

INNOVATION WEEK 2018 OVERVIEW: KEY INSIGHTS, IMPLICATIONS AND NEXT STEPS WITH ANNEXES

1. Event overview

A transformation of energy systems is underway worldwide, setting the course towards a more inclusive, secure, accessible, low-carbon and sustainable future. Renewable power, particularly from the variable renewable energy (VRE) sources of solar and wind, is central to that change.

Progress is being made, costs have fallen, and solutions are emerging. However, to ensure secure energy access and to tackle climate change, the pace needs to be far quicker. Delivering a renewable-powered future will require the cost-effective integration and expanded use of high shares of variable renewable energy.

IRENA Innovation Week 2018 (IIW18) was convened to explore some of the solutions needed to achieve this.



On 5-7 September 2018, delegates from more than 70 member countries of the International Renewable Energy Agency (IRENA) gathered in Bonn, Germany, for IRENA's second Innovation Week. The diverse group of over 350 experts and decision makers from the public and private sectors met for three days, aiming to: showcase examples of innovative solutions from around the world; deepen their mutual understanding of the opportunities and challenges; and explore how to accelerate and broaden the uptake of solutions and so benefit many more countries.

Discussions focused on the latest developments in **enabling technologies, business models, system operation** and **market design** that are:

- » Enabling much **higher deployment** of variable renewable energy sources, such as solar and wind;
- » Increasing the **flexibility of power systems** to integrate variable renewable generation at lower costs than present options;
- » Supporting the **increased electrification** in the end-use sectors of transport, industry and buildings, powered by renewable electricity.

The presentations and discussion confirmed huge progress during the two years since the first IRENA Innovation Week. Yet significant challenges remain.

The event was informed by past and ongoing IRENA analysis and built on the success and insights from IRENA's first Innovation Week in 2016. Speakers and delegates came together for 12 sessions (spanning **Markets and Citizens**, **Digitalisation and Decentralisation**, and **Electrification** tracks), plus five plenary discussions. In addition, an interactive Global Innovation Showcase highlighted the work of 15 award-winning small and medium-sized enterprises.

Through the efforts of hundreds of pioneering companies, supported by far-sighted governments, many of the innovative solutions required for a renewable-powered future are already available. As IIW18 underlined, the challenge (and opportunity) now is to accelerate and broaden the uptake of those solutions, so that all countries can reliably integrate high shares of renewables into their energy systems.

2. Summary of key insights and implications

The key insights and priorities for action from IIW18 discussions are summarised below. These points are expanded on in Annex A and B of the on-line version of this report, and in a series of Session Summary Reports. Those documents together with videos of all sessions and the slides presented are available on the IRENA Innovation Week website (<http://innovationweek.irena.org>).

Insight		Challenge	Implications
1 Many renewable energy integration solutions are already available, and pioneers are showing what can be achieved.	Many of the solutions we need (for the cost-effective integration of renewable power and the electrification of end-use sectors) exist, and a globally diverse range of countries and companies are leading the way, pioneering innovative solutions and demonstrating their potential...	... <i>but</i> , to date, relatively few solutions are being widely deployed, and, where deployed, they are not being utilised to their full potential. A big gap remains between the front-runners and the trailing pack in the adoption of innovative solutions. Many decision makers are uncertain about the right solutions for their applications.	<ul style="list-style-type: none"> » Uptake needs to be accelerated and broadened to many more countries and companies. » Many more countries and companies can take confidence and inspiration and learn from the experiences of pioneer adopters. » Learning should be more widely shared. Insights from trials and pilots should be more fully and systematically captured and more widely disseminated.
2 Considered, clever and flexible market design is essential to foster innovation.	Some energy markets and regulations are showing how markets can carefully and cleverly be adapted to reflect the needs of power systems with higher shares of VRE and to respond to the trends of digitalisation, decentralisation and electrification...	... <i>but</i> , in many countries policy makers and regulators are still unclear on the consequences of the shift towards VRE and are concerned about the implications for security and reliability of supply. Existing regulations are often a barrier to the piloting and adoption of innovative solutions.	<ul style="list-style-type: none"> » Governments and regulators need to work with industry to create safe and secure opportunities for innovations to be trialled and, if successful, adopted. » More sharing of experiences and lessons learned is needed to give confidence to regulators on what can be done and how to do it.

