Disruptive innovative solutions enabling 100% renewable power systems

Workshop

28 November 2019
Agenda
Welcome address

Paul Durrant, Programme Officer, Renewable Energy Innovation (IRENA)
Round-table introduction

All participants
Project Overview

Ms Elena Ocenic, Programme Officer, Innovation Networks (IRENA)
**Introductory remarks**

**Participating countries**

43 IRENA member countries have pledged to achieve some form of 100% renewable energy target in the coming decades. First IRENA member countries invited to join these activities based on policy targets to achieve **100% renewable power** (rather than 100% renewable energy) by 2030, 2040 or 2050 respectively. Uruguay and Paraguay are frontrunners in the operation of a power system with 98% and 100% of the power generated in 2017 from renewable energy sources. The activities are open to countries that have less specific targets and would like to explore a high ambition for renewable power.

<table>
<thead>
<tr>
<th>Country</th>
<th>Target Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costa Rica</td>
<td>100% renewable power by 2030</td>
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<tr>
<td>Denmark</td>
<td>100% renewable power by 2050</td>
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<tr>
<td>Germany</td>
<td>At least 80% renewable power by 2050</td>
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<tr>
<td>Norway</td>
<td>100% renewable power by 2050</td>
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<tr>
<td>Spain</td>
<td>100% renewable power by 2050</td>
</tr>
<tr>
<td>Sweden</td>
<td>100% renewable power by 2040</td>
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<tr>
<td>Uruguay</td>
<td>98% renewable power generated in 2017</td>
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<tr>
<td>Paraguay</td>
<td>100% renewable power generated in 2017</td>
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</tbody>
</table>
Additional innovation work (funded by Sweden)

Workstream 1: Experience sharing programme on innovative solutions for very high shares of renewable power by mid-century

Activity
- Engagement with member countries having similar policy targets
- Engagement with experts, academia and private sector

Input
- IRENA’s 160 member countries
- IRENA’s analytical tools and knowledge base (ITC, KFC)

Output
- Online & offline engagement (regional workshops, online workshops)

Outcome
- Innovation network of countries with high renewable power targets
- Outlook for future international collaboration on this topic

January 2019

Workstream 2: Country-level innovation study

Activity
- Internal IRENA (ITC, KFC) engagement
- Engagement with member countries
- Engagement with key stakeholders in Sweden

Input
- National and regional circumstances, approaches to innovation, as well as challenges & opportunities for a decarbonised power system by 2040
- Qualitative analysis of disruptive innovations
- Power-sector insights

Output
- Knowledge creation (published in a report)
- Outreach & dissemination of knowledge in Sweden, as well as other interested member countries

Outcome
- Informed decision-makers in Sweden
- Informed decision-makers in other member countries participating in the project

January 2020

100% Renewable Power
Online workshops
Workshop in Uruguay

Innovative solutions for 100% renewable power
Swedish case study

January 2019

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## Past activities

<table>
<thead>
<tr>
<th>Type of workshop</th>
<th>Tentative date</th>
<th>Description</th>
<th>Location</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>6&lt;sup&gt;th&lt;/sup&gt; June 2019</td>
<td>Focus on sharing national objectives for renewable power and expected/experienced <strong>challenges</strong></td>
<td>Remote</td>
<td>Link</td>
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<tr>
<td>In-person</td>
<td>17&lt;sup&gt;th&lt;/sup&gt; July 2019</td>
<td>Focus on <strong>innovative solutions for 100% renewable power systems by mid-century</strong> by exchanging perspectives, plans and good practice in working towards very high levels of renewable power. Workshop takes place back-to-back with the IRENA Innovation Day (15-16&lt;sup&gt;th&lt;/sup&gt; July).</td>
<td>Montevideo, Uruguay</td>
<td>Link</td>
</tr>
<tr>
<td>Online</td>
<td>10&lt;sup&gt;th&lt;/sup&gt; October 2019</td>
<td>Focus on sharing national <strong>experiences</strong> with the application of innovative solutions</td>
<td>Remote</td>
<td>Link</td>
</tr>
<tr>
<td>Online</td>
<td>28&lt;sup&gt;th&lt;/sup&gt; November 2019</td>
<td>Focus on <strong>disruptive innovative solutions</strong> enabling 100% renewable power systems</td>
<td>Remote</td>
<td>Link</td>
</tr>
</tbody>
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Workstream 2

Innovation Landscape Report for VRE integration + 30 Innovation Landscape Briefs + Swedish case study

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
# 30 innovations for VRE integration

