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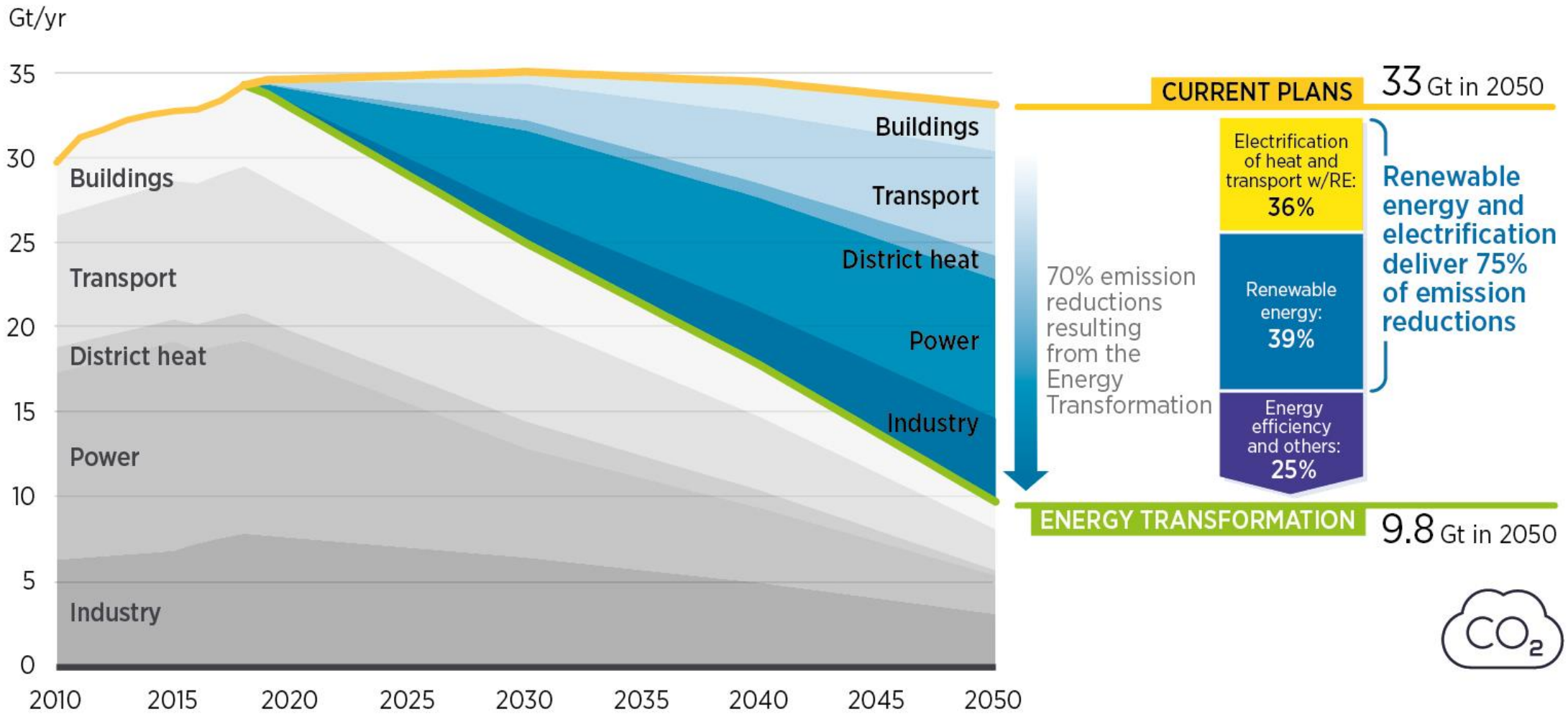
Innovations for 100% renewable power: a systemic approach

Presenters:

- Arina Anisie, Innovation team
- Elena Ocenic, Innovation team

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

The Energy Transformation



Source: IRENA Global Energy Transformation: A roadmap to 2050 (2019 edition)

Wind & solar PV at the core of the energy transition

Cost reduction in the period 2010 - 2018

77% Solar PV

30% Onshore Wind

Electricity share in generation mix

	Solar PV	Onshore Wind
In 2050	25%	35%
2018	2%	6%

- 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.

