services provided by Energy Pool.

She stressed the differences between operating as an aggregator in the French and German markets (Energy Pool operates in both). France expects to have up to 16 GW of demand-side management by 2035, while Germany expects up to 7.2 GW by 2037 without a voluntary policy. To put this in perspective, 21 GW were activated in 2019 in Europe, she said. By 2030, more than 130 GW were expected. To provide context to this number, peak demand in the EU27⁴ in 2022 was roughly 86 GW.

In line with Emanuele Taibi, Energy Pool estimated bidding prices between EUR 300 per megawatt hour (MWh) and EUR 2 000/MWh, for upward activated lead times of up to 30 minutes, with a duration of between 1 and 2 hours. This means healthy revenue could be harnessed for ancillary services. These numbers were based on Energy Pool’s market expertise, its own prediction tools and real-time market monitoring.

Balancing market activities in Q1 2023 in France: with right signals, consumer reacts



⁴ All 27 member states of the European Union.

Energy Pool alone already operated in 10 countries, Tarnai said, operating assets that gave a total flexible capacity of 6 GW. This indicates that the market exists, she said, and is building up. The cases of the cement industry and the agri-horticulture sector were presented, indicating that these sectors presented demand-side management potential.

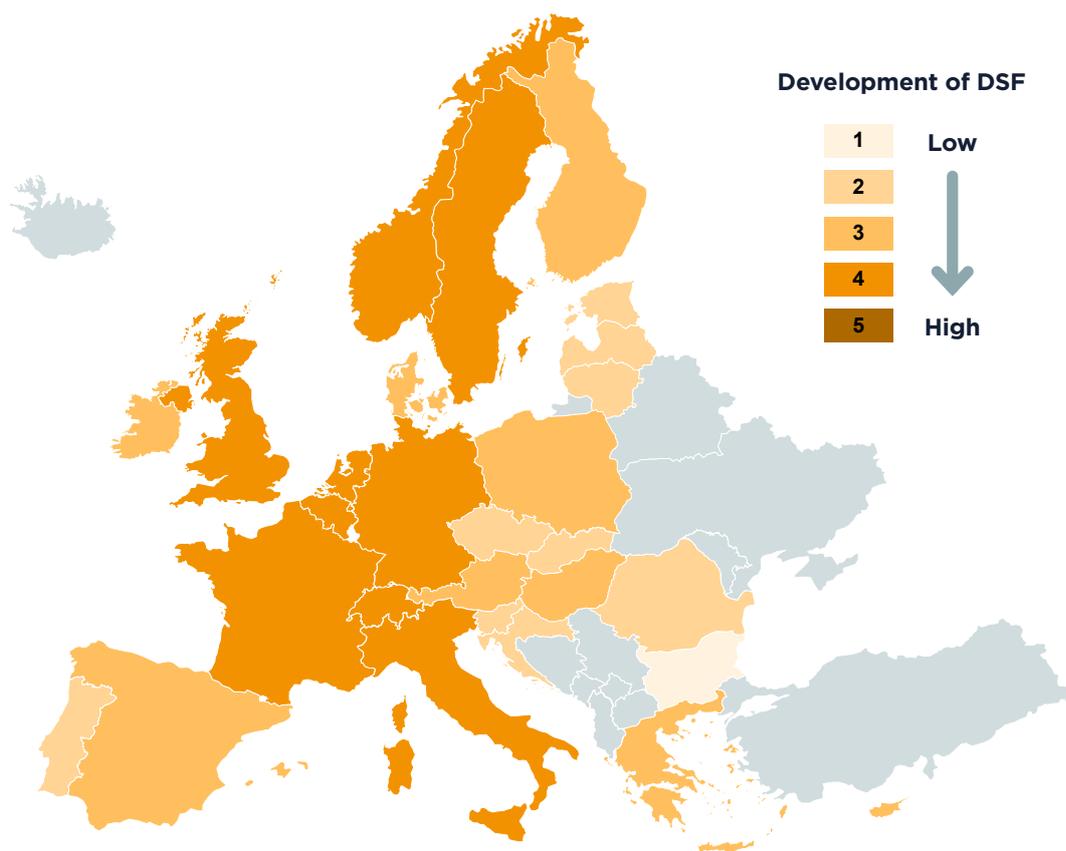
Volatility is the new business model

Michael Villa, CEO, SmartEn

Michael Villa, CEO, SmartEn, summarised the needs, risks and opportunities related to setting up a more flexible energy system. He also said that European policy is moving in the right direction, but more progress is required in terms of certainty. In this sense, the European Green Deal Implementation Plan 2024-2029 could be a great opportunity, he said.

Michael Villa discussed key factors unlocking demand side flexibility in Europe. He said that demand-side management (or demand-side flexibility) potential is still unlocked in Europe, especially in southwest and eastern Europe. He said that by activating demand-side management, the EU had already saved EUR 16 billion in 2023 in total gas costs. These savings had the potential to double in 2025, he added.

Development of demand-side management, Europe



Source: smartEn (2023), *2022 Market Monitor for Demand Side Flexibility*, Smart Energy Europe, <https://smarten.eu/wp-content/uploads/2023/02/DSF-Market-Monitor-2022.pdf>

The potential benefits to the energy system and consumers that demand-side management can provide by 2030 are summarised:

Potential benefits of demand-side management

| Energy system | Consumers |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• Renewable energy curtailment reduces by 15.5 TWh (61%)• 37.5 million tonnes (8%) saved in GHS emission/year• Avoidance of at least 60GW of peak generation capacity, saving EUR2.7 billion/year• EUR11.1-29.1 billion/year saved in grid CAPEX investments | <ul style="list-style-type: none">• Consumers with flexible assets benefit directly, more than EUR71 billion/year• All consumers benefit from lower wholesale prices and system costs, over EUR300 billion/year |

Case studies from Asia

Panellists:

- Hideyuki Umeda, Director for International Policy on Carbon Neutrality, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), Japan
- Sylvie Tarnai, Chief Strategy Officer, Energy Pool
- Songsong Chen, Division Director and Senior Engineer in the Department of Electricity Consumption and Energy Efficiency, China Electric Power Research Institute (CEPRI)

The Japanese case

District heating and cooling has a role in balancing markets(...) Regional microgrids are central for demand-side management in Japan

Hideyuki Umeda, Director for International Policy on Carbon Neutrality, Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (METI), Japan

Hideyuki Umeda, Director for International Policy on Carbon Neutrality, Agency for Natural Resources and Energy, METI, began the session by stressing the importance of training in enabling the growth of flexibility markets. This was so, he said, even though Japan already has more than 50 aggregators.

He then highlighted the support demand response provides in minimising blackouts, especially in island areas. In Japan, he said, there are 57 aggregators and in 2023, balancing capacity had reached 2.5 GW. This was based on successful bids in public offerings for balancing power at the general electricity transmission and distribution utilities. The aim was to increase this capacity at an annual rate of 0.5 GW/year, while also promoting of internet-of-things (IoT) technologies.

Demand response strategies in Japan had already proved effective, he then added, helping to supply power during black outs in the city of Isumi, where some 96 hours had been provided, and Kurima island, where microgrids had been able to mitigate typhoon blackouts.

Umeda highlighted the role of district heating and cooling systems in storing energy during periods of surplus. Regional microgrids enabled efficient energy production. Efficient co-ordination of energy supply and demand with the microgrid also avoided the costs of larger networks, he said.

Sylvie Tarnai, Chief Strategy Officer, Energy Pool, then complemented the Japanese overview, pointing out that EnergyPool operates in Japan in co-operation with its local partner, the Tokyo Electric Power Company (TEPCO). The mission of Energy Pool in Japan is to value the flexibility potential of district heating and cooling systems, with the focus on urban areas like Tokyo, she said.

Japan, she said, had the greatest density of PV installed capacity in the world. This had led to more than 7.5 gigawatt hours (GWh) of demand curtailment and more than 124 GW of demand stimulation in 2022. This issue could only be resolved by incorporating demand-side management strategies at scale, she said. This would include district heating and cooling systems that could leverage flexible assets, such as water tanks. In addition, load modulation in Japan represented an innovative service for integrating more VRE.

The Chinese case

Songsong Chen, Division Director and Senior Engineer in the Department of Electricity Consumption and Energy Efficiency at CEPRI, covered best practices in demand-side management in China's state grid. China is experiencing growing demand for cooling, he said, with this representing a third of peak load in 2020. At that time, about 60 GW was curtailed to ensure normal operation of the power grid.

Overall, he continued, the Chinese power grid is facing two main issues: (1) frequent short-term power supply and demand conflicts occurring due to seasonal extreme weather; and (2) the amount of wind and solar capacity connected to the grid continuing to increase, increasing demand for flexibility sources.

By the end of August 2023, he said, on-grid wind and PV capacity in China reached 910 GW, with an estimated rate of annual increase of around 160 GW. According to the 14th Five-Year Plan's Modern Energy System Planning document issued by the National Energy Administration (NEA), installed capacity in wind and solar renewable energy would be 1 000 GW by 2025. Given this growth – and even taking account traditional flexibility sources, such as pump-hydro or fossil-fuel technologies – there would be a large gap in flexible capacity, as presented in the table below.

China: flexibility gap, 2020-2050 (GW)

| GW | | 2020 | 2025 | 2030 | 2050 |
|---------------------------------|--------------------------------|------------|------------|------------|--------------|
| Variable renewable energy | | 500 | 1 000 | 1 500 | 4 000 |
| Traditional regulatory measures | Flexible coal-fired | 100 | 200 | 300 | 400 |
| | Gas-fired | 100 | 150 | 180 | 230 |
| | Pump-hydro | 32 | 68 | 120 | 170 |
| | Electrochemical energy storage | 3 | 20 | 200 | 610 |
| Gap | | 265 | 562 | 700 | 2 590 |

China's policies are therefore focusing on the following aspects:

- Encouraging the tapping of demand-side resource potential and promoting its participation in the market. China's recommendations include: establishing and optimising a unified, standardised system for demand-side management privacy and security; and unifying interactive interface inspection and certification standards.
- Peak load reduction.
- Facilitating VRE integration.
- Upgrading energy efficiency policies.

Case studies from the United States

Panellists:

- Siva Gunda, Vice-Chair, CEC
- Daniel Bowermaster, Senior Programme Manager, EPRI
- Gregory Poilasne, Co-Founder, Director, Chairman and CEO, Nuvve

Shaping demand is pivotal in achieving a more resilient energy system, in view of more frequent extreme weather events

Siva Gunda, Vice-Chair, CEC

Siva Gunda, Vice Chair, CEC, began the session by providing some insights into the current state of the demand-side management market in California.

He began by stressing the importance of shaping the demand profile. In California, due to hot weather events, daily peak loads are moving from late afternoon to early evening, as demand remains high and PV production is no longer available. This new shape requires a ramp-up capacity of more than 10 MW from 10 a.m. to 8 p.m., moving from a net demand of 23 MW to a little over 33 MW. He also stressed the importance of tackling demand-side management from various perspectives. These included different time scales – from seconds to years – and strategies such as ramping up mitigation, frequency control or behavioural changes.

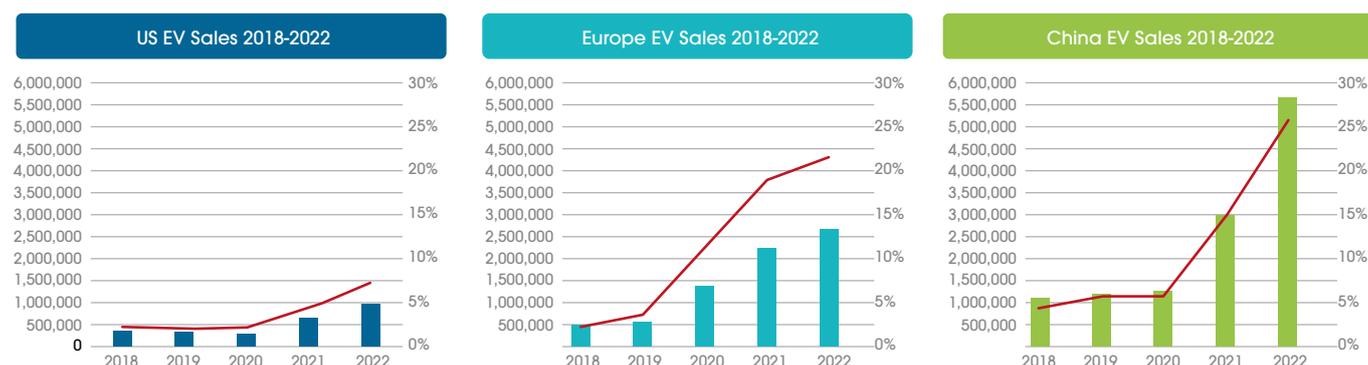
In particular, he said, five dimensions should be taken into account when it came to setting actions to foster demand-side management. These were: responsiveness, duration, frequency, reliability and cost. Then, Gunda provided some insights into California’s planning processes focusing on extreme weather events. For these, an emergency disaster recovery strategy has been planned. This included an emergency load reduction programme, demand-side grid support and distributed generation backup assets.