	Insight		Challenge	Implications
3	Innovation has the most impact when it reflects the needs and wishes of consumers and communities.	Increased decentralisation of energy resources, increased local ownership and increased awareness of the environmental implications of energy production is changing the ways that people engage with the energy system. Consumers and communities must be involved with and benefit from the transition...	... <i>but</i> , there is only a limited understanding of how end-users will interact with the energy system, and current operating models do not fully reflect the needs of citizens or the potential role of active consumers.	<ul style="list-style-type: none"> » Governments and companies need to gather better insights into consumers' needs and expectations and their willingness to adopt innovations, and should tailor solutions accordingly. » Some consumers are likely willing to play an active role in the energy system, but the benefits must be clear and automation is needed to make responses simple.
4	Digitalisation can enable smarter, better-connected, more reliable and ultimately lower-cost energy systems.	Digital innovations (such as artificial intelligence, the Internet of Things, blockchain, etc.) are starting to significantly impact power systems in many different ways, with applications in supply, system operation and demand being piloted by both start-ups and established energy companies...	... <i>but</i> , that disruptive potential is only beginning to be understood and is far from being fully exploited. The implications for established models and actors and the risks are not yet fully understood.	<ul style="list-style-type: none"> » Technologies exist, but smart applications are still limited. Energy systems should make far more use of the "smartness" that digital innovations enable. » Many more pilots and deployments of digital-enabled solutions are needed in a wider range of circumstances.
5	Renewable energy-supplied electrification will be the primary route for decarbonising transport, buildings and industrial energy use, if done intelligently, while also providing greater flexibility for the integration of solar and wind power.	Driven by the increasing affordability of renewable electricity and by falling costs for end-use technologies such as electric vehicles, coupled with the need to decarbonise end-use sectors, electrification will rapidly grow to dominate transport, buildings and industrial energy use. These new uses can provide great flexibility to the power system and support the integration of high shares of variable renewables...	... <i>but</i> , that trend will create both new supply challenges and new flexibility options. Unless carefully and intelligently managed, power systems risk being disrupted or costs risk rising significantly.	<ul style="list-style-type: none"> » More analysis and pilot programmes are needed to better understand the potential of electrification for each sector and the infrastructure consequences. » Electrification strategies must be planned carefully and delivered intelligently, with close connections to strategies for the accelerated roll-out of renewable energy and consideration of wider societal changes.

3. Next steps for IRENA

The richness of discussions and feedback from many participants demonstrated the value of IIW18 in bringing together a diverse group to explore and share insights into the many common challenges and opportunities of innovative solutions for renewable power integration. While the event showcased a great deal of progress, much more can and should be done.

IRENA's innovation programme aims to support countries in accessing the information and learning that they need to support innovation in their country and to apply innovations in their energy systems. IRENA will use the insights gained from this event, alongside insights from other related activities, in upcoming events and reports. In particular, IRENA will:

- » Utilise its convening forums to disseminate insights from the IIW18 discussions and explore implications. For example, a Ministerial-CEO roundtable discussion on the disruptive impacts of innovation in renewable-powered energy systems is to be held at the IRENA Assembly in January 2019.
- » Publish a detailed analysis of the Innovation landscape for the integration of variable renewable energy during the coming period. That project should help decision makers navigate key choices to be made to foster innovation and provide a thorough overview of the innovations and solutions emerging around the world. A clear, easily navigable framework is intended to show how the many emerging innovations relate to each other and to the energy system, and which innovations could be relevant to different system needs.
- » Explore further opportunities to convene its membership and the private sector, including co-organising national or regional Innovation Days in 2019 and 2020 and convening a third IRENA Innovation Week (tentatively) planned for mid-2021.