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables, IRENA (2019), Global energy transformation: A roadmap to 2050 (2019 edition)

Three innovation trends

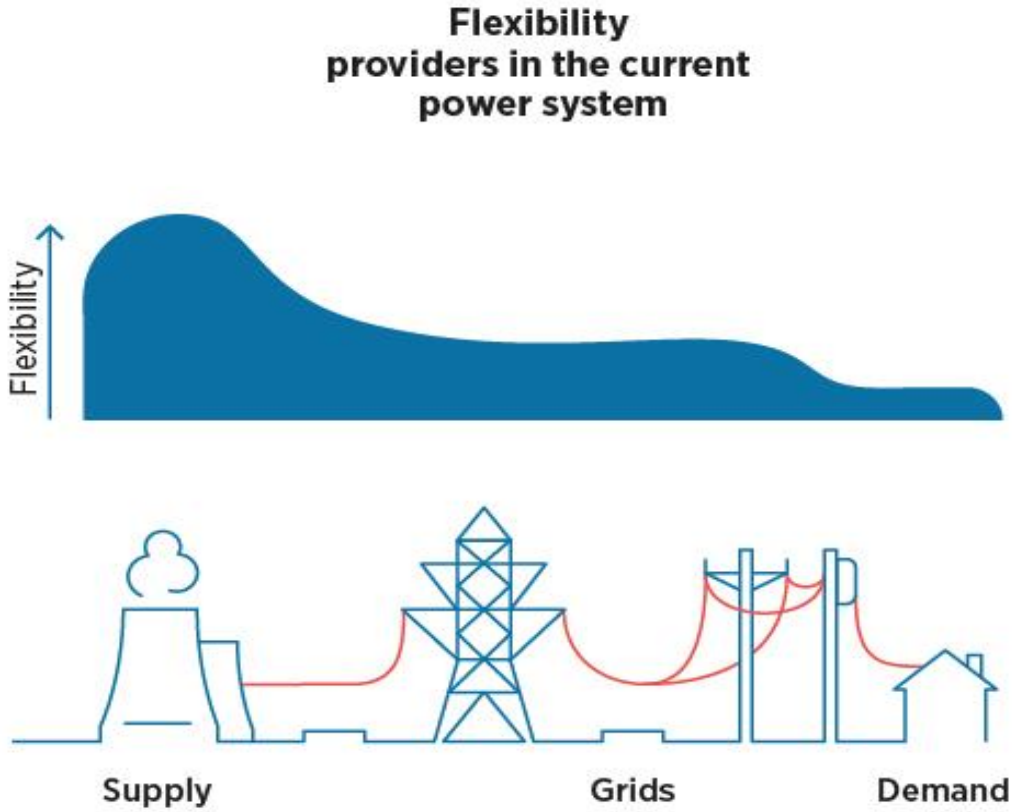
- Electrification of end-use sectors is an emerging solution to **maintain value and avoid curtailment of VRE**, and help decarbonize other sectors

- The increasing deployment of Distributed Energy Resources (DERs) turns the consumer into an active participant, **fostering demand-side management.**