The EV load hasn’t caused issues yet because programmes have not been successful in rolling-out EVs

Daniel Bowermaster, Senior Programme Manager, EPRI

Daniel Bowermaster, Senior Programme Manager, EPRI, then focused his presentation on e-mobility in the context of demand-side management. He began by providing an overview of the EV market in the United States, which is advancing at a slower pace than the European and Chinese markets.

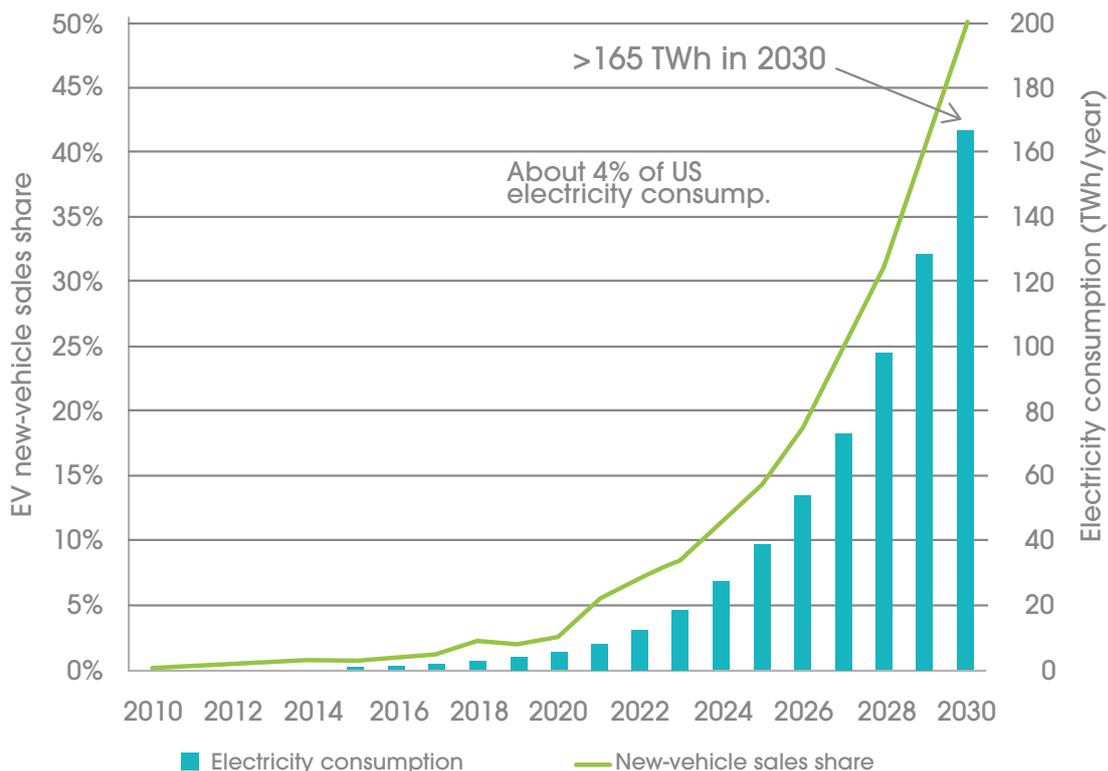
EV sales, Europe, China and the United States, 2018–2022 (units)



The number of EV sales in the United States represented more than 14 TWh of ‘movable’ flexible new load, he said. This should be smartly accommodated by the market and represented a great opportunity for the industry. However, the EV market across the United States was uneven, which meant some energy systems would need to be more prepared in terms of flexibility. As an example, new EV sales in some California counties were around 40% of total car sales, while in other states, such as Alaska, Maryland or Oregon, only reached around 20% of the total.

Policies in the United States are trying to support the roll-out of EVs, however, he said. An executive order from President Joe Biden’s administration aimed for EVs to reach 50% of all new passenger vehicle sales by 2023. From 2027 onwards, new economy rules for medium- and high-duty vehicles were also expected to be introduced to the market. Projections show that EVs would account for more than 165 TWh of electricity demand by 2030. This represents 4% of total US electricity consumption, which also represents major opportunities for the demand-side management market.

EV electricity consumption and new EV sales share, 2010-2030 (% , TWh/year)



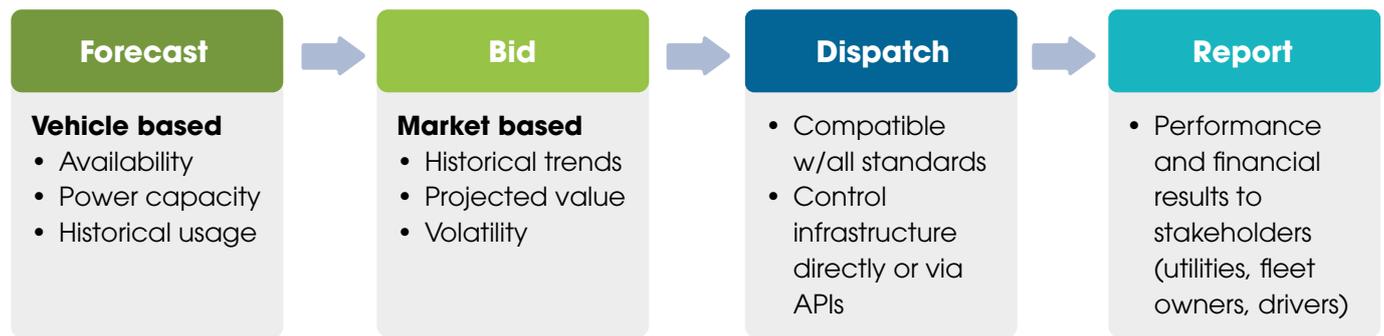
Bowermaster then focused on the role of EVs as flexibility providers. He also said that EVs had not been a problem yet for power systems because programmes for their roll-out had not yet been fully successful.

The power of V2G: an average US household consumes 30 kilowatt hours (kWh) per day and an electric school battery bus, which does not operate for 3-4 months a year, can store 150 kWh

Gregory Poilasne, Co-Founder, Director, Chairman and CEO, Nuvve

Gregory Poilasne , Co-Founder, Director, Chairman and CEO, Nuvve, then spoke, saying that there was evidence of V2G initiatives all over the globe. Nuvve, he said, was already providing this service in Demark and in the United States, China, Portugal and other countries. Nuvve had developed a platform that included forecasting, bidding, dispatching and reporting services. These met the needs of drivers, batteries and the grid on a second-by-second basis.

The Nuvve platform: Forecasting, bidding, dispatching and reporting



API = Application planning interface

Nuvve, he said, was dedicating a great deal of effort to forecasting services because is an area where benefits could be maximised and the grid greatly benefited. Nuvve's forecasting is based on price signals which subsequently reflected the status of the balance between supply and demand. Therefore, their forecasting service aims to find moments when there is surplus generation in order to incentivise consumption.

Francisco Boshell from IRENA then closed the session by thanking METI for its support in the work done by his agency and in the co-organisation of the session.

DEMAND SIDE MANAGEMENT & STORAGE



SESSION 4
WED 27 SEPT

TODAY WE FOCUS ON CASE STUDIES

THE NEED FOR FLEXIBILITY ON BOTH SIDES

WE MUST WORK ON BOTH SUPPLY & DEMAND IN ORDER TO COMBAT CLIMATE CHANGE

STRUCTURAL CHANGES

- RECONSTRUCTED
- PROVIDE MORE PROTECTIONS

JAPAN

HOW TO RESPOND?

ADVANCED TECHNOLOGIES

GOAL IS 8X CAPACITY INCREASE IN RE-ELECTRIFICATION (EV)

BASE POLICY FOR PRODUCTION OF GREEN TRANSFORMATION (EV)

DEGREE OF OPPORTUNITIES:

- POSITIONED TO USE INTO PRODUCTIONS

DE-RISK FOR INVESTORS

HOW TO DE-RISK?

FIELD VISION: INFRASTRUCTURE TRADING OF THE FUTURE

BALANCING SUPPLY & DEMAND

MANAGEABLE SUPPLY → FLEXIBLE

MANAGEABLE DEMAND → FLEXIBLE

MORE INTERESTING STORAGE OPTIONS:

- HEAT PUMPS
- MAIN THERMAL STORAGE DEVELOPMENT

UTILITY SCALE E-STORAGE

- BULK ANCHORAGE
- TRANSMISSION

STRONG MOMENTUM ON SHIFTING TIME DIRECTIONS

NOW IS THE MOMENT FOR GREEN INVESTMENT

WE DON'T KNOW, BUT WE MUST BE OPEN TO GET OUTSIDE

3X CAPACITY INCREASE

HEAT PUMPS & PVs IN HOUSEHOLDS

SMART ELECTRIFICATION

WHAT ARE SOME SCENARIOS?

- DYNAMIC CAPACITY
- EV BATTERIES
- LESS FLUCTUATIONS
- 25% REDUCTION
- FLEXIBILITY WITH PEAK DEMAND
- SMART ELECTRIFICATION DECREASES MAXIMUM USE OF LINES AND IMPROVES THE SCENARIO
- ACCURATE POSITIONING INVESTMENT

INTEGRATE SYSTEMIC CHANGES

SOME RESULTS

NEXT FRONTIER?

ENERGY POOL

FRANCE, UK, FIN

STILL SMALL ROLE

ENABLING DSM:

- PRODUCTION WILL DRIVE CONSUMPTION
- MID-SIZE COMPANY ACTIVE IN 10 COUNTRIES
- G&W ASSETS

CONSULTING

SOFTWARE SOLUTIONS

MECHANISMS?

- CAPACITY MARKET
- LONG-TERM CALL FOR TENDERS
- SET MARKET D-1
- SYSTEM SERVICES TENDERS ARE

FRANCE TARGET: 6.5 TB 2030

DEMAND SIDE MANAGEMENT

- STRATEGIC ADVICE
- PROCESS TRANSFORMATION & HYBRIDIZATION
- SOFTWARE SOLUTIONS

SOLUTIONS EXIST! THEY ARE WAITING TO BE IMPLEMENTED!

PEAK SHAVING IN FRANCE → HIGHEST FLUCTUATION

INDUSTRIAL CONSUMER:

- CEMENT PLANT
- M&O - INDUSTRIES
- PAPER

EMTS SYSTEM

SOFTWARE SOLUTIONS TO MANAGE A GRID-CONSTRAINED CONSUMER

JAPAN

IN PARTNERSHIP WITH AEP&C & ERC

- 3,000 SITES
- 250 SITES

INNOVATION → VIRE WITH GOAL TO MAXIMIZE SOLAR OUTPUT UTILIZATION

DISTRICT HEATING & COOLING

HOW TO SITES CONNECTED

→ HUGE FURTHER POTENTIAL

KEY TAKEAWAYS!

- TECHNOLOGY NOT USED TO FULL POTENTIAL
- BUSINESS MODELS NEEDED!
- REGULATION & ACCURATEMENT NEEDED!
- COMMUNICATION BETWEEN ALL STAKEHOLDERS
- HOW TO ENGAGE CONSUMERS?

smartEn

MEMBERS? - HOORHOS & COMPANIES

FOCUS ON PROSUMERS!

25% IN THE EU!