## ENABLING TECHNOLOGIES

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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<td>1</td>
<td>Utility-scale batteries</td>
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<tr>
<td>2</td>
<td>Behind-the-meter batteries</td>
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<tr>
<td>3</td>
<td>Electric-vehicle smartcharging</td>
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<tr>
<td>4</td>
<td>Renewable power-to-heat</td>
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<tr>
<td>5</td>
<td>Renewable power-to-hydrogen</td>
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<td>6</td>
<td>Internet of things</td>
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<tr>
<td>7</td>
<td>Artificial intelligence and big data</td>
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<tr>
<td>8</td>
<td>Blockchain</td>
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<tr>
<td>9</td>
<td>Renewable mini-grids</td>
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<td>10</td>
<td>Supergrids</td>
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<tr>
<td>11</td>
<td>Flexibility in conventional power plants</td>
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</tbody>
</table>

## BUSINESS MODELS

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<thead>
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<th>Description</th>
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<tbody>
<tr>
<td>12</td>
<td>Aggregators</td>
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<tr>
<td>13</td>
<td>Peer-to-peer electricity trading</td>
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<tr>
<td>14</td>
<td>Energy-as-a-service</td>
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<tr>
<td>15</td>
<td>Community-ownership models</td>
</tr>
<tr>
<td>16</td>
<td>Pay-as-you-go models</td>
</tr>
</tbody>
</table>

## MARKET DESIGN

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>17</td>
<td>Increasing time granularity in electricity markets</td>
</tr>
<tr>
<td>18</td>
<td>Increasing space granularity in electricity markets</td>
</tr>
<tr>
<td>19</td>
<td>Innovative ancillary services</td>
</tr>
<tr>
<td>20</td>
<td>Re-designing capacity markets</td>
</tr>
<tr>
<td>21</td>
<td>Regional markets</td>
</tr>
<tr>
<td>22</td>
<td>Time-of-use tariffs</td>
</tr>
<tr>
<td>23</td>
<td>Market integration of distributed energy resources</td>
</tr>
<tr>
<td>24</td>
<td>Net billing schemes</td>
</tr>
</tbody>
</table>

## SYSTEM OPERATION

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>25</td>
<td>Future role of distribution system operators</td>
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<tr>
<td>26</td>
<td>Co-operation between transmission and distribution system operators</td>
</tr>
<tr>
<td>27</td>
<td>Advanced forecasting of variable renewable power generation</td>
</tr>
<tr>
<td>28</td>
<td>Innovative operation of pumped hydropower storage</td>
</tr>
<tr>
<td>29</td>
<td>Virtual power lines</td>
</tr>
<tr>
<td>30</td>
<td>Dynamic line rating</td>
</tr>
</tbody>
</table>

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Innovative solutions for 100% renewable power: Swedish case study

Solution I

- Enabling technologies
  - Utility-scale batteries
  - Internet of Things
  - Artificial intelligence and big data
- Market design
  - Increasing time granularity in electricity markets
  - Innovative ancillary services
- System operation
  - Advanced weather forecasting of variable renewable power generation

Solution II

- Enabling technologies
  - Internet of Things
  - Artificial intelligence and big data
  - Blockchain
- Market design
  - Increasing time granularity in electricity markets
  - Regional Markets

Solution III

- Enabling technologies
  - Behind-the-meter batteries
  - EV Smart charging
  - Renewable power-to-heat
  - Internet of Things
  - Artificial intelligence and big data
  - Blockchain
- Business models
  - Aggregators
- Market design
  - Time-of-use tariffs
  - Innovative ancillary services
  - Market integration of distributed energy resources
- System operation
  - Future role of DSOs
  - Co-operation between TSOs and DSOs
  - Virtual power lines

Solution IV

- Enabling technologies
  - Renewable power-to-heat
  - Renewable power-to-hydrogen
  - Artificial intelligence and big data
- Market design
  - Increasing time granularity in electricity markets
  - Innovative ancillary services
  - Regional Markets

Pan-European market as flexibility provider with effective collaboration amongst system operators

Decarbonisation of end-use sectors via electrification with RES
I. Decarbonisation and electrification of end-use sectors
Solution IV: Decarbonisation of end-use sectors via electrification with RES

Schematic representation of innovative solution IV

- Renewable power-to-heat
- Renewable power-to-hydrogen
- Artificial intelligence and big data

Market design

- Increasing time granularity in electricity markets
- Innovative ancillary services
- Regional Markets
Decision whether to consume or trade renewable power on the regional wholesale electricity market could be based on the market price signals (European context). If released for consumption, renewable electricity can either contribute to:

1) **Direct electrification** of the power-, heat or transport end-use sectors, which in turn opens the door to electricity and heat storage as well as electric vehicle (EV) smart charging;
2) **Indirect electrification**, through the production of hydrogen via electrolysis and its use in transport, housing and industrial applications;
3) **Storing renewable hydrogen** over longer periods of time, which could be reconverted to power and traded on electricity markets when profitable, based on market price signals;
4) **Enabling the provision of ancillary services** to the transmission system operators from electrolysis, hydrogen storage and EV batteries via EV smart charging technologies.
Guiding questions

1. Drawing on ‘Solution IV - Decarbonisation of end-use sectors via electrification with RES’, what is your country’s stance on decarbonisation of end-use sectors via indirect (e.g. renewable power-to-hydrogen) and direct (e.g. renewable power-to-heat) electrification? E.g. Have any targets been expressed on renewable power-to hydrogen or on sector coupling?