IRENA will also explore additional ways to further support these objectives. For example, IRENA will consult with its members on mechanisms for strengthening the gathering and sharing of insights from pilots and pioneering deployments.

For further information on the insights from this report, to provide comments or feedback, or to express interest in engaging with IRENA's follow-on activities, please contact the Innovation Week team at IRENA: innovationweek@irena.org



ANNEX A:

SUMMARY OF DISCUSSIONS

Progress in innovation solutions

IRENA Innovation Week 2018 (IIW18) showcased a diverse range of projects. Examples highlighted by speakers included:

- » **Innovative approaches to aggregating small power producers and/or electricity storage solutions** (e.g., Next Kraftwerke from Germany and Tiko Energy Solutions from Switzerland managing Virtual Power Plants (VPPs); Global Sustainable Energy Solutions (GSES) from Australia using embedded networks);
- » **Off-grid solutions providing energy access through mini-grids with smart metering and mobile payments in rural areas** (e.g., Power Corner from France operating mini-grids in Tanzania with micro-utility platforms; Solshare building smart peer-to-peer grids in Bangladesh);
- » **Innovative solutions for flexible electrification** (e.g., VERBUND AG from Austria using green hydrogen production in a steel plant for grid services; TenneT from the Netherlands using flexible capacities from an interconnected pool of electric vehicles for frequency reserve response services; Danfoss from Denmark using vapour compression systems as flexibility enablers).

In three days IIW18 could highlight only a few dozen of the many hundreds of examples of innovative approaches to building more flexible and integrated power systems that are being trialled and deployed around the world. The discussion at IIW18, however, clearly indicated that many of the solutions that are needed to fully exploit renewable power exist, and many are being demonstrated successfully in real-world deployments.

IIW18 highlighted both the diversity of challenges that different countries and regions face and the diversity of solutions. Delegates from major industrial economies, from small-island developing states (SIDS), from low-income economies, from the Global South and from the Global North shared their perspectives on the challenges they faced. While many solutions are broadly relevant, they may not fit directly with the needs of each country or region. Tailoring solutions to local needs is critical.

A range of countries and companies are showing what can be done. That is a promising start and demonstrates the potential of innovation. However, the adoption of innovative solutions is still confined to a relatively small number of pioneering countries and companies. Moving from limited pilots to wider-scale adoption remains particularly challenging.

Building a renewable-powered future will require an accelerated uptake of existing and new solutions. Events such as IIW18 help to raise awareness of the potential of innovation, and attendees at IIW18 commented that they took inspiration from the examples they saw and from the experiences of others. Many more countries and companies could be inspired by and learn from those who are pioneering these solutions, and so rapidly broaden their adoption.

Discussions did suggest, however, that the landscape is perceived to be very complex, and that decision makers lack the detailed and relevant information they need on pilots and deployments to make informed choices. Many attendees stated that this lack of information is a key barrier to fully exploiting the potential of innovation. The positive and negative experiences from trials and pilot deployments are often not well documented, and the insights are not widely accessible.

There is a case, therefore, for the more systematic gathering of information from around the world on what has been tried, what worked, what didn't and why, and for that information to be packaged in ways that decision makers can access and utilise it.

The roles of markets and citizens

A strong theme of IIW18 was the need for **technology innovation** to go hand-in-hand with **innovations in business models, market design and system operation**. Across the event delegates heard numerous good examples of such a systemic approach to innovation. Appropriate market design is a critical enabler of the flexible integration of renewable energy, and for governments it can be the lowest-cost and most powerful lever available.

Speakers in many sessions highlighted that, in general, innovations in **market design and regulation** continue to lag behind **technology and business models**. In many places, this remains a barrier to the effective adoption of innovative solutions. Specifically, markets must encourage flexible behaviour on the supply side and properly reward demand-side response, which in turn will stimulate innovation in technology and business models. For example, the Electricity Storage session highlighted how the varying treatment of batteries in markets has a big impact on battery deployment.

Panellists emphasised that markets and regulatory frameworks need to adjust rapidly to the growing competitiveness of storage and to ensure that regulations reflect the full value of storage to the energy system to be compensated.