VOLATILITY

MORE FLEXIBILITY

NEEDS INVESTMENT

- RESILIENCE
- ENDURE AFFORDABILITY
- RISKS OF SUPPLY-ONLY FOCUS

RESULTS 2020

- RE-ENGAGEMENT REDUCED BY 61%
- AVOIDANCE OF GOALS OF PEAK GENERATION CAPACITY

WHY ARE WE STILL MISSING POTENTIAL?

- BARRIERS!
- LACK IN NON-FOSSIL DEES
- DELIVERED SIGNALS IN RETAIL PRICES
- TAXES
- LIMITED ACCESS TO DATA

EVEN DURING EMERGENCY SITUATIONS THE EU SHOULD BE ABLE TO RESPOND

CHINA

STATE GRID

SEASONAL EXTREME WEATHER

HUGE FLUCTUATIONS

RESULT IN DSM WITH A 562 GW GAP IN 2025

DEMAND SIDE:

- MARKET STRUCTURE TOOLS
- IMPACTS OF POLICIES
- IMPLEMENTATION OF VIRE INTERGRATION
- OPERATING EFFICIENCY

ENCOURAGEMENTS:

- REPARTMENTS
- ENTITIES REGULATORY AUTHORITIES
- PROMOTE CONSTRUCTION
- FIVE YEAR PLAN
- SUBSIDIES FOR 25 REGIONS

RECOMMENDATIONS:

- PREFERENCE OF VOLUNTARY CARBON MARKET
- HIGH INVESTMENT WITH LOW PARTICIPATED RESULTS
- PRIVACY SECURITY

IMPACTS OF POLICIES

- IMPLEMENTATION OF VIRE INTERGRATION
- OPERATING EFFICIENCY

SENDING MESSAGE: "TURN OFF LIGHTS!"

TO MILLIONS OF CITIZENS

WITH IMMEDIATE RESULTS

BEHAVIOR DRIVEN RESPONSE!

RECOMMENDATIONS:

- BEHAVE AVAILABILITY
- EXPLORE CENTRALIZED MARKET CHALLENGER?
- FLEXIBLE PRICING
- AMI DEPLOYMENT
- INFRASTRUCTURE MODERNIZATION

AVERAGE EV MARKET 8.5% ACROSS COUNTRY

MORE IN CALIFORNIA

NO MAJOR GRID PROBLEMS

EV POPULATION:

- 85% NOT ENROLLED
- 15% ENROLLED

IN CHARGING PROGRAMS

NUVE

EV'S ARE UNRELIABLE: IF UNPLUGGED & NEED TO PARK FOR LONG PERIODS OF TIME

ADJUSTING CHARGE RATE IS IMPORTANT

- DIFFERENT TESTING → TO MOVE LOAD ACROSS EVS
- EV - SCHOOL BUS PROJECT IN US → PERIOD LONG TIMES → HUGE NUMBER OF PATRONS

DENMARK

FORECASTING IS VERY IMPORTANT!

USA

BY @IRISMAERTENS FOR VISUAL HARVESTING

Photographs from the session 'Demand-side management and storage: Case studies'



Enabling data driven decision making

Mission Innovation's Energy Innovation Metrics Hub



Session organised in partnership with the EC JRC

Mission Innovation, a global initiative fostering clean energy innovation.

Mission Innovation (MI), a global initiative fostering clean energy innovation, established the Insights Module to enhance access to evidence and monitor progress in innovation. The Insights module serves as a forum for governments dedicated to advancing clean energy and is integral to tracking MI missions and facilitating learning from national programmes.

In 2023, MI was also working on the Energy Innovation Metrics Hub. This hub aims to create an online repository and dashboard, consolidating innovation data and metrics to enable data driven decision making. MI's knowledge partners, the EC JRC, the International Energy Agency (IEA) and IRENA, have contributed their expertise to make the hub a comprehensive resource for countries, researchers and citizens.

This session focused on gathering feedback and discussing the design of the hub. During the discussion, stakeholders from the innovation community and policy makers engaged in a dialogue to ensure that the hub effectively supports decision making in the realm of clean energy innovation.



Key actions

for policy makers

1. **Prioritise the assessment and reporting of data.** The importance of these should be recognised in tracking actual progress. Measurable quantitative indicators should be established to guide and accelerate the energy transition effectively.
2. **Prioritise the analysis of patent data, scientific publications and other relevant metrics.** Their significance as indicators for innovation, commercialisation and market progress should be acknowledged. Incorporating these insights into policy making is essential for robust policy development.
3. **Recognise the significance of overcoming challenges related to data reporting.** Addressing issues such as timing, processing needs and ensuring data availability and quality is crucial for informed decision making and effective policy development to support the energy transition.

Highlights of the session

Setting the scene

Introducing MI

Eleanor Webster, Head of Secretariat at MI, welcomed participants to the session. She emphasised Mission Innovation's collaborative nature and highlighted key partnerships with agencies such as the EC JRC, the IEA and IRENA. She outlined MI's goal to catalyse a decade of action and investment in clean energy research and development.

She then emphasised the pivotal role of MI Missions and their aim to deliver over 200 demonstration projects, globally, accelerating the cost competitiveness of clean energy technologies. Notably, the Clean Hydrogen Mission exhibited promising progress, she said, identifying 83 hydrogen valley projects in 33 countries. She then underscored the global collaboration that was evident across all seven missions.

She then turned to the significance of the MI Innovation Platform, which was dedicated to strengthening the global clean energy innovation ecosystem and enhancing confidence in emerging solutions. Her succinct overview highlighted the critical elements of MI's initiatives, setting the stage for a focused and collaborative session.

The MI Insights Module and Energy Innovation Metrics Hub

Ingrida Murauskaite-Bull, EC JRC Project Officer and MI Insights Module Manager, introduced the objectives and activities of the MI Insights Module. She explained that the objective of the module is to strengthen access to robust evidence on progress in innovation in order to inform effective decision making.

Key activities included creating the Energy Innovation Metrics Hub and supporting MI Missions to track progress through data-driven key performance indicators (KPIs). They also included developing the MI Member Insights Report and National Innovation Pathway and organising events and producing case studies as part of a newly-established think tank.

The Energy Innovation Metrics Hub would also leverage the in-house knowledge of its collaborating partners, she said. The EC JRC would contribute data on private R&D investment in clean energy technologies and patent indicators. IRENA would contribute data on standards, the levelised cost of electricity (LCOE) and total installed capacity. Finally, the IEA had committed to contributing data on public R&D and venture capital investments in clean tech start-ups.

The Energy Innovation Metrics Hub also aimed to provide comprehensive coverage of clean energy innovations, enhanced data interpretation, a centralised and easy-to-navigate platform for analysis, and increased awareness. It would support MI missions in making informed decisions and enhance MI's visibility, she added.

Input presentations on tracking innovation progress from JRC, IRENA and the IEA

Aliki Georgakaki, Project Leader of Energy Transition Insights for Policy at EC JRC, then shared some insights on private R&D investments and patent data.

Given the diverse scope of this area, she highlighted the challenge of adapting patenting trends to MI missions. This, she said, made comparisons and translation into practical insights more challenging. Private R&D investments constitute two-thirds of overall R&D investments. However, breaking down these numbers into different technologies presents challenges, as companies may track their R&D budget at an aggregate level, rather than providing a detailed breakdown. There remains a need for further discussion on how to address these challenges, she said, and to determine what information was most valuable while finding the right balance between obtaining the most recent data and having sufficient detail.

Georgakaki went on to say that open questions for the MI Energy Innovation Metrics Hub revolved around the format and granularity of data and metrics, the design of effective classification and the most effective presentation and visualisation of data.

Francisco Boshell, Head of Innovation and End-Use at IRENA, then introduced the Innovation Life Cycle, a framework illustrating the developmental stages of technology.

This cycle consists of five key stages: basic science and research, applied research and development (R&D), demonstration, market development, and commercial diffusion. These stages offer insights into the progress of innovation within a specific technology, with feedback loops between them revealing gaps and opportunities, he said. While indicators such as R&D investments, patents, and scientific publications had been standard for over a century, there is a growing need to incorporate new indicators that better capture current developments and policy makers' interests in specific technologies.

One proposed approach is leveraging social media platforms such as LinkedIn. Isolated indicators only present a partial view, however, capturing just one side of the story. The real challenge lies in identifying meaningful linkages between indicators to provide a comprehensive and accurate portrayal of the innovation landscape.

Suzu Leprince, Energy Data Officer at the IEA, then introduced the IEA research, development and demonstration (RD&D) database. This encompassed data on research, development and demonstration budgets funded by national governments and state-owned enterprises since 1974.

She then highlighted trends in diversification, highlighting a significant shift in public R&D spending. Over the past five years, she said, the surge in public R&D spending by IEA countries had been notably fuelled by energy efficiency, with the most substantial increase observed in hydrogen and fuel cell technologies.

Leprince also provided insights into venture capital investments, noting a surge in early-stage equity funding for energy start-ups. Clean mobility and renewables lead in venture capital investment, yet prevailing macroeconomic conditions have impacted the availability of capital, potentially leading to a leaner 2023 for later-stage deals. Notably, the majority of venture capital funding in the energy sector had been directed towards US-based start-ups, while Europe excelled in hydrogen and China actively invested in mobility and batteries. Emerging markets and developing economies accounted for a mere 5% of total energy sector venture capital funding, she said.

Discussion and stakeholder engagement

The presentations were followed by a discussion. Some of the key takeaways were:

- Significant challenges in collecting innovation data revolve around its availability, timing, and quality. Convincing countries to report their data is crucial, but it is equally important not to overburden them with reporting duties. Therefore, fostering collaboration and the sharing of data and information among institutions working on this task is vital. Mission Innovation plays a pivotal role as a platform to facilitate this collaborative effort.
- To meet the 2030 targets, it is crucial to triple the current installed renewable capacity. This ambitious goal underscores the importance of innovation in accelerating our progress. Policy makers play a vital role in this journey by designing effective policies. Access to the right information is key for them to make informed decisions that drive innovation forward. The interconnected nature of tripling capacity, accelerating advancements and fostering innovation highlights the need for a comprehensive strategy. Metrics emerge as a critical tool, providing valuable insights to guide policy making and ensure our collective efforts are well-informed and impactful.
- The Energy Innovation Metrics Hub embodies the principle that what gets measured gets done, showcasing the commitment of three major international institutions (IRENA, the IEA, the EC JRC) to consolidating knowledge. A clear map and ongoing progress assessments are crucial. The hub serves not only to measure achievements, but also to pinpoint gaps and identify opportunities for collaboration.
- Research, innovation and strengthened international co-operation form the bedrock of the response to climate change. Introducing new technologies to the market is essential in order to discover the right pathways to decarbonisation of our energy system by 2050. The enormity of the challenges requires a collaborative, global effort and this is where the value of MI shines — bringing together major innovators from across the world.

ENABLING DATA DRIVEN DECISION-MAKING

MISSION INNOVATION ENERGY INNOVATION METRICS HUB IN PARTNERSHIP WITH JRC

DAY 3
SESSION 2
WED 21 SEPT

WELCOME!
ELEANOR WEBSTER
MI IS AN ACTION-ORIENTED PLATFORM
ENHANCE GLOBAL INVESTMENT IN INNOVATION

- INFLUENCE MEMBERSHIP
- ACCELERATE RE INNOVATION → TO DRIVE DOWN CARBON
- BRING DOWN COST OF INNOVATION
- STRENGTHEN ECOSYSTEM ON OUR PLATFORM WORKING ON INSIGHTS

INSIGHTS MODULE
ACCELERATE INNOVATION!
COORDINATE
FLEXIBLE
COORDINATE
CROSS-CUTTING

WE LAUNCHED A **THINK TANK**
FACILITATE INTEREST
WORKSHOPS
SHARE BEST-PRACTICE

COMMITMENTS?
INVESTMENT ↑
NATIONAL PATHWAYS
WORKSTREAMS
METRICS

HUB
VISIBILITY

INTERNATIONAL DEVELOPMENT ONLY INVESTS WITH PROVEN UPTAKE
AS SHOWN IN OFFSHORE WIND & BIOFUELS
WE BRING TOGETHER **SCIENCE TO SUPPORT POLICY**
WE DEAL WITH INSIGHTS SUCH AS
INFRASTRUCTURE
INNOVATION SUPPLY CHAIN

HOW TO BUILD A STORY FOR STAKEHOLDERS?
DATA + METRICS SPECIFIED PER STAKEHOLDER

LEARNING TRENDS
CHALLENGE
DIFFERENCES IN SCORES
VARIOUS METRICS

INTERESTED TO GET INVOLVED?
GET IN TOUCH BEFORE OCTOBER 6th

IRENA HOW WE SUPPORT M.I.?
USE QUANTITATIVE DATA
INDICATION 30 INNOVATION BRIEFS
SUB-CATEGORIES

WHY INDICATORS MATTER?
INNOVATE ON INDICATORS, INNOVATION → CATEGORIES

TRACKING INNOVATION PROGRESS

PUBLIC R&D
WE PROVIDE ANALYSIS & COLLECT COUNTRY DATA

VC TRENDS
VC INVESTMENTS
EARLY-STAGE EQUITY FUNDING HAS EMANATED
→ LATER STAGE HAS MORE UPTAKE

WE MUST SPEED UP INNOVATION!