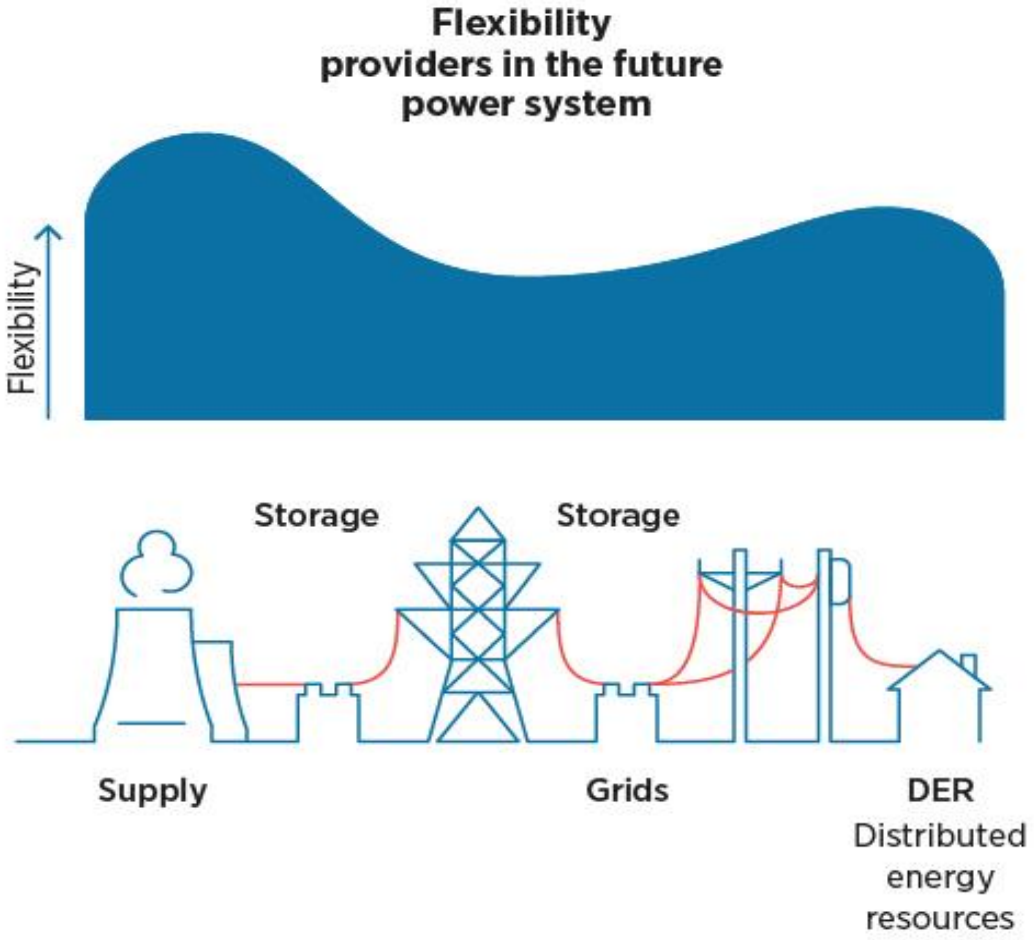
- Digital technologies enable **faster response, better management of assets, connecting devices, collecting data, monitor and control**

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

Innovation unlocks flexibility across the power system



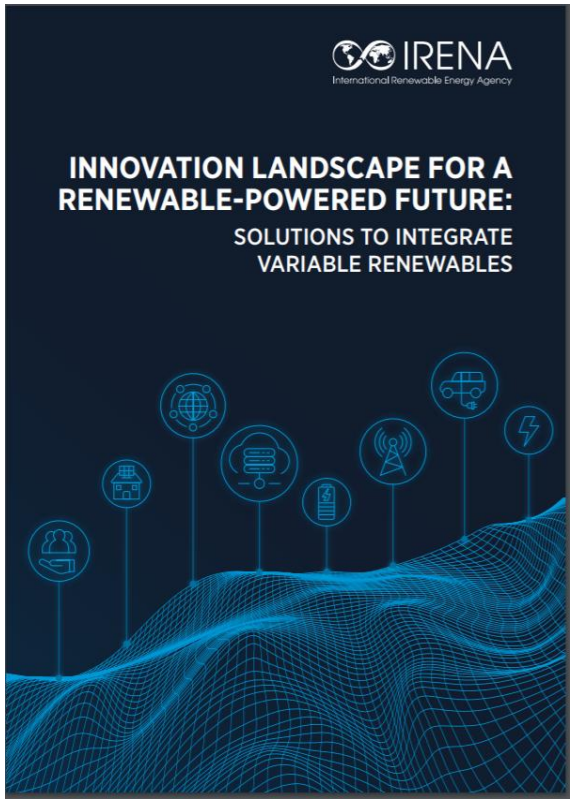
Flexibility sources: Flexible generation