In the Markets session speakers commented that **most current power system markets are not yet fit for an energy system based on renewables**, and this mismatch often introduces additional transition barriers. Markets, or power system set-ups, for a renewables-based energy system need to address two needs in particular: 1) the procurement, with low financing costs, of generation technologies that are associated with high capital expenditure and low operational expenditure, and 2) the enablement of flexibility.

Participants in the session discussed the basic structure of a power system set-up that addresses these issues, and provided examples of initiatives that are responding to these requirements, such as the value-based auctions in the Mexican electricity market and the deployment of schemes to enable and procure flexibility. Regulators often show understandable caution to experiment, but techniques such as regulatory “sandboxes” have successfully minimised risk and allowed innovative solutions to thrive. Governments and regulators can take inspiration and learning from these pioneering examples to stimulate innovation in their own markets.

The need to **put people at the heart of the energy transition** came up in many sessions, and not just in those focused specifically on the role of consumers and citizens. Increased decentralisation of energy resources, increased local ownership and increased awareness of the environmental implications of energy production are changing the ways that people engage with the energy system. Speakers emphasised the need to embed innovations in the communities that they support, the need to ensure that people “buy in” to the changes and the need for the energy transition to be “fair and inclusive”.



Speakers in the Citizens session made the point that citizen empowerment is a cornerstone of a participative and inclusive transition. They suggested that to be successful, the transition needs to be inclusive, participative, collaborative, involving, fair and just. All too frequently, citizens and their communities are seen as largely passive actors, identified principally as consumers. Yet their needs and interests need to be considered proactively as projects are designed and policies formulated.

An understanding of the socio-economic impacts of renewable energy deployment and of the energy transition needs as much attention as technical, financial and market design issues do. With empowered citizens at the heart of the transition, the four main dimensions of empowerment – choice, participation, governance and responsibility – can be addressed. Speakers suggested that the conceptual framework should evolve from considering citizens only as “consumers” or “prosumers” towards their consideration as “users” or “prousers” at the heart of the energy system, reaching an appropriate balance between competition, regulation and collaboration.

Across multiple sessions IIW18 highlighted examples of user engagement such as: Sonnen from Germany, which connects consumer electricity storage through a sharing platform; the “Living from the air of the sky” project in Pujalt, Spain, where a community-owned wind power plant generates energy equivalent to the consumption of 2 000 families; and the FLEXCoop aggregator that is creating more inclusive energy markets for energy co-operatives in Europe. Speakers emphasised the need for better insight into how end-users will interact with the changing energy system and deeper thinking on how to support and incentivise that engagement.

The rising importance of digitalisation

Many sessions featured the role of digital technologies, with speakers highlighting the **potential for digitalisation to enable smarter, better-connected, more reliable and ultimately lower-cost energy systems**. Discussions highlighted multiple strong examples of the use of digital technologies coupled with business models that are enabling more integrated and more flexible systems.

As energy systems become more complex, especially due to decentralisation and the emergence of new small players, the need for and value of digital tools such as blockchain and artificial intelligence to manage and glean insights from complex data continues to increase. To date **artificial intelligence** (AI) has been used in fairly limited ways – for example in meteorology, control and predictive maintenance. The vast majority of data in the energy sector remains uncaptured, let alone analysed and applied. Increasing digital connectivity is creating enormous amounts of granular data that will require AI in order to be used effectively – aiding decision making and planning, condition monitoring, robotics, inspections, certifications and supply chain optimisation, and generally increasing efficiency.

Discussion of **blockchain** (the distributed ledger technology made famous by Bitcoin but with the potential for much wider application) highlighted the rapidly growing interest in this technology, with the session moderator stating that, at that point in time, USD 466 million had been invested globally in blockchain applications for power systems, with at least 189 companies working on such applications. Advocates of blockchain technology in the energy sector claim that the technology offers myriad possibilities and could pave the way for sophisticated, transparent networks that manage the entire energy value chain while fostering grid-edge flexibility. This includes: increased visibility of network assets; smooth billing, sales and payments; innovative financing mechanisms; efficient contract management; decentralised energy trading; real-time green certificate attribution; and more.