WE COLLECT DATA FROM COUNTRIES

WHAT WE DO WITH DATA:
GOES BACK TO 70'S
UPTAKES IN R&D SPECIFICALLY HIGH IN 90'S
EFFICIENCY & FUEL COSTS HAVE HIGHEST INVESTMENT

IEA
BUDGETS OF NATIONAL BUDGETS FOR R&D:
4 LEVELS LIKE
EFFICIENCY
RENEWABLES
RECH
NUCLEAR

WE WORK ON **ESTIMATES**
WHEN WE DON'T GET DATA FROM FOR EX. CHINA

ROADMAPS
TO COLLECT INNOVATION DATA:
PUBLICATIONS/REPORT
PUBLIC INVESTMENT
TRACKING CLEAN ENERGY

CHALLENGES
OF COLLECTING DATA & COMMERCIALIZED REA?
REPORTING IS MORE BASED ON ESTIMATING
AVAILABILITY
TIMING OF DATA
CORRECTNESS OF DATA

AUDIENCE QUESTIONS
HOW TO AVOID DOUBLE WORK?
WE UTILIZE AS MUCH AS POSSIBLE IN-HOUSE

DEPLOYMENT?
WE WORK WITH SAM ON INNOVATION & DEPLOYMENT

GET TO KNOW THE AUDIENCE!
YES WE USE DATA
WIDE-RANGE OF ORGANISATIONS & GROUPS
POLICY-MAKING & DATA PROVISION ARE MAIN BENEFITS
DATA-TRACKING IS OUR BIGGEST CHALLENGE

NEW INDICATORS
THAT ARE OF INTEREST?
FOSSIL FUELS
COUNTRIES

KEY TAKEAWAYS?
CHANGE MUST BE LARGE-SCALE
WE MUST DO THIS TOGETHER!
DELIVERY AS IMPORTANT AS PLAN
WE BRING DATA TOGETHER AS KEY INPUT TO POLICIES & IDENTIFY GAPS & OPPORTUNITIES.

Photographs from the session 'Enabling data driven decision making'



Collaborative framework for high shares of renewables



Session co-facilitated by Japan and El Salvador

Innovative solutions, built upon a combination of individual innovations, should bring together those elements necessary for a transformative impact on the way societies currently consume energy. Such solutions must not only be technology-based, but also include innovations in market design and regulation, system planning and operation, and business models.

Innovative solutions should bring a transformative impact on the way societies currently consume energy.

Innovative solutions will therefore emerge from leveraging synergies between advances across multiple components of the energy system in a process called systemic innovation. This process is essential if effective structural transformation of the energy economy is to be achieved.

Priorities for this include: making the necessary technology available; defining the regulatory framework for sending the right signals to market players; accounting for innovations in systems' planning stages; and enabling innovative business models to emerge that capture the value added from smart electrification strategies.

Furthermore, one-size-fits-all solutions do not exist. The optimal strategy for each energy system and the implementation of various innovations depends on the country context and its system-specific variables.

This session brought together industry stakeholders to share experiences of energy system innovation. It had a specific focus on innovative technology and business solutions for the cost-effective integration of a high share of renewables in the energy system. The session looked closely at different aspects of trends in innovation, the changing roles of future energy systems, enabling technologies, business models, market design and system operation.



Key actions

for policy makers

1. **Accelerate the energy transition through innovation electrify end-use energy demand.** This should be done while minimising infrastructure costs and optimising power systems. The bulk of the energy transition relies on renewable electricity as the main, future energy carrier.
2. **Consider innovation for smart electrification.** This has four dimensions: technology, business models, regulation and systems operation. Smart electrification creates a virtuous circle in which end-use sectors such as mobility, industry and buildings are decarbonised while new loads become flexibility options for the system.
3. **Promote innovation in markets and energy systems.** Remuneration from the market must be technology agnostic.
4. **Take into account consumer and energy communities.** These are important stakeholders in the future energy systems.
5. **Ensure enabling conditions for investments and drive innovation.** This should be done in developing countries in particular in order to significantly improve access to sustainable energy.

Highlights of the session

Hideyuki Umeda, Director for International Policy on Carbon Neutrality, Agency for Natural Resources and Energy, METI, opened the session by highlighting its emphasis on innovative technology and business solutions for the cost-effective integration of high shares of renewables into energy systems.

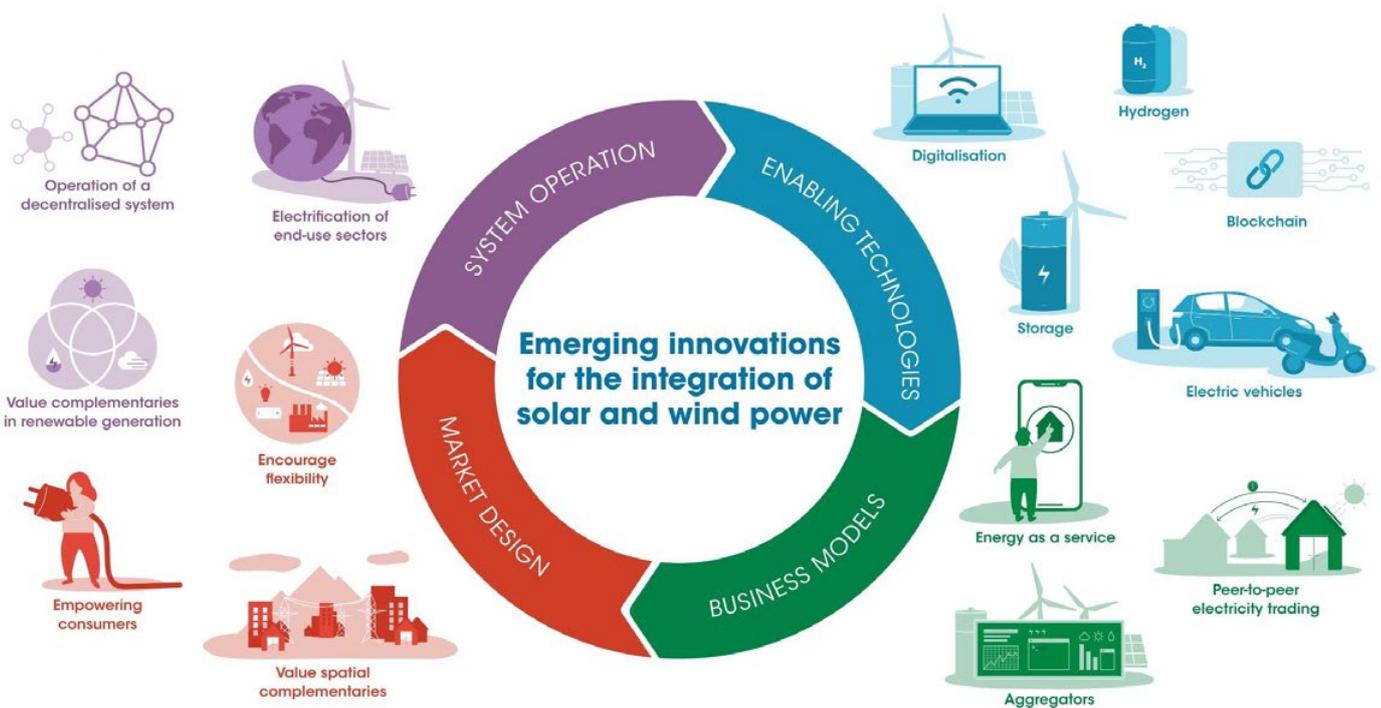
Gauri Singh, Deputy Director-General of IRENA, then reiterated the necessity of tripling renewable power generation capacity by 2030, from 300 GW to 1 000 GW per year, if the 1.5°C climate goal was to be achieved. This would require developing the necessary infrastructure, policies and institutional capacities to accelerate the global energy transition.

Setting the scene

Francisco Boshell, Head of Innovation and End-Use Applications, IRENA, then delivered a scene-setting presentation on innovation for the energy transition.

Power system transition, he said, is propelled by three innovation trends: electrification, decentralisation and digitalisation. Electrification of end-use sectors is an emerging decarbonisation pathway to maintain value and avoid the curtailment of VRE. The increasing deployment of distributed energy resources turns the consumer into an active participant, fostering demand-side management. Digital technologies enable faster responses, better asset management, device connectivity, data collection, monitor and control. Systemic innovation for power system flexibility is required.

Emerging innovations for the integration of solar and wind power





Panel discussion

Moderator: Gurbuz Gonul, Director, Country Engagement and Partnerships, IRENA

Panellists:

- Martin Hartvig, Senioringeniør, PhD, Energinet, Systemperspektiv
- Bruce Douglas, CEO, Global Renewable Alliance
- Rudolf Zauner, Senior Innovation Manager, Corporate Innovation and New Business, Verbund
- Alex Oudalov, Power Systems of the Future Manager, Hitachi Energy
- Anser A. Shakoor, Managing Director, Europe GE Energy Consulting
- Chigozie Nweke-Eze, CEO Integrated Africa Power

In the discussion, experts discussed trends in energy system innovation with a focus on digitalisation, decentralisation and electrification.

Digitalisation, based on information and communications technology (ICT) development is being embraced at all levels of the energy system. This included the use of technologies such as asset control for real-time operation – enabling us to see the ‘heartbeat’ of the grid – electricity aggregation, the management of heat pumps, EVs and electrical appliances. Decentralisation with enhanced resilience of electricity supply supported by energy storage and microgrids could offer a number of localised solutions. Electrification with power to heat could be applied in transport, heating and cooling and the production of synthetic fuels.

Moreover, the rise of EVs was noted as the most visible trend, with growing demand for electricity resulting and this causing an impact on grid management. Interconnectivity, with a possible focus on a resilient grid system, was also stressed as another trend that required more connection of different assets, leveraging the complementarity of demand and electricity supply from renewables.

The experts then noted new players in energy system development. These were making a significant impact by bringing innovation into the system, developing heat pumps, energy storage, EVs and renewables. It was pointed out that market design and regulation are critically important, if innovation was to happen.

It was then emphasised that not only technology and policy, but also appropriate market design enabled a variety of players to be innovative in the decarbonisation of the energy system and electrification of the power system. Continuous innovations are needed even for established technologies, such as solar PV, concentrated solar power (CSP) and wind, and in system operation as well.

The panel then concluded that markets needed to become more stable and flexible, providing adequate signals for investment in innovation. In addition, it was noted that the remuneration aspects of the market should be taken into consideration in order to promote development of the supporting technology for a large share of renewables in the system. This aspect should also be agnostic when it came to the type of technology used.

Concerning system operation, the panel agreed that an innovative way of efficient and effective use of existing assets is needed to achieve a secure supply at an affordable price. Where possible, co-location of consumption with production before power entered the grid, as well as more efficient and smarter use of the existing grid – including systems of ‘emergency lanes’ – should be considered.

In terms of the business model perspective on system innovation, it was highlighted that steps in the last mile toward completing targets are the most difficult. This is because there is no business-as-usual case and often, the development of new infrastructure is required. There could be major challenges in such development, too, with a ‘not in my back yard’ (NIMBY) reaction possible. There is a need to come up with different concepts and roles in the energy sector. These includes prosumers and demand responses on the industry side, along with sector coupling.

