Innovations for 100% renewable power: a systemic approach

Presenters:
• Arina Anisie, Innovation team
• Elena Ocenic, Innovation team

TUESDAY, 17 MARCH FEBRUARY 2020 • 10:00 – 10:30 CET
The Energy Transformation

Wind & solar PV at the core of the energy transition

Cost reduction in the period 2010 - 2018

- Solar PV: 77%
- Onshore Wind: 30%

Electricity share in generation mix

- Solar PV: 25% (2018) → 35% (In 2050)
- Onshore Wind: 2% (2018) → 6% (In 2050)

- Wind and PV are variable energy sources – addressing variability is crucial for high deployment.
- Today’s challenge – integrating high shares of wind and PV in power systems.
- Power-system flexibility is key to the cost-effective use of renewables.

Three innovation trends

- Electrification of end-use sectors is an emerging solution to maintain value and avoid curtailment of VRE, and help decarbonize other sectors
- The increasing deployment of Distributed Energy Resources (DERs) turns the consumer into an active participant, fostering demand-side management.
- Digital technologies enable faster response, better management of assets, connecting devices, collecting data, monitor and control

Source: IRENA (2019). Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Innovation unlocks flexibility across the power system

Flexibility sources:
- Flexible generation
- Regional interconnections and markets
- Demand response
- Storage
- Power to X

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
Systemic innovation for wind and solar PV integration

Source: IRENA (2019). Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables
30 Innovation Briefs


#IRENAinsights
Innovations do not emerge in isolation. Synergies between innovations are needed.
Flexibility solutions for a wind and solar PV integration

### Supply-side flexibility solutions
1. Decreasing VRE generation uncertainty with advanced generation forecasting
2. Flexible generation to accommodate variability

### Grid flexibility solutions
3. Interconnections and regional markets as flexibility providers
4. Matching RE generation and demand over large distances with Supergrids
5. Large-scale storage and new grid operation to defer grid reinforcements investments

### Demand-side flexibility solutions
6. Aggregating distributed energy resources for grid services
7. Demand-side management
8. RE mini-grids providing services to the main grid
9. Optimising distribution system operation with distributed energy resources

### System-wide storage flexibility solutions
10. Utility-scale battery solutions
11. Power-to-X solutions

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Systemic innovation in the international context

100% renewable power

Online workshops  Workshop in Uruguay

January 2019

January 2020

100% renewable power by 2030  100% renewable power by 2050  At least 80% renewable power by 2050  100% renewable power by 2050  100% renewable power by 2040  98% renewable power generated in 2017  100% renewable power generated in 2017

Costa Rica  Denmark  Germany  Norway  Spain  Sweden  Uruguay  Paraguay

#IRENAInsights
Each solution tackles a different segment of the power sector value chain

Swedish electricity production (2017)

39% by 2040

- hydropower
- nuclear
- wind
- CHP (mainly renewables)

Key system operation challenges:

- **Ensuring power system stability**: annual average inertia is expected to decrease from 202 GWs (2020) to 159 GWs (2040);
- **Balancing demand and supply**: greater consumption in the South and significant hydropower generation in the North;
- **Expanding the network**: long lead times for distribution & transmission infrastructure (EUR 15 billion to be invested by 2025).
Solution I – Innovative ancillary services from renewables

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

▶ Provides innovative ancillary services both from conventional and variable renewable energy sources;
▶ Ensures the security and stability of the power system and the provision of new ancillary services, including frequency and voltage support from VRE sources;
▶ Enables the provision of such ancillary services with the help of more precise solar and wind power generation forecasts.

Sweden – Battery energy storage system at Forshuvud hydropower plant for better ancillary services

Sweden – VRE participating in the existing ancillary service market

Germany – EWeLiNE, ORKA, ORKA2 and Gridcast projects improving VRE generation forecasts

United States – Flexibility incentivised in California with innovative ancillary services
Solution II – Pan-European market as flexibility provider

**Enabling technologies**
- Internet of Things
- Artificial intelligence and big data
- Blockchain
- Supergrids

**Market design**
- Increasing time granularity in electricity markets
- Regional markets

- Improves flexibility in the existing pan-European market design;
- Fosters collaboration among system operators in Sweden, the Nordic, Baltic and wider European region;
- Ensures clear and effective division of responsibilities to manage an increasingly complex, decentralised and digitalised power system.

**Solution II**
Pan-European market as flexibility provider with effective collaboration among system operators

Europe – intraday trading between non-adjacent market areas
Europe – 15- and 30-minute intraday products traded closer to real-time delivery

Denmark – 53% VRE integration thanks to supergrids and regional market
European transmission system operators – pilots for a common balancing market

Intraday market coupling 21 countries

IRENA (2020), Innovative solutions for 100% renewable power in Sweden
Solution III – System-friendly integration of DERs

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 distribution system operators
- Co-operation between transmission and distribution system operators
- Virtual power lines

Solution III
System-friendly integration of distributed energy resources

- Aggregates distributed energy resources to optimise distribution system operation;
- Balances supply and demand daily;
- Manages network congestion at the distribution level in the context of wind shortage/surplus in the short term, until transmission projects with long lead times are implemented.