However, the use of blockchain is in its infancy and its potential is still largely unproven. While many promising applications were highlighted at IIW18, the discussions made clear that the applications and their value are only beginning to be explored. Key hurdles that stand in the way include regulatory uncertainty, scalability, lack of interoperability and standards, and lack of technological maturity and awareness, among others.

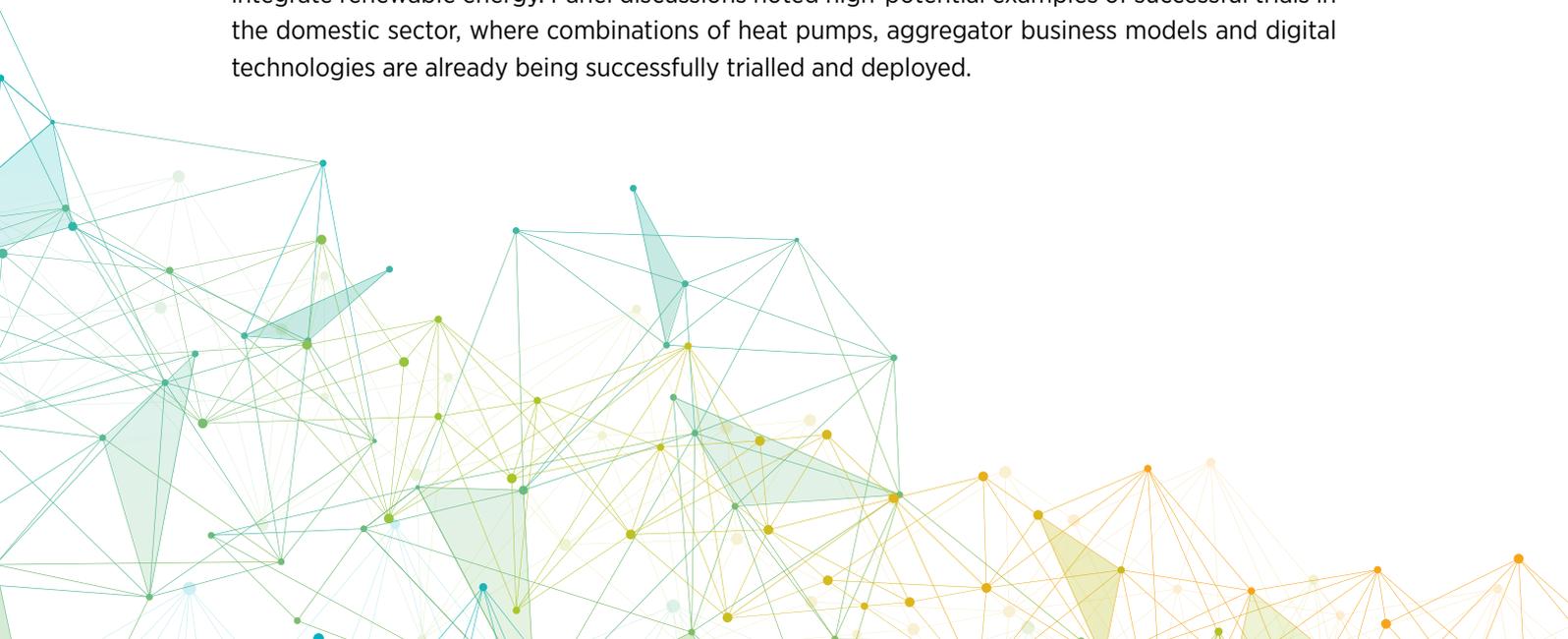
Digitisation is also a **key enabler of broadened energy access**. The IIW18 session on off-grid applications discussed how to support the development, deployment and dissemination of a broad range of innovative energy access solutions and evaluated their relevance in the context of the global energy transformation. Those discussions showed how, by using solar panels, smart phones and the internet, empowered consumers in low-income countries are now leapfrogging into an information-based digital economy that is growing much faster than the global economy – creating opportunities for growth and job creation while addressing climate change. Project development in developing countries, particularly for projects under 5 megawatts, is also seeing a boost due to novel financing mechanisms, such as those using blockchain, allowing contributors across the globe to finance small pieces of projects while being able to track the energy generated and receive payment without the need for trusted intermediaries.