The panel experts then noted the abundance of renewable energy resources in Africa and underlined the importance of considering how the availability of other resources, such as land and critical minerals, could contribute to promoting access to energy.

The panel then referred to the important electricity needs of African countries and the prospective export of green hydrogen. It was pointed out that innovations in how the enabling factors could be realised in an efficient, sustainable and environmental-friendly way could also occur. The panellists agreed that there was a major role for the finance and public sectors in driving innovation and encouraging more participation by the private sector.

The panellists then highlighted the importance of facilitating a systemic innovation that was integrated into system operation, noting the growing pressure on electricity grids with electrification. This innovation included new approaches in operational planning and the reassessment of overall formulations of business models in the system. It also included innovations in frequency restoration technology, in part with a combination of storage batteries. Sector coupling with optimised use of existing assets, consumer empowerment for the optimised energy system – potentially with demand response – and the interoperability of transmission and distribution grids were also considered. New opportunities for shifting demand into the power sector from other energy sectors, along with public and private sector and regional-international collaboration were also discussed.

After the panel discussion, Takeru Bessho from the Sekisui Chemical Company presented R&D work on the innovative technology of the perovskite solar cell. An example of this was being exhibited at Innovation Week 2023.

Vanessa Interiano, Co-facilitator, Co-ordinator for International Energy Affairs and Permanent Representative to IRENA, El Salvador, closed the meeting by noting that the session was part of a series of thematic discussions within the collaborative framework. All these sessions were dedicated to addressing the challenges faced by countries around the world and finding practical solutions. Discussions undertaken within this collaborative framework would guide IRENA members on their path to the deployment and effective use of a large share of renewables in their energy mixes.

COLLABORATIVE FRAMEWORK ON ENHANCING DIALOGUE ON HIGH SHARES FOR RENEWABLES

CAURI SINGH WELCOME TO A DIVERSE GROUP TO DISCUSS THIS TOPIC.

ALL SECTORS OF THE ECONOMY MUST BE PART & BENEFIT OF THE RENEWABLE TRANSITION

KEEP SHARED VISION OF THE PARIS AGREEMENT TO ENHANCE THE EXPANSION OF RE.

3x THE CURRENT CAPACITY CHANGE IS URGENT!

90% OF ELECTRICITY TO BE SUPPLIED BY RE IN 2050

THIS RATE OF CHANGE NEEDS A SMART APPROACH

1 TRILLION / YEAR NEEDED TILL 2050 FOR CHANGE

\$2,000,000,000,000 NEEDED YEAR!

3 TRENDS

- MAINTAIN VALUE
- FASTENING DEMAND-SIDE MANAGEMENT
- DIGITALIZATION

IF WE DO NOT GO FOR A SMART APPROACH, THIS COST COULD DO UP TO 10 TRILLION!

DIGITALIZATION, DECENTRALIZATION, MODULARIZATION

DENMARK: 50% OF ELECTRICITY IS NOW WIND-POWERED

DESIGN THE GRID TO ACCOMMODATE THE INFLOW OF RE.

USE GRID EFFICIENTLY FOR H₂ WE MUST USE ALL ASSETS EFFICIENTLY

NEW BUSINESS MODELS? LOST MILE IS MOST DIFFICULT

NEW INFRASTRUCTURE IS HARDEST

WE INNOVATE TO OVERCOME GROWTH BARRIERS

NOT IN MY BACK-YARD HAS BECOME BUILD ABSOLUTELY NOTHING ANYWHERE NEAR ANYBODY

USE ENERGY COMMUNITIES

WE MUST THINK DIFFERENTLY & BUILD NEW BUSINESS MODELS TO ACCOMMODATE

USE DEMAND RESPONSE

REGULATION ENABLER FOR INNOVATION

WE ARE SEEING FAST & UNPREDICTABLE CHANGES

WE WILL NOT BE ABLE TO LOOK INTO THE FUTURE OF ENERGY SUPPLIES

WE MUST THINK OF OLD MEETS NEW IDEAS

OPTIMIZE ENERGY SYSTEMS!

NEW ROLES & INNOVATIONS IN NEXT TEN YEARS ARE HUGE

EX. **IKEA** NOW OWNS MORE WIND POWER THAN STORES

INNOVATION MUST BE 1ST PRIORITY!

TRANSITION MARKETS MUST FOCUS ON SIGNALS TO INVEST IN INNOVATION

- SOFTWARE
- HYDROGEN & BATTERIES

INNOVATION IN SYSTEM OPERATION

WILL ONLY BE A REALITY WITH EXTREME INNOVATION

RENUMERATION IS KEY TO CREATION OF OUR RE REVOLUTION!

INCENTIVISE NEW SOURCES OF DEMAND TO BE INTEGRATED

EMPOWERED CONSUMERS AS A HUGE TREND

WE SEE EXTREMES: COMPETITIVE MARKETS

- NO COMPETITIVE MARKETS
- MIDDLE OF THESE EXTREMES
- ALL THESE MUST SUPPORT CONTINUOUS INNOVATION

DIGITALISATION IS ADDRESSING A BROAD-RANGE OF VARIABLES & CHALLENGING

FORECASTING THROUGH TOOLS FOR METRICS & DATA ARE EMERGING

INNOVATION EXAMPLE: SEKISUI CHEMICAL COMPANY

- SUPPORTED BY GREEN INNOVATION & NATIONAL COLLABORATION
- WITH UNIVERSITY COLLABORATION

ACCESS & DISTRIBUTION WILL PLAY A BIG ROLE IN REACHING 90% GOAL

INEQUALITY OF ENERGY ACCESS MUST BE ADDRESSED

WE MUST LOOK INTO MAPPING POTENTIAL

BE INNOVATIVE IN FINANCING TO MANAGE RISKS OF AFRICAN MARKET

TAKING INTO ACCOUNT THE SOCIO-ECONOMIC IMPACTS & EFFECTS ON ENVIRONMENT!

OUR CHEMICALS ARE IN SOLAR CELLS:

- MORE DURABLE & EFFICIENT THAN SI SOLAR CELLS
- WITH IODINE, DB, CHEAP & EASY TO MANUFACTURE

ALL CONSUMERS MUST BE EMPOWERED TO DO SO!

PRACTICAL FRAMEWORK FOR IMPLEMENTATION

WE MUST LOOK INTO H₂ FOR AFRICA AT AN EFFICIENT EXPORT RATE?

WHAT ARE THE POSSIBILITIES?

Photographs from the session 'Collaborative framework for high shares of renewables'



Strategic considerations for sector coupling in long-term energy scenarios



Session organised in partnership with GET.Transform

Enhancing our understanding of how to integrate sector coupling elements into the energy planning process.

This session was the first discussion of sector coupling held within the scope of IRENA's Long-term Energy Scenarios Network (LTES Network). The session mapped out the key factors scenario practitioners need to consider when including sector coupling aspects in their long-term energy scenarios.

The takeaways and outcomes of the session were then expected to enhance our understanding of how to integrate sector coupling elements into the energy planning process. Moreover, these findings will shape future discussions within the LTES Network.



Key actions

for policy makers

1. **Prioritise intersectoral collaboration and encourage active collaboration between different sectors.** These should include transportation, industry and energy in order to ensure a cohesive approach to sector coupling. This collaboration is essential for realising the full potential of integrated energy systems.
2. **Develop and refine regulatory frameworks that support sector coupling and the integration of a variety of energy sources.** This includes creating policies that facilitate the adoption of innovative technologies and business models.
3. **Allocate resources towards improving the quality and accessibility of energy data.** High-quality data is crucial for accurate modelling and informed decision making in energy planning.
4. **Emphasise resilience and affordability in all energy planning and policy measures.** Prioritise the resilience of the energy system and the affordability of energy for consumers. This ensures that the transition to clean energy is sustainable and equitable.
5. **Support innovation in energy technologies.** Foster an environment to drive technological innovation, particularly in areas such as hydrogen production, EV integration and renewable energy sources. This support can be through funding research, providing incentives for development, or facilitating public-private partnerships.

Highlights of the session

The panellists emphasised the complexity of implementing sector coupling in energy systems. This approach is crucial for a comprehensive and efficient transition to clean energy systems, particularly in integrating different energy sectors, such as electricity, transport and heating.

A significant challenge highlighted in the discussions was the need for quality data and robust modelling techniques. The ability to accurately forecast and plan for future energy needs and the integration of various energy sectors depended heavily on reliable data and advanced modelling capabilities.

The importance of policy measures and market mechanisms in driving the energy transition was also underscored. Policy makers need to create conducive environments for the adoption of sector coupling technologies, and market dynamics should be leveraged to encourage efficient energy use and investment in clean technologies.

The panellists also discussed the need for continuous innovation and the development of new technologies to facilitate sector coupling. This included advances in areas such as hydrogen production, energy storage and smart grid technologies.

Finally, effective stakeholder co-ordination and collaboration were highlighted as critical for successful sector coupling. This involved aligning the interests and actions of various actors – including government agencies, energy providers, technology developers and consumers – to ensure a cohesive approach to energy transition.

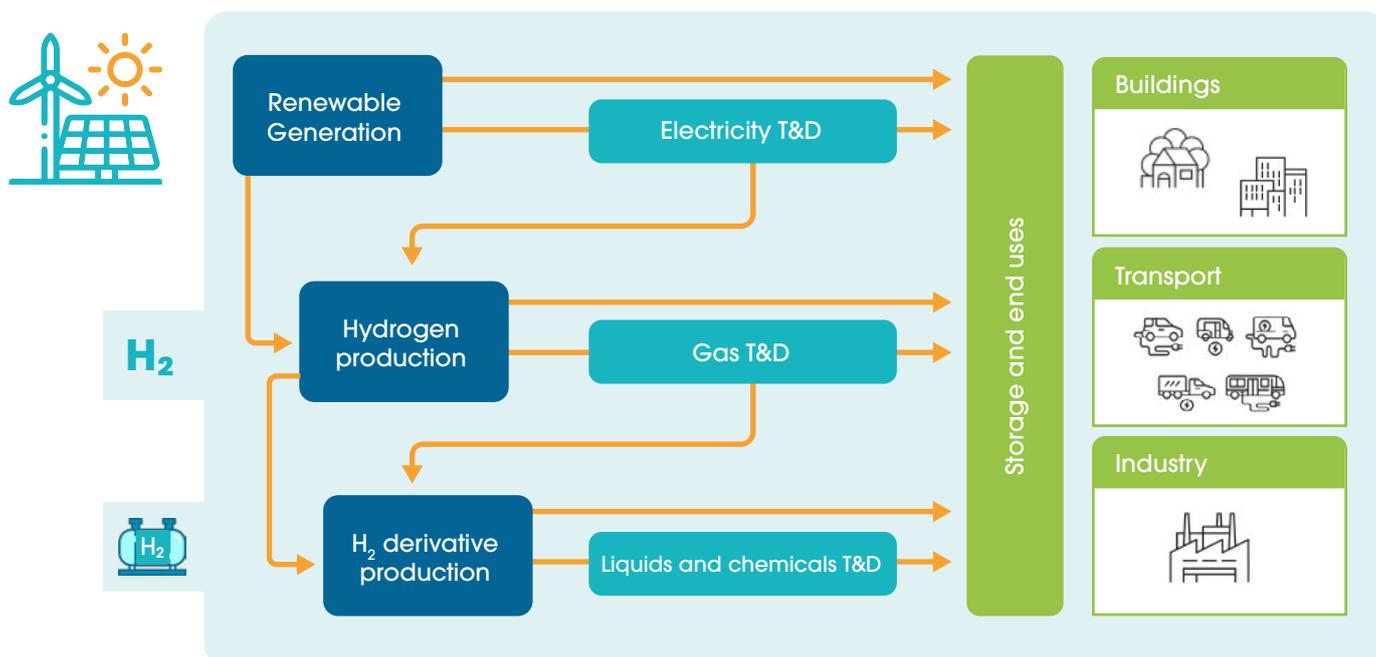
Setting the scene

Asami Miketa, Head of Energy Transition Planning and Power Sector Transformation, IRENA, welcomed participants and delivered a scene-setting presentation. In this, she noted the need for an integrated approach to energy planning. Furthermore, she said, it had been observed that innovation not only encompassed technology, but also included regulation and business models.