2. Would it be feasible to implement solution IV (or a similar solution) in your country in order to integrate larger shares of VRE in the power system, while decarbonizing other end-use sectors? Which barriers did you identify, and what opportunities could arise?

3. Looking at examples of similar implemented solutions, are there any comparable projects being trialed or planned for the future in your country?
Spain
Sweden
Uruguay
DISRUPTIVE INNOVATIVE SOLUTIONS
URUGUAY

IRENA, NOVEMBER 2019
Decarbonization of end-use sectors via *indirect* electrification:

*Power to hydrogen for transport (heavy duty and Coach buses). Pilot project*

- Production of green hydrogen based of electricity from the grid (97 % renewable). Demand management (19 hours per day)
- One hydrogen fueling station in Montevideo
- 10 heavy vehicles (intercity buses range 500 km / road trucks range 900 km)
- 10 vehicles @ 1000 km / day => 600 ~ 900 kg H2 / day

- Renewable Power to Hydrogen
- Internet of Things
- Artificial Intelligence and Big Data
- Pay as you go models
- Time of use tariffs
- Advanced forecasting of variable renewable power generation
Decarbonization of end-use sectors via indirect electrification:

*Power to hydrogen for transport (heavy duty and Coach buses)*

**Barriers**

- Commercial buses are only urban (there are no commercial Coach Buses)
- Is not easy to buy trucks (serial production doesn’t exist)
- Large scale Hydrogen Storage to store Energy surplus (if country doesn’t have salt mines)
- Fossil fuels cheaper than hydrogen from electrolysis (until 2030)
- New and expensive infrastructure
- Security perception
- Connection to the grid is expensive. Isolated solar plus Wind parks to produce hydrogen have to be analyzed
Decarbonization of end-use sectors via direct electrification:

*Power to heat with energy surplus*

- Electric boiler uses only energy surplus
- Functions in parallel with fossil fuel boiler

- Renewable Power to Heat
- Internet of Things
- Artificial Intelligence and Big Data
- Advanced forecasting of variable renewable power generation
Decarbonization of end-use sectors via direct electrification:

*Power to heat with energy Surplus*

**Barriers**

- Energy surplus hours are not equal every year (Hydro’s share is 50% with high annual variability). The Utility can guarantee a quantity of surplus hours in 7 years.

- Connection to the grid is expensive.
Regulatory initiatives
Regulatory initiatives:

*Power to heat with energy surplus*

- demands use only energy surpluses
- energy surplus tariff: 30 USD/MWh (supplement fuel oil or natural gas 50 USD/MWh)
- institution hires a certain power
- utility ensures a number of hours of energy surplus for 7 years
- utility turns the general key on and off remotely
- take or pay
Thank you....
DISRUPTIVE INNOVATIVE SOLUTIONS URUGUAY

IRENA, NOVEMBER- 2019
Interactive discussion
II. Social innovation and regulatory sandboxes
4. What is your view on the topic of social acceptance? Could you share any examples or initiatives aimed at increasing the social acceptance of technology-driven innovations in the context of integrating higher shares of renewables in the power mix?

5. Are there any insights or best practices from regulatory initiatives encouraging actors to experiment and test technology-driven innovations in the context of integrating higher shares of renewables in the power mix?
Interactive discussion
III. Discussion on future engagement
Guiding questions

6. What role should IRENA play to accelerate innovation in the area of decarbonization of end-use sectors with renewables?

7. Would you like to engage on this (or similar) subject in the future? If yes, which topics do you perceive as particularly important to discuss within an international arena?
Next steps
Next steps

➔ December 2019: IRENA shares feedback survey and minutes of this online workshop

➔ 10 January 2020: “Enhancing Dialogue among Countries with High Shares of Renewables in their Energy Systems with a panel about innovation

➔ 11-12 January 2020: IRENA Assembly
Thank you very much for your participation!
Further reading

- IRENA (2019), Innovation Landscape for a renewable-powered future: Solutions to integrate variable renewables: [Link](#)

- IRENA (2019), Innovation Landscape Briefs:
  - ✓ Market design briefs: [Link](#)
  - ✓ Enabling technologies: [Link](#)
  - ✓ Business models: upcoming
  - ✓ System operation: upcoming

- IRENA (2020), Innovative solutions for 100% renewable power - Swedish case study: upcoming

- IRENA (2019), Innovation Outlook smart charging for Electric Vehicles: [Link](#)

- IRENA (2018), Hydrogen from renewable power: Technology outlook for the energy transition: [Link](#)