In general, across many sessions, the IIW18 discussion demonstrated that the **disruptive potential of digitalisation is only beginning to be explored** and is far from being fully exploited. While technically much is possible, in practice deployment is still modest and a lot of “smartness” is not used – energy systems are still mostly rather “dumb”. Many more pilots and deployments of digital-enabled solutions are needed in a wider range of countries and applications to fully understand and explore the benefits, risks and impacts.

The benefits of electrification with renewable energy

IRENA's analysis indicates that electrification will rapidly grow to dominate transport, buildings and industrial energy use, and IIW18 discussions supported that conclusion. This electrification trend will create both new supply challenges and new flexibility options. IIW18 included sessions on the electrification of heat and transport, the role of electricity storage and the electrification of fuels, in particular through renewable energy-produced hydrogen. The consistent theme through all of the discussions was that increased electrification must be planned carefully and delivered smartly to minimise challenges and maximise benefits.

Discussion on the **electrification of heat** highlighted the potential to deliver multiple benefits – decarbonising through renewable sources and reducing overall consumption due to better efficiency of heat pumps, while smart heating has the potential to become a flexibility option to integrate renewable energy. Panel discussions noted high-potential examples of successful trials in the domestic sector, where combinations of heat pumps, aggregator business models and digital technologies are already being successfully trialled and deployed.



Specific examples discussed at IIW18 included: the FLEXYNETS concept presented by Eurac Research from Italy, which is deploying a new generation of intelligent district heating and cooling networks; and modular long-term heat storage solutions from Brennmiller Energy, based in Israel. Several speakers highlighted that industrial heating is the larger opportunity but also a bigger challenge due to specific sectoral requirements and to long time horizons (moving “quickly” can mean 20-year time frames).

The session on **electrification of transport** explored the implications for the power system of the accelerating uptake of electric vehicles (EVs), the synergies with the increased availability of renewable energy, and the resulting potential to deliver increased system flexibility and lower overall investment in system capacity.

Expert speakers highlighted how sales of EVs are growing rapidly. A few locations are already at the tipping point where EV use is mainstream, while others are approaching that point rapidly. The presentations demonstrated that smart charging is now a proven concept, with platforms successfully piloted in multiple cases (e.g., a pilot in Denmark had bid over 50% of EV charge time to contribute flexibility to the grid).

The panel discussion highlighted that charging occurs in a highly complex landscape, with different scales, times and types of consumer behaviours. If there is an uncoordinated mass adoption of EVs, there is real potential for local blackouts and for over-expenditure on network development. Significant uncertainties also remain in how flexibility provision fits in this wider picture. Avoiding a chaotic roll-out of e-mobility will require co-ordination among a wide range of players.

The session on **electricity storage** highlighted that the applications and benefits of electricity storage are potentially very wide ranging. Electricity storage systems can provide ancillary services such as frequency regulation and voltage support, help to firm variable renewable energy (VRE) capacity, shift electricity generation to when it is most needed and help to defer capacity investments. Islands and other off-grid communities are already relying on electricity storage in combination with renewables for reliable and cheap electricity, and large markets, such as in the United States, are proving the commercial case.

The discussion among panellists suggested that load shifting or peaking capacity is the largest potential market for battery energy storage solutions over the long term. However, in the short term, competitive advantage in high-value ancillary service provision and stacked revenue streams are providing an avenue for deployment that will help drive down costs far enough to reach competitiveness with conventional peaking capacity.

New business models supported by digitalisation (e.g., smart home energy management systems) are increasing the value of behind-the-meter battery systems, which usually are focused on diurnal electricity storage but also can provide grid services through aggregators. Speakers highlighted that Germany alone has more than 100 000 home battery systems, which are capable of doubling self-consumption rates for residential solar photovoltaic systems from 30-40% to 60-80%.