Sweden – Time-of-use tariffs
Sweden – Smart Heat Grids
Sweden – Coordinet project
Netherlands – EV batteries for grid stability
Denmark – Parker Project
Germany – Aggregator providing grid services to the transmission system operator
Solution IV – Decarbonization of end-use sector via electrification with VRE

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

▷ Decarbonises end use sectors such as direct heat and transport via electrification with renewable energy sources;
▷ Enhances flexibility and helps maintain system stability via direct and indirect electrification via power-to-X technologies (such as renewable power-to-heat and renewable power-to-hydrogen);
▷ Is part of a truly complex, yet disruptive solution, for sectors that are difficult to decarbonise, such as iron and steel industries.

Sweden – Decarbonising the building sector (blocks and houses)
Sweden – Decarbonising the iron and steel industry – HYBRIT project
Sweden – Decarbonising the heating and cooling sector – EctoQrid project

Europe, Asia – Decarbonising the transport sector (ships, trains, cars and bikes)
Austria – Decarbonising the steel industry – H2FUTURE project
Uruguay – Decarbonising the industry – Renewable power-to-heat coupled with wind power
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 consumed, 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.

➔ **Technology alone is not enough. Enabling frameworks must be adjusted to ensure a smooth transition!**
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 in Sweden: Link
Questions & Answers

Please use the ‘Questions’ feature on the webinar panel
Next webinars

- WEDNESDAY, 1 April 2020 • 10:00 – 10:30 CET
  “Global Renewables Outlook-IRENA’s view on key technologies for the Energy Transformation to 2050”

- THURSDAY, 16 April 2020 • 10:00 – 10:30 CET
  “Storage Valuation Framework”
Thank you!

innovationday@irena.org
Implementation example - Sweden (Solution IV)

Decarbonising the iron and steel industry - HYBRIT project

- Steel industry accounts for ca. 7% of global CO2 emissions and 10% of Swedish CO2 emissions
- Reduction of CO2 emissions in iron and steelmaking processes and substitution of coal using renewable hydrogen
- Conducted through the consortium of Swedish steelsmaker SSAB, power utility Vattenfall, and LKAB, Europe’s largest iron ore producer
- EUR 50-60 million funding from the Swedish Government
- Aim to have a pilot plant (proof of concept) operational by 2020 and a demonstration plant post-2024
- Contribution to power system flexibility and VRE integration
Europe, Asia – Decarbonising the transport sector (ships, trains, cars and bikes)

- **Scotland**: Renewable hydrogen in passenger ferry – HYSeas III project
- **France**: Renewable hydrogen ship for research – Energy Observer vessel
- **Europe**: (Renewable) hydrogen trains, cars and bikes
- **Asia**: Deployment of **fuel cell electric vehicles** (FCEVs) and renewable hydrogen filling stations:
  - **China**: 1 million FCEVs & 1000 filling stations by 2030 (1791 FCEVs & 15 filling stations in 2018)
  - **Japan**: 800,000 FCEVs & 900 filling stations by 2030 (2926 FCEVs & 100 filling stations in 2018)
  - **Republic of Korea**: 6.2 million FCEVs & 1,200 filling stations by 2040 (900 FCEVs & 14 filling stations in 2018)
Priority solutions based on country/system context

Flexibility vs Cost

- Power-to-X solutions (Power-to-Hydrogen)
- Matching RE generation and demand over large distance with supergrids
- Utility-scale battery solutions
- RE mini-grids providing service to the main grid
- Flexible generation to accommodate variability
- Demand-side management
- Aggregating DER for grid services
- Power-to-X solutions (Power-to-Heat)
- Interconnections and regional markets as flexibility providers
- Optimising distribution system operation with DER
- Decreasing VRE generation uncertainty with advanced weather forecasting
- Avoiding grid reinforcements investments with innovative operation of lines

Potential to increase system flexibility

Supply-side solutions
Grid flexibility solutions
Demand-side solutions
System-wide storage solutions

Flexibility vs Implementation Complexity

- Interconnections and regional markets as flexibility providers
- Matching RE generation and demand over large distance with supergrids
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- Optimising distribution system operation with DER
- Demand-side management
- RE mini-grids providing service to the main grid
- Utility-scale battery solutions
- Power-to-X solutions (Power-to-Heat)
- Decreasing VRE generation uncertainty with advanced weather forecasting
- Avoiding grid reinforcements investments with innovative operation of lines
- High-impact low-cost solutions

Potential to increase system flexibility

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