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



Innovation Landscape Report

ENABLING TECHNOLOGIES	BUSINESS MODELS	MARKET DESIGN	SYSTEM OPERATION
1 Utility-scale batteries 2 Behind-the-meter batteries	12 Aggregators 13 Peer-to-peer electricity trading 14 Energy-as-a-service	17 Increasing time granularity in electricity markets 18 Increasing space granularity in electricity markets 19 Innovative ancillary services 20 Re-designing capacity markets 21 Regional markets	25 Future role of distribution system operators 26 Co-operation between transmission and distribution system operators
3 Electric-vehicle smart charging 4 Renewable power-to-heat 5 Renewable power-to-hydrogen	15 Community-ownership models 16 Pay-as-you-go models	22 Time-of-use tariffs 23 Market integration of distributed energy resources 24 Net billing schemes	27 Advanced forecasting of variable renewable power generation 28 Innovative operation of pumped hydropower storage
6 Internet of things 7 Artificial intelligence and big data 8 Blockchain			29 Virtual power lines 30 Dynamic line rating
9 Renewable mini-grids 10 Supergrids			
11 Flexibility in conventional power plants			

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

30 Innovation Briefs

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https://www.irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future

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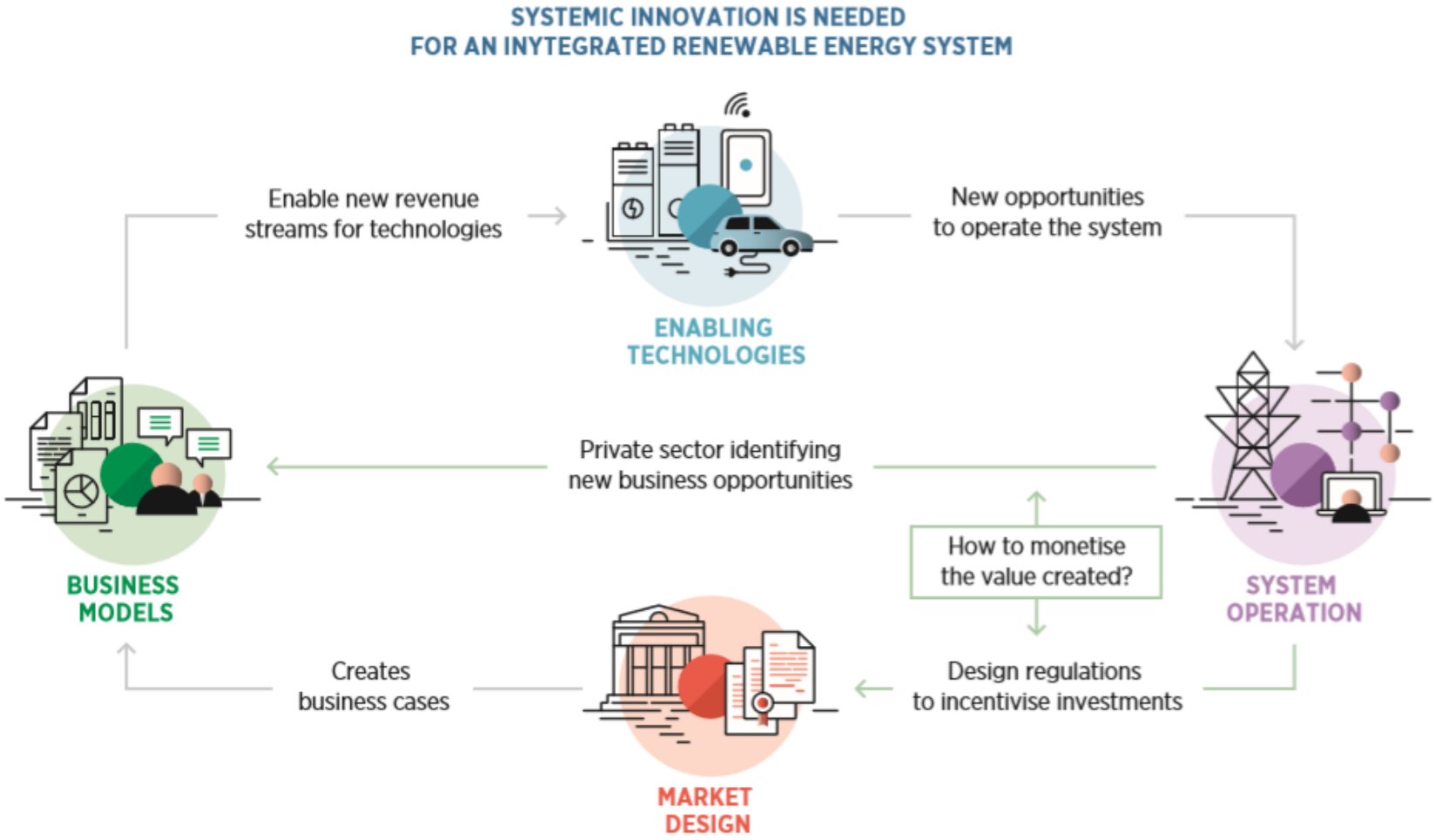
Systemic innovation for wind and solar PV integration