She then went on to say that the sector-coupling dimension of long-term energy planning presented itself differently in different countries. Some already incorporated all sectors in their energy planning, while others did not. An inter-sectoral approach requires collaboration from multiple ministries and agencies, she said.

Miketa then noted that electrification of end-use sectors is one of the key solutions in climate-compatible growth. Power-to-methanol (PtM), power-to-heat (PtH) and power-to-hydrogen (PtH₂) are key aspects of the electrification discussion. She then concluded that in energy planning, direct and indirect electrification pathways and planning smartly to optimise infrastructure are both necessary.

Electrification pathways: Power to X



Angela Mutsotso, Associate Professional – Clean Energy Transition Scenarios, IRENA, then gave a presentation in which she noted that sector coupling in LTES is important for several reasons. These included: decarbonisation of multiple sectors; increased flexibility and system resilience; economic efficiency; holistic energy system planning; stimulating innovation; and meeting climate goals.

In a variety of ways, she then added, flexibility remained a key concern. This was evident in the integration hydrogen production, EV charging, demand-side responses and in thermal energy storage.

Various examples from the International LTES Forum 2022 and the Innovation Landscape for Smart Electrification were then given in order to set the stage for the following discussion.

Panel discussion

Moderator: Christopher Gross, Team Lead, GET. Transform, GIZ

Panellists:

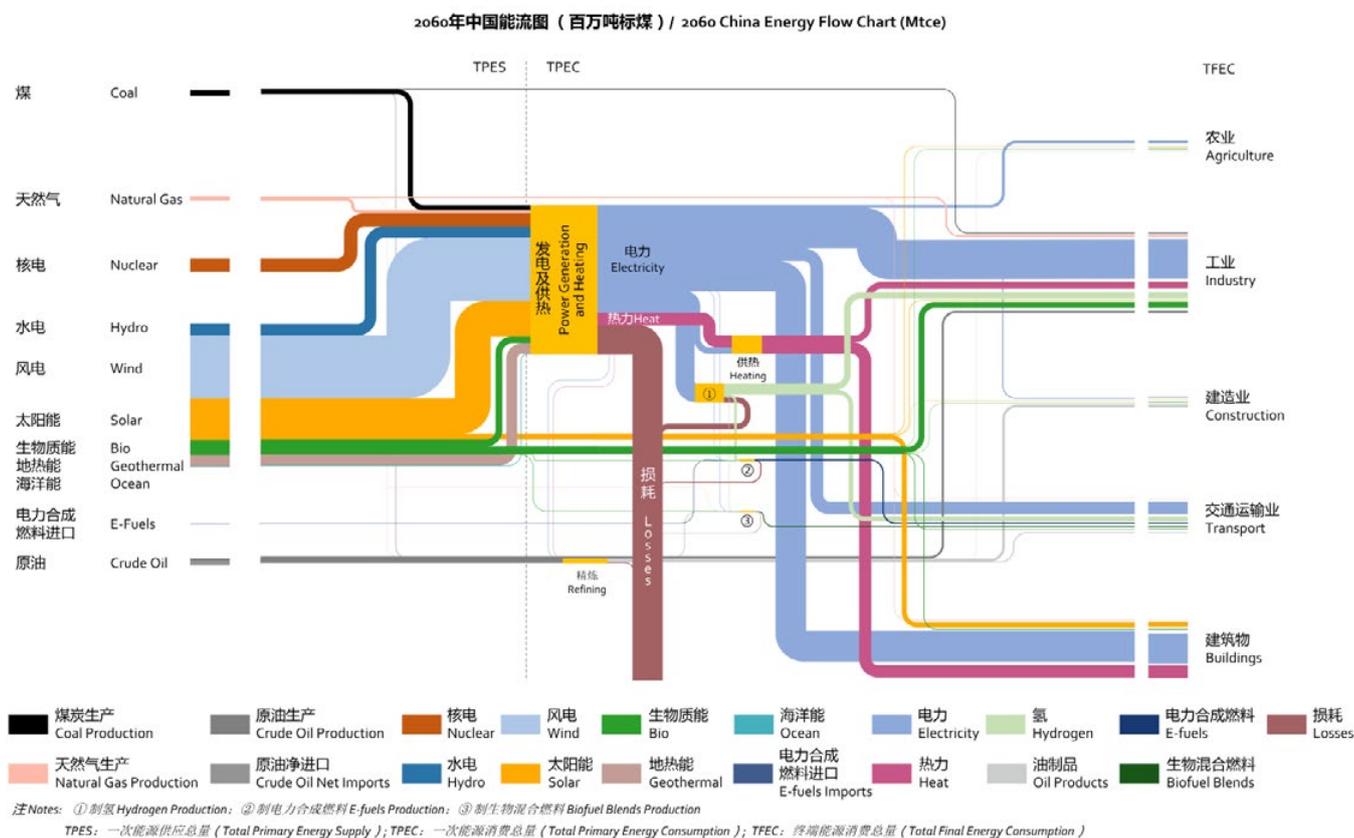
- Martin Hartvig, Senior Engineer, Energinet, Denmark
- Claire Nicolas, Senior Energy Economist, ESMAP, World Bank
- Kaare Sandholt, Chief International Expert China Energy Transformation Programme, Energy Research Institute of the Academy of Macroeconomic Research (ERI), China

Kaare Sandholt, Chief International Expert China Energy Transformation Programme, ERI, made a brief presentation in which he noted that ERI released an annual energy outlook considering the whole energy system of the country. This showed how China's industrial sector is both large and mainly dependent on fossil fuels. However, there are plans to incorporate hydrogen into the transport and industrial sectors by 2060.

Sandholt then presented the energy flow chart for the 2060 scenario. This showed that sector coupling was embedded in the system. The major trends expected in the 2060 outlook included: (1) energy efficiency in end-use sectors; (2) electrification in the industrial, transport and building sectors; (3) the power system becoming the energy provider; and (4) a fossil fuel phase down and phase out.

He noted that it was necessary to use high-quality data and modelling tools while incorporating sector coupling to influence policy measures that would enable a smooth transition.

China energy flow chart 2060



Source: Energy Research Institute (2021), *China Energy Transformation Outlook 2021*, Chinese Academy of Macroeconomic Research.

Claire Nicolas, Senior Energy Economist, ESMAP, World Bank, then noted that the World Bank's work in sector coupling is fairly new. Until a few years ago, modelling had focused on the short to medium term and in-house modelling tools only focused on the power sector, not on the whole energy sector. There had been a move to explore the link between development and climate change, and there is a move to incorporate 20-30-year forecasts. It is important that sector coupling is incorporated into models, and to this end, there are several models, including the TIMES model used at the national level.

Martin Hartvig, Senior Engineer, Energinet, Denmark, then agreed that sector coupling is key, as it involves planning for the future. Modelling is helpful, but there is a need to account for sudden, large changes. As an example, he said that while moving to 50% wind in the Danish system was manageable, moving to 100% is more taxing. He then said that Energinet had worked on modelling hydrogen in the energy system and this would be discussed further.

Hartvig then noted that Energinet had taken a multi-sector approach to energy planning in which the state-owned TSO incorporated gas into the power grid. It is necessary to make sure investments are in line with the entire energy system. It is vital to combine a system approach with a resource approach. Sector coupling could avoid inefficient measures such as curtailment of wind energy, which are needed for future systems.

Nicolas then drew attention to the fact that the key considerations on sector coupling that the World Bank had incorporated had been focused on expanding energy planning from the power system to the whole energy system. The next step in expanding energy planning is to include the transport system, as fleet electrification is already ongoing and EV demand would impact overall power demand massively.

In response to a question about the critical trade-offs addressed during planning and whether China weighed direct against indirect electrification, Sandholt said that for least-cost optimisation, direct electrification was preferable. However, he added, hydrogen would be incorporated into the energy system when direct electrification was not possible.

- **Is the least cost option enough to induce behavioural changes on the demand side?**

Sandholt noted that energy planning in China is not purely driven by economic considerations but by targets, including the net zero target. China is currently working with low-carbon targets and is not necessarily planning to accelerate the phase-out of coal capacity, but to use it for hydrogen production instead. In this way, net zero would eventually be achieved.

Hartvig then noted that least-cost metrics and other national goals drove energy planning. Resource potential also played a key role in shaping the results. There was a need, he said, to further investigate model results. It was important to look into viable, as opposed to non-viable futures and select the best solution.

Nicolas then noted that the least cost solution could be different from the absolute least cost, but both could achieve a lot in terms of decarbonisation. This was where modelling analysis showed its value, she said. It enabled different pathways to be tested, outliers to be identified and the consequences of different decisions to be evaluated in terms of their climate impact.

- **How is cross-ministerial co-ordination and stakeholder engagement being incorporated into the planning process?**

Sandholt noted that ERI is a think tank which informed policy makers on potential pathways. As such, it does not have a comprehensive stakeholder process, as the institute focuses on creating scenarios and making recommendations. Following the announcement of dual climate goals for China, ERI had created multiple scenarios for different sectors, he said.

Hartvig then said that Energinet involved multiple stakeholders across the whole supply chain, including manufacturers and a consortium of wind power producers in Germany and the Netherlands.

- **What are possible future challenges related to sector coupling?**

Nicolas noted that co-ordination with stakeholders was one of the main challenges due to the differences in skills and understanding in different sectors. The modelling and scenarios in the power, transport and heating sectors were not the same, she added. As such, there is a need to educate all stakeholders to ensure uniformity of understanding.

Sandholt then noted that a lack of quality data is one of the biggest obstacles, given that the future is uncertain. The role of modellers is to inform policy makers on different options and pathways. When modelling, it is vital to identify which measures and regulations are necessary, how to stimulate the market and identify the innovation pathways necessary for the desired future.

Hartvig then said that Denmark had invested extensively in technology, with transparency around technology costs vital. There is also a need for better and more accurate data to ensure more accurate models, he added.

- **What role does the LTES Network play in terms of knowledge exchange?**

Nicolas noted that data collection and data sharing are important, and the LTES network plays a key role in sharing lessons on co-ordination and consultation.

Sandholt added that the network's role in sharing experiences was important, and it was helpful to continue sharing lessons on the different ways of modelling and scenario design. The network should consider sharing lessons on how models were developed and used in light of the energy transition, he concluded.

Photographs from the session 'Strategic considerations for sector coupling in long-term energy scenarios'



Innovations and technological pathways to decarbonise hard-to-abate sectors



Unless significant policy changes are pursued, three energy-intensive industries and three key transport modes will account for 38% of energy and process emissions and 43% of final energy use by 2050.

The industries are iron and steel, chemicals and petrochemicals, cement and lime, while the transport modes are road freight, aviation and shipping.

The industries are iron and steel, chemicals and petrochemicals, cement and lime, while the transport modes are road freight, aviation and shipping. These sectors are known as 'hard to abate' as progress in their decarbonisation remains limited and lacks the commercialisation of innovative, low-carbon production processes. Yet, their decarbonisation is also crucial to achieving the Paris Climate target of limiting the global temperature rise to 1.5°C.

Decision makers and industrial stakeholders are therefore currently exploring low-carbon solutions and innovative strategies to transform these sectors. This invitation-only workshop convened industry, academia and policy experts as part of this exploration.



Key actions

for policy makers

1. **Deploy a comprehensive suite of measures to commercialise low-carbon technologies in the hard-to-abate sectors.** This should include sector-specific emissions reduction targets, harmonised standards and certification, as well as supportive policy tools and regulations.
2. **Co-finance and invest in physical infrastructure.** This should be done in order to ensure a reliable energy supply to energy-intensive consumers.
3. **Create early demand for green products.** This can be done through mandates, subsidies for first-of-its-kind projects, public procurement, sectoral agreements on carbon footprints and other programmes.
4. **Promote innovative business models and encourage public participation.** This can be done by establishing incentives for consumers to pay green premiums.
5. **Ensure that all financial decisions are in line with the goal of achieving sustainability and align with the objectives of the Paris Agreement.** Mobilise private capital through innovative financing instruments such as risk-sharing and grants via blended finance for scaling up low-carbon production routes.
6. **Adjust regulations and develop capacity development programmes.** This can enhance the attractiveness of jobs in the hard-to-abate sectors.
7. **Foster international collaboration to facilitate international trade.** Steps towards this include aligning regulations and production processes, sharing best practices and sharing lessons learnt.