The IIW18 discussion on the role of **hydrogen** highlighted its potential synergies with the direct electrification of some end-use applications. Where direct electrification is not practical or economical, renewable fuels will be necessary. Hydrogen and bioenergy are among the few options in this space.

The session was informed by insights from IRENA's newly published report *Hydrogen from Renewable Power – Technology Outlook for the Energy Transition*. Speakers described examples of the integration of hydrogen generation and use into energy systems, including: the Fukushima Plan for a New Energy Society, a model construction for a hydrogen-based society that will be applied during the Tokyo

Olympic Games in 2020; Chile's exploration of the business case to export hydrogen from solar production to supply global demand; and a study in the United Kingdom to assess the technical-economic feasibility of converting the existing natural gas network to 100% hydrogen.

In industry, where certain processes require hydrogen as a key feedstock, a clear opportunity to shift to hydrogen produced from renewables was discussed to substitute process energy produced mostly from natural gas. At the same time, hydrogen production from renewable electricity was presented as a potential source of flexibility for the power system, with gas infrastructure acting as seasonal storage for electricity.

In general, successful electrification with renewable energy will require strategies that harness the synergies between the consumption of clean power and the integration of high shares of VRE (e.g., smart charging of EVs, electricity storage providing grid services, aggregation of heat pumps and electric boilers for demand response, use of surplus renewable power for hydrogen hydrolysers, etc.), as well as strategies that take into account the technical limits of electrification for each sector and consider the infrastructure consequences.