Innovations do not emerge in isolation.
Synergies between innovations are needed

Flexibility solutions for a wind and solar PV integration

SUPPLY-SIDE FLEXIBILITY SOLUTIONS	
I	Decreasing VRE generation uncertainty with advanced generation forecasting
II	Flexible generation to accommodate variability

GRID FLEXIBILITY SOLUTIONS	
III	Interconnections and regional markets as flexibility providers
IV	Matching RE generation and demand over large distances with Supergrids
V	Large-scale storage and new grid operation to defer grid reinforcements investments

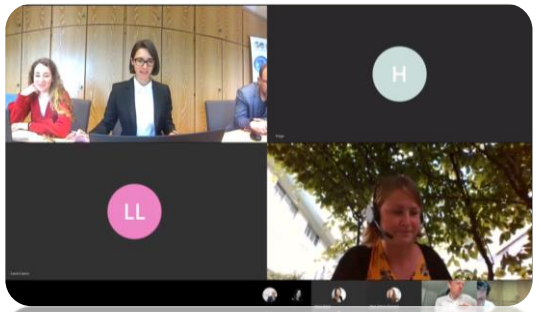
DEMAND-SIDE FLEXIBILITY SOLUTIONS	
VI	Aggregating distributed energy resources for grid services
VII	Demand-side management
VIII	RE mini-grids providing services to the main grid
IX	Optimising distribution system operation with with distributed energy resources

SYSTEM-WIDE STORAGE FLEXIBILITY SOLUTIONS	
X	Utility-scale battery solutions
XI	Power-to-X solutions

Systemic innovation in the international context

100% renewable power

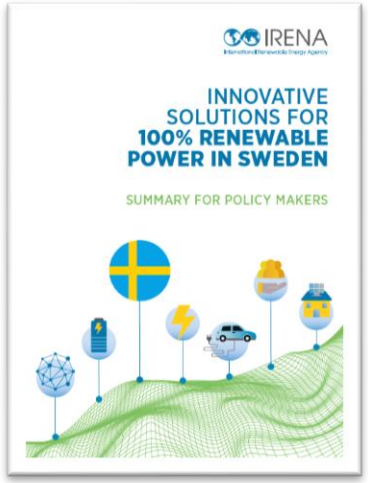
Online workshops



Workshop in Uruguay

Costa Rica	Denmark	Germany	Norway	Spain	Sweden	Uruguay	Paraguay
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 2050	100% renewable power by 2040	98% renewable power generated in 2017	100% renewable power generated in 2017