Highlights of the session

Francisco Boshell, Head of Innovation and End-Use Applications, IRENA, opened the workshop by highlighting the prominent role of hard-to-abate sectors. He also drew attention to the limited number of commercial projects existing today and the need for systemic innovation to promote the rapid deployment of low-carbon technologies.

Gayathri Prakash, Programme Officer, Innovation and End-use Sectors, IRENA, then provided an overview of IRENA's past and ongoing work on end-use sectors. An open discussion was followed where results from an expert survey circulated before the workshop were presented. Experts then exchanged views on essential enabling conditions and measures in technologies, infrastructure, policies, regulations, markets and finance to support the decarbonisation of hard-to-abate sectors.

Setting the scene

Boshell then set the scene by stating the importance of the Paris Agreement targets and reaching net zero by mid-century.

In IRENA's 1.5°C climate-compatible scenario, by 2050, electricity would account for half of global final energy consumption, he said; the remaining half would need to be met with a wide range of other low-carbon energy carriers. Meanwhile, direct electrification is limited in hard-to-abate sectors, which included heavy industries such as cement, steel and chemicals manufacture. It is also limited in heavy-duty transport such as trucking, shipping and aviation.

Boshell then highlighted a variety of contemporary challenges and insisted on the need for a wide range of policy support and financial measures to mitigate them. He said that innovation plays a crucial role in fostering the pace of transition and this innovation needs to be systemic, covering a variety of aspects.

He then introduced the survey circulated before the workshop to over 100 experts working on the hard-to-abate sectors. He said that 40 responses had been received. On this note, he encouraged the participants to actively engage in the workshop by sharing their views and expertise. Boshell also asked participants to provide feedback on IRENA's ongoing work in collaboration with the European Commission on the development of enabling frameworks for the decarbonisation of hard-to-abate sectors.

Prakash then highlighted the vital role of hard-to-abate sectors in achieving global climate targets. Demand for materials such as steel, chemicals and cement – and the fuels to transport them worldwide is expected to rise significantly in the coming years. In the context of addressing the global climate emergency, it is therefore imperative to produce those materials and use them in a sustainable manner.

She then said that direct electrification is limited in the hard-to-abate sectors. Critical technologies, such as clean hydrogen and its derivatives, are under development today and could reduce emissions from those sectors, however.

Increasing materials efficiency and circularity presents the fastest and most viable opportunity to cut emissions soon. However, to fully transition these sectors in the next three decades, a systemic innovation beyond technology is needed, including pillars such as physical infrastructure, regulations, market designs, stakeholder engagement, capacity building and knowledge sharing.

Over the last few years, IRENA has produced many insightful reports on end-use sectors. These included reports on reaching zero with renewables, a report on steel sector circularity for the G20 India presidency in 2023, innovation outlooks on renewable ammonia, renewable methanol and many others. IRENA is actively engaging with its member countries and industry stakeholders via collaborative frameworks in, for example, green hydrogen. IRENA was also collaborating with Allianz on industry decarbonisation initiatives among other initiatives.

IRENA's ongoing work in collaboration with the European Commission on developing an enabling toolkit to promote systemic innovation in hard-to-abate sectors was also presented. The key takeaways from this workshop would then be taken as inputs for this project and for IRENA's ongoing activities.

Panel discussion

Moderator: Gayathri Prakash, Programme Officer, Innovation and End-use Sectors, IRENA

Participants:

- Tudor Florea, Ministry of Energy Transitions, France
- Ralph-Uwe Dietrich, DLR
- Aleksandra Waliszewska, E3G
- Cesar Barraza-Botet, Universidad de La Sabana, Colombia
- Zoran Stanic, EIB
- Joana Argemi, OECD
- Lars Borger, Neste Germany GmbH

IRENA has a global membership and collaborates with governments, industry and a diverse range of stakeholders. In the discussion, experts provided feedback on how IRENA could therefore support international collaboration, mitigating barriers and aiding in the acceleration of renewables-based solutions in hard-to-abate sectors.

The open discussion focused on five pillars:

1. Vision and Policies

This pillar focused on the industry's requirements from governments in terms of strategies, targets, supporting policies and regulations to enable the transformation of hard-to-decarbonise sectors.

2. Enabling technologies and infrastructure

This pillar centred on remaining gaps in technology and infrastructure, along with their costs. It also explored the potential role of governments in addressing these challenges.

3. Markets, Business and Finance

This pillar focused on strategies for different stakeholders that could lead to the establishment of a market for green commodities. It also tried to address the challenges companies face in scaling up breakthrough technologies, particularly in financing first-of-kind facilities. The pillar also explored potential ways for green commodity producers to maintain competitiveness in the global market.

4. Skills and capacity development

This pillar delved into the challenges and opportunities associated with developing the skills and capacities necessary to facilitate discussion and identify the roles of industry and governments in capacity development.

5. International collaboration

This pillar centred on the role of IRENA. With its country membership close to universal, the pillar looked at how its access to governments could support its member countries, along with industrial stakeholders, in harnessing opportunities for renewable energy adoption and addressing the challenges of international collaboration in hard-to-abate sectors.

At the beginning of each discussion segment, the results of an expert survey – circulated well before the workshop – were presented. Following this, experts were invited to provide short comments on the discussion segment and relevant areas.

The last part of the discussion segment was then opened to participants to share their expertise and insights to identify key enablers in decarbonising the hard-to-abate sectors specific to the discussion segment.

Highlights from the discussion

Decarbonising hard-to-abate sectors is possible by pursuing multiple technological pathways in parallel with systemic innovative approaches. Each sector has multiple low-emission technologies, with a combination of these options – tailored to local specificities – is necessary to scale up the energy transition.

Low-carbon technologies exist today, but a suite of policy support tools and regulatory measures is necessary for their commercialisation. Clear sector-specific emissions reduction targets, harmonised certifications and standards, carbon pricing mechanisms, and a shorter permitting process are essential. Direct government support, such as providing tax incentives and subsidies for low-carbon technology R&D, is necessary. Stricter regulations, penalties and circularity or eco-design standards would help. Phasing out fossil fuel subsidies and applying higher carbon taxes to fossil fuels to fund low-carbon alternatives could also accelerate the transition.

Upfront investment in infrastructure is pivotal in promoting the adoption of low-carbon technologies. The necessary infrastructure should include a reliable supply of renewable electricity, green hydrogen, storage capacity and pipelines. Governments, in collaboration with the private sector, could, for example, establish joint ventures to finance infrastructure projects.

Aligning investments with the Paris Agreement in hard-to-abate sectors is necessary, with an emphasis on sustainability, climate, energy security and innovation. As emerging and developing economies will produce most future materials, innovative instruments for mobilising private capital – such as risk-sharing and grants through blended finance – will be essential.

Creating an early market for green products is a key enabler to driving down the high costs associated with low-carbon technologies. Measures that can create an early market for green products making these technologies cost-competitive with conventional ones should be undertaken. These include measures such as enforcing green product mandates – an example being blending mandates in the aviation industry. They also include providing public subsidies for first-of-its-kind projects; forming sectorial agreements on carbon footprints; and using demand pool instruments enabled through public procurement.

Due to increasing societal pressure, private companies are now obliged to incorporate climate change impacts into their business models and adopt fossil-free production processes. Consumers are willing to pay premiums for eco-friendly products and governments can encourage this by providing incentives for consumers who choose to buy green. Furthermore, new business models are emerging that do not link economic growth to resource intensity.

A holistic flexibility option is needed to assess additional services and associated costs. Given that hard-to-abate sectors need to be operated continuously with a reliable energy supply, additional flexibility services need to be assessed. This assessment should be performed in the light of their value-added to the system and costs incurred.

Regulations and capacity building can play a role in enhancing job attractiveness in hard-to-abate sectors. Education, training programmes, knowledge sharing and clear perspectives are necessary to build adequate expertise and attract a workforce in these sectors. European legislation being developed specifically on clean tech manufacturing, for example, provides conditionality and ensures that the sector is supported by providing attractive jobs with good pay and other enabling terms. In emerging and developing countries, the lack of institutional skills and access to funding need to be tackled with support from multilateral banks and the developed world. Some oil and gas companies are investing in renewables and fostering reskilling of labour in the transition.

International collaboration across borders and among stakeholders is paramount to remove current barriers and enable the decarbonisation of hard-to-abate sectors. IRENA, with its global membership, can facilitate international collaboration by promoting dialogues between government and industry stakeholders. It can establish co-ordinated milestones to transition the hard-to-abate sectors at the necessary scale and pace to align with the Paris climate goals. IRENA can create synergies by working with other international organisations, certification bodies and relevant stakeholders. It can support international partnerships to scale up low-carbon fuels and the trade of green commodities with harmonised definitions, standards and conditions. Furthermore, IRENA can examine the socio-economic impacts of realising a fair and just energy transition while sharing knowledge, best practices and supporting the Global South in its decarbonisation efforts.

Photographs from the session 'Innovations and technological pathways to decarbonise hard-to-abate sectors'



Symposium on the green hydrogen economy



The necessity of quality infrastructure (standards, certification, testing and metrology)



Session organised in partnership with the International Organisation for Standardisation (ISO), the International Electrotechnical Commission (IEC) and the German Metrology Institute (PTB)

The corresponding quality of hydrogen processes infrastructure needs to be addressed to ensure green hydrogen production and trade are safe as well as sustainable.

Hydrogen is widely recognised by the international community as a key enabler in accelerating the attainment of the 1.5°C scenario. The most attractive pathway for its development, due to its high decarbonisation potential, is its production by electrolysis powered by renewable energy.

Hydrogen processes are increasingly complex and capital intensive, however, in terms of the infrastructure for its generation, processing and distribution. An often overlooked but important component that needs to be addressed in tandem with this is the corresponding quality of this infrastructure, in order to ensure green hydrogen production and trade are safe, as well as sustainable.

Quality infrastructure provides the technical basis for the secure development of the green hydrogen sector.

Quality infrastructure (QI) is the national system of organisations, policies, legal frameworks and practices required to assure quality, safety and sustainability of products and services. It consists of the key components of metrology, standardisation, accreditation and conformity assessment (including testing, certification and inspection). QI thus provides the technical basis for the secure development of the green hydrogen sector. It helps to reduce various risks – such as safety, financial and reputational – while also supporting the achievement of the intended, positive sustainability impacts of investments.

To raise awareness on the necessity of a strong QI ecosystem in support of green hydrogen development, the main objectives of this symposium were:

- Get feedback on the approach employed for IRENA's ongoing QI Roadmap for green hydrogen.
- Raise awareness of well-established QI elements at international levels already in place and serving the broader hydrogen market.
- Present the key QI developments that are taking place for the green hydrogen sector, as well as identify gaps where QI is still needed across the green hydrogen value chain.
- Discuss recommendation on how QI can be integrated into hydrogen strategies.



Key actions

for policy makers

- 1. Actively strengthen the link between hydrogen policy and QI.** It can still be observed that international policy makers do not always fully grasp the concept of QI, nor its importance. Hence, international and regional QI bodies need to undertake continuous awareness raising efforts. These should educate stakeholders on the necessity of QI for safe and sustainable production, as well as trade for products such as hydrogen and its derivatives.
- 2. Engage in international standardisation for green hydrogen.** Standards are a key element of QI. International standards such as those of the ISO and IEC should be adopted as national standards to the greatest extent possible. This enables the removal of barriers to global trade. ISO and IEC international standards are developed in line with the six principles for the development of international standards of the World Trade Organisation (WTO) Technical Barriers to Trade Committee. Countries should actively engage with the technical committees of international bodies like the ISO and IEC to ensure that their national context is properly reflected in international standards.
- 3. Use international standards and international conformity assessment services.** Many international standards already exist that address safety and the use of equipment, systems and the necessary competences of persons associated with the production, distribution and use of hydrogen. These standards include an internationally harmonised approach to the testing and certification of equipment, services and the competence of persons by the International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx). To date, more than 30 000 international certificates covering the use of equipment where hydrogen may be present have been issued. This internationally harmonised approach by the ISO and IEC is the basis of the second edition of the United Nations Common Regulatory

Arrangements (UN CRA) initiative, second edition, published November 2022. This initiative was undertaken as a means of supporting global trade among both established and emerging economies. Policy makers are reminded of this UN CRA initiative and its application to all United Nations member states.