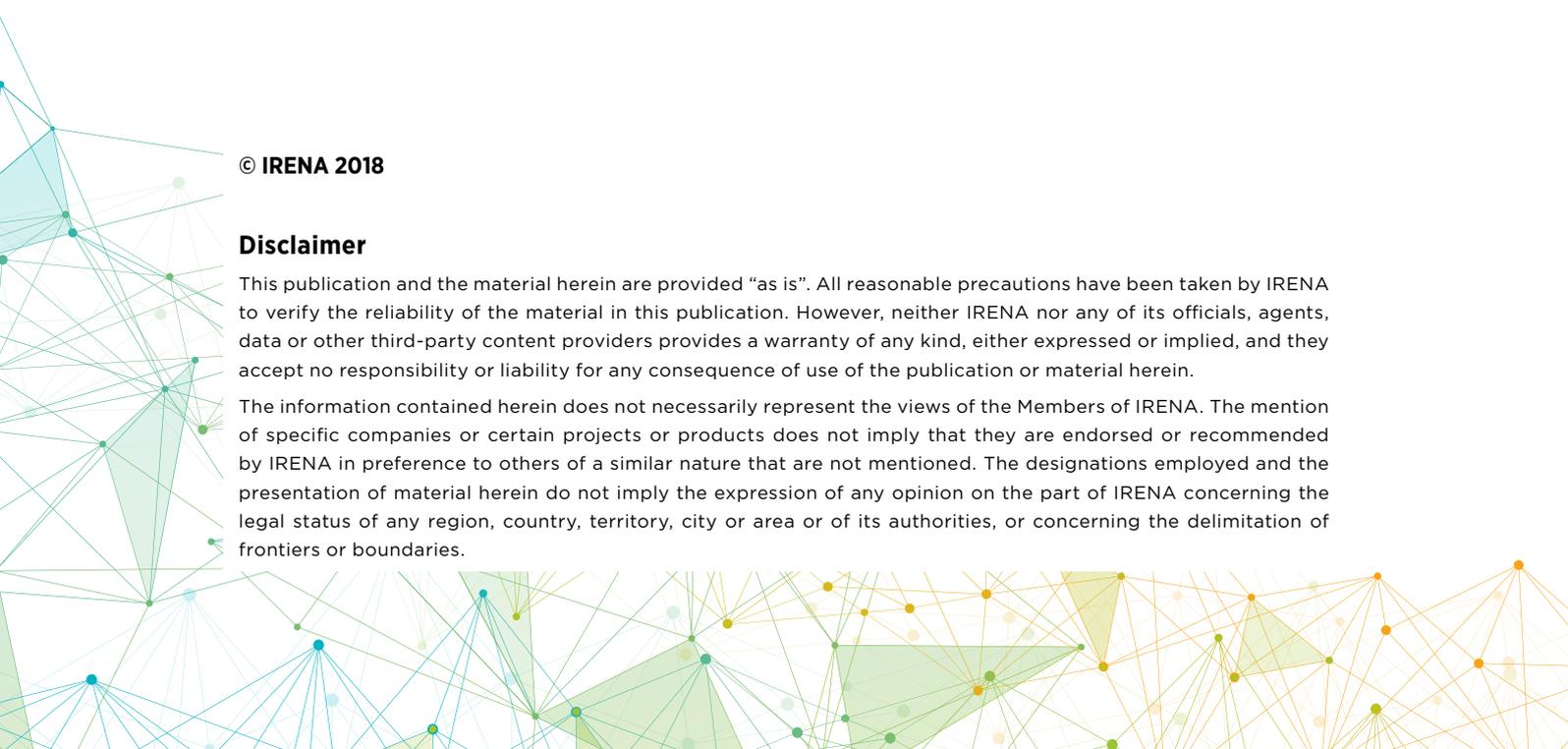


ANNEX B:

PROGRESS SINCE IRENA INNOVATION WEEK 2016 (IIW16)

Discussions at the first IRENA Innovation Week, held in May 2016, resulted in six key takeaways. In the subsequent two years significant progress has been made, but IIW18 illustrated that some of the same issues remain while new challenges have emerged.

1	<p>In 2016 IIW16 concluded that: The technology to push a global renewable energy transformation in the next two decades is already here, but more innovation is needed in policy formulation and business models.</p> <p>In 2018 IIW18 showed that: A more systemic approach to innovation is beginning to take hold, with many examples of solutions that combine innovation in technology with innovations in business models, market design and/or system operation.</p>
2	<p>In 2016 IIW16 concluded that: Markets need to adapt as renewable energy takes a greater share, with new regulatory approaches and policies to ensure its long-term success.</p> <p>In 2018 IIW18 showed that: Some markets have started to adapt to encourage solutions that increase the flexibility of the power systems and to incorporate higher shares of VRE, but many market barriers to change remain. More sharing of experiences and lessons learned is needed to give confidence to regulators on what can be done and how to do it.</p>
3	<p>In 2016 IIW16 concluded that: The relationship between information technology and renewable energy is essential, but the full scope of complementarities is yet to be fully understood.</p> <p>In 2018 IIW18 showed that: The digitalisation of energy is happening and accelerating rapidly; however, the full potential and risks are not yet fully understood. IIW18 and the upcoming IRENA reports on the “Innovation landscape for the integration of variable renewable power” are helping decision makers navigate those developments.</p>
4	<p>In 2016 IIW16 concluded that: Electricity storage is integral to the renewable energy transformation, with diverse views on the forms it will take.</p> <p>In 2018 IIW18 showed that: Electricity storage remains a key technology, and its use is expanding. Beyond that, however, the electrification of end-use sectors is now a decarbonisation strategy that is being pursued enthusiastically globally thanks to cheap renewable electricity.</p>
5	<p>In 2016 IIW16 concluded that: Innovation can be found at all scales, from micro-grids to continental super-grids, from rich to poor.</p> <p>In 2018 IIW18 showed that: Thanks to the distributed nature of renewable energy as well as digital technologies, micro-grids and super-grids can clearly complement and support each other.</p>
6	<p>In 2016 IIW16 concluded that: Flexibility is key, and context-relevant solutions are essential.</p> <p>In 2018 IIW18 showed that: Flexibility remains key to the affordable use of low-cost VRE. As the diversity of solutions highlighted at IIW18 showed, innovation is beginning to unlock flexibility across the complete power system on the supply side, in grids and on the demand side.</p>



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