January 2019 ⟷ *January 2020*



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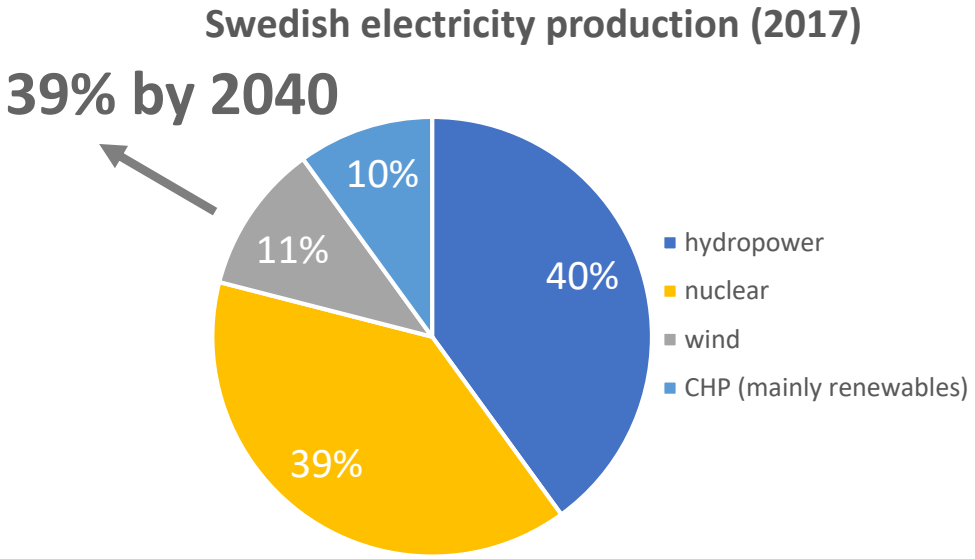
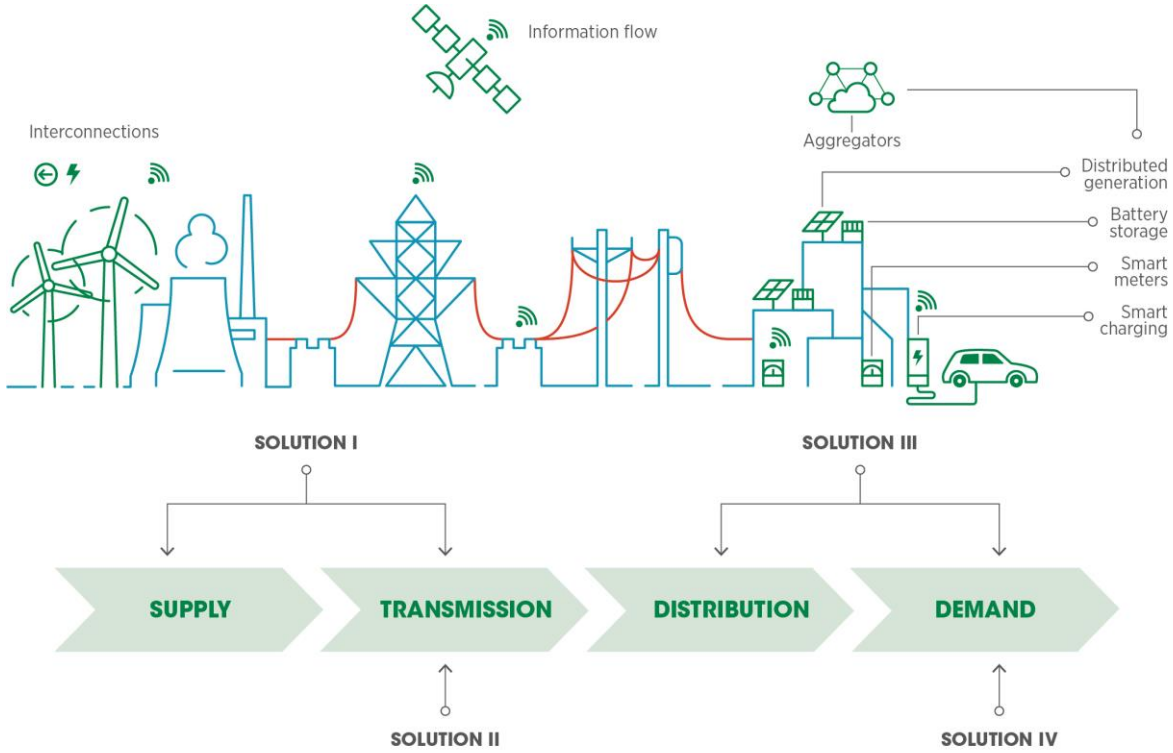
Each solution tackles a different segment of the power sector value chain





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