4. **Foster international dialogue on the methodologies and definitions of low-carbon hydrogen.** In the absence of convergence around international standards, dialogue is crucial. Regulatory co-operation can avoid unnecessary negative impacts on trade and can be an effective means of building trust among regulators.
5. **Actively facilitate the participation of relevant stakeholders in the technical committees of QI institutions.** To ensure that QI services continue to evolve in an equitable manner, as well as to take into account the specific needs of emerging economies, it is essential that policy makers encourage their national and regional QI bodies to actively join and participate in the activities of the various technical committees of international QI organisations. These include the ISO and IEC and their conformity assessment activities.⁵
6. **Invest in training skilled personnel.** QI efforts by countries must also include the capacity to develop personnel skills that will oversee the installation, operation and maintenance of different components along the hydrogen value chain. The IEC, for example, has its IECEx certification scheme, which offers training and certification services for equipment, facilities, conformities and personnel to ensure components and persons operating in explosive environments conform to international technical and safety standard requirements. These services include the issuing of a dedicated, IECEx Certificate of Personal Competence for the safety of hydrogen systems.

⁵ As referred to by the UN CRA initiatives, these include: the ISO Committee for Conformity Assessment (ISO CASCO), IECEx, the IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE), the IEC Quality Assessment System (IECQ), and the IEC System for Conformity Assessment Schemes for Electro-technical Equipment and Components (IECEE). These are in addition to the activities of the International Laboratory Accreditation (ILAC), International Accreditation Forum (IAF) and the International Bureau of Weights and Measures (Bureau International des Poids et Mesures – BIPM).

Highlights of the session

Jaidev Dhavle, Associate Programme Officer – Innovation for the Energy Transition, IRENA, opened the symposium by delivering a presentation on IRENA’s approach to developments in its roadmap for establishing a QI ecosystem for green hydrogen.

This roadmap is being developed under the auspices of an IRENA-PTB project entitled, *Quality infrastructure (QI) for green hydrogen: Technical standards and quality control for the production and trade of renewable hydrogen*.

The key steps that underpin the roadmap are: (1) mapping out the techno-economic potential for green hydrogen; (2) developing a cohesive strategic policy to achieve techno-economic goals; (3) undertaking an assessment of QI services availability and gaps; (4) leveraging QI checklists to identify the essential QI services to be established in support of green hydrogen development; and (5) developing a roadmap for a dedicated national action plan which can guide the implementation of efforts to strengthen the availability of identified QI services.

Andrei .V. Tchouvelev, Chair of Sub-committee 1 within ISO TC 197, then presented an overview of the activities of his sub-committee. This primarily focuses on developing standards for the application requirements of hydrogen technologies at large scale and in horizontal energy systems with hydrogen as a central link in the value chain. He also presented an overview of a forthcoming methodology (ISO TS 19870) that would enable a uniform approach to determining the GHG emissions associated with the production, conditioning and transport of hydrogen to the consumption gate (including indirect emissions).

Martin Thedens, Chair of IEC TC 31, then provided an overview of the different technical and safety standards for electrical and non-electrical (mechanical) equipment that operated in explosive environments. This emphasised the explosive and hazardous characteristics of hydrogen.

The standards from his technical committee focused on: (1) the classification of explosive atmospheres; (2) the selection criteria for suitable equipment for use in explosive atmospheres; (3) the design, manufacturing and testing requirements for such equipment, both electrical and mechanical; and (4) the installation of equipment in explosive environments. The core objective of these IEC standards was to prevent ignitions in an explosive environment.

Paul Meanwell, Chair of IECEx, and Thorsten Arnhold, Member of the IEC Conformity Assessment Board, then provided a joint presentation on the IECEx. This is a voluntary global system open to any qualifying certification body and/or testing laboratory involved in the testing of products. It was also open to certification services used in areas where an explosive atmosphere may be present.

In addition to providing conformity certifications for equipment and facilities operating in explosive atmospheres, the system also offers a certification scheme for personnel competencies. This is to ensure that the relevant individuals have the knowledge and skills necessary to assess the technical and safety compliance of equipment operating in explosive environments – including the specific safety aspects of hydrogen systems.

Bo Shu, Head of the PTB Reaction Kinetics Group, provided an overview of the metrological requirements for the hydrogen value chain. This chain is long and encompasses, but is not limited to, the modelling of gas networks, safety technology, accurate measurement of single measurands and the collection of reference data. It also extends to the alignment of activities with existing regulation/conformity assessment. He also presented a preview of PTB's forthcoming hydrogen strategy. This would have five pillars, he said: quality, safety, billing fairness, knowledge transfer and supporting innovations. The strategy explicitly points out the common goals and the measures to be implemented by relevant stakeholders in achieving a metrological and safety framework of action for hydrogen.

Key points from the open discussion

The moderated open discussion touched upon the general QI services required for production, distribution, and sustainability of hydrogen. The broad exchanges of ideas and viewpoints can be summarised in the following way:

- **Strike the correct balance for QI conformity.** A major effort is needed to promote QI. This includes identifying and filling any identified gaps, while balancing environmental and social integrity with not overburdening stakeholders with requirements that delay the deployment of green hydrogen.
- **Align standards with market trends.** There is a strong need to support an international approach to standardisation, rather than focusing on national standardisation. This is because market trends dictate that economies of scale in green hydrogen can be best and most rapidly achieved with a single international set of standards. A globally harmonised approach brings consistency in testing and certification, rather than wasteful repeat testing/certification to address specific national standards.
 - While current market trends show support for other technologies – for example, currently there are abundant standards for hydrogen light duty and fuelling stations – there is only a small market for this technology. This is due to the current popularity and demand for EV passenger cars, the ease of deploying charging stations for them and the convenience of charging light duty vehicles (although some markets are showing a slowdown in such demand). In contrast, it is expected that there will be a large market for hydrogen-based fuels for ships and airplanes. However, while international QI elements and structures are available, the associated use and support for international QI (for example, in standards and certifications) needs a greater emphasis in certain areas.
- **Invest in training skilled personnel.** QI efforts by countries must also include the capacity to develop personnel skills that will oversee the installation, operation and maintenance of different components along the hydrogen value chain. The IEC's IECEx certification scheme being a good example.
- **Accounting standards must be all encompassing.** Carbon accounting standards must cover emissions across the whole life cycle. ISO standards are a good starting point; however, it is necessary that all stakeholders review and provide suggestions to improve their scope. The forthcoming ISO Technical Specification TS19870 standard provides a methodology for determining the GHG emissions associated with the production, conditioning and transport of hydrogen to the consumption gate. This document considers indirect emissions, including those associated with upstream activities in the raw material acquisition phase, the raw material

transport phase and other stages. GHG emissions contributions are defined in terms of carbon dioxide equivalent (CO₂eq). To support consistency in applying international standards, through its quality assessment system, IECQ, the IEC provides an internationally harmonised service for issuing International Carbon Footprint Verification Statements. These are issued to organisations that follow internationally accepted pathways in determining their carbon footprint claims. International confidence in GHG emissions claims is essential.

- **Sustainability aspects must not be overlooked.** It is important to look beyond emissions accounting and ensure that sustainability standards better cover aspects related to impacts on water and land demand and associated social impacts.
- **Promote digital solutions and leverage existing digitalisation tools and standards.** These can support a streamlining of requirements in standards across the whole hydrogen value chain. The adoption of digital avenues can also promote enhanced traceability, as well as demonstration of compliance with international QI requirements.
- **Promote harmonisation of QI elements.** To ensure that hydrogen and its derivatives have sustainable – as well as equitable – access to international markets, it is essential that international harmonisation of QI for green hydrogen is undertaken so that a level playing field is created for all stakeholders involved in the industry. International QI organisations such as the IEC, ISO, and the BIPM can serve as leaders, driving these efforts on national and regional QI bodies.
- **Provide a voice for developing countries.** In updating existing QI services, as well as in developing new ones (such as new standards), it is extremely important that developing countries are given ample conduits to share their opinions, as well as ensure these services support their development objectives. The engagement of developing countries in international standardisation technical committees must be promoted and supported.
- **Strengthen the link between policy and QI.** It is still widely observed that international policy makers do not fully grasp the concept of QI, nor its importance. Hence, it is necessary for international and regional QI bodies to undertake continuous awareness raising efforts to educate these stakeholders on the necessity of QI for safe and sustainable production, as well as for trade in products such as hydrogen and its derivatives.
- **Foster international collaboration.** International collaboration will be instrumental in harmonising general concepts and conformity assessments, ensuring environmental integrity and safety, creating opportunities for value addition in the Global South and in developing robust green hydrogen markets, based on QI.

Photographs from the session 'Symposium on the green hydrogen economy'



Further Reading:

<https://www.irena.org/Publications/2023/Jan/Creating-a-global-hydrogen-market-Certification-to-enable-trade>

<https://www.irena.org/Publications/2023/Jun/Innovation-landscape-for-smart-electrification>

IRENA-WTO Report: [International trade and green hydrogen: Supporting the global transition to a low-carbon economy](#)

IRENA (H₂ Policy Toolkit): [Green hydrogen for Sustainable Industrial Development: A Policy Toolkit for Developing Countries](#)
(by IRENA, UNIDO and IDOS)

Youth and innovators hub



Session organised in partnership with IEEE
Young Professionals

Keynote speakers

- Nawal Al-Hosany, Permanent Representative of the United Arab Emirates to IRENA
- Gauri Singh, Deputy Director-General, IRENA

Panel discussion 1

Moderator: Sajith Wijesuriya, National Renewable Energy Laboratory (NREL)

Panellists:

- Takuro N. Murakami, National Institute of Advanced Industrial Science and Technology
- Adekoyejo Kuye, Co-founder and Managing Director, KAMIM Technologies Limited
- Ghida Ismail, Board Member, Sustain The World
- Natashsa Louise Jones, CEO, Metris Energy
- Augusto Facundo Diaz, Co-Founder / Head of Projects, HD Photovoltaics

Panel discussion 2

Moderator: AbdulRahman Fahmy, Consultant, IRENA

Panellists:

- Clara Neppel, Senior Director European Business Operations, IEEE Technology Centre
- Anastasia Kuskova, CEO, Sirius
- Suzana Fred Munuo, CEO, Gilsun Technologies Peace
- Olalekan Bello, CEO, Chemotronix Ltd
- Ioan-Dacian Jurj, Cofounder, Renergia

Closing remarks: Riccardo Toxiri, IRENA

YOUTH & INNOVATORS HUB

DAY 2
SESSION 2

ENGAGEMENT OF YOUTH IS ESSENTIAL → WE NEED...

INNOVATIVE & CREATIVE MINDS!

TO MAKE SOLUTIONS EFFICIENT & ACCESSIBLE

BE PART OF THE POSITIVE CHANGE FOR ALL OF US!

DR. NAVAL AL-HOGANI IRENA

HELP TO DRIVE THE CHANGE

NO ENERGY TRANSITION WITHOUT financing

THIS IS OUR BIGGEST CHALLENGE!

PRIORITIZE EDUCATION

MEET & UNDERSTAND SOCIAL CONCERNS IN ORDER TO INVOLVE SOCIETY

DR. NAVAL AL-HOGANI IRENA

ANY BUILDING CAN BECOME A POWERPLANT!

NOT ONLY SOFTWARE, ALSO INNOVATIVE HARDWARE!

ALMOST ALL SOFTWARE IS DEVELOPED BY YOUNG PEOPLE!

CAPITAL IS KING!

ADRIANO VITTORE DO SAMPAIO

CLARA NEPDEL IRENA

Photographs from the session 'Youth and innovators hub'



IRENA INNOVATION WEEK

Renewable solutions to decarbonise end-use sectors

Summary report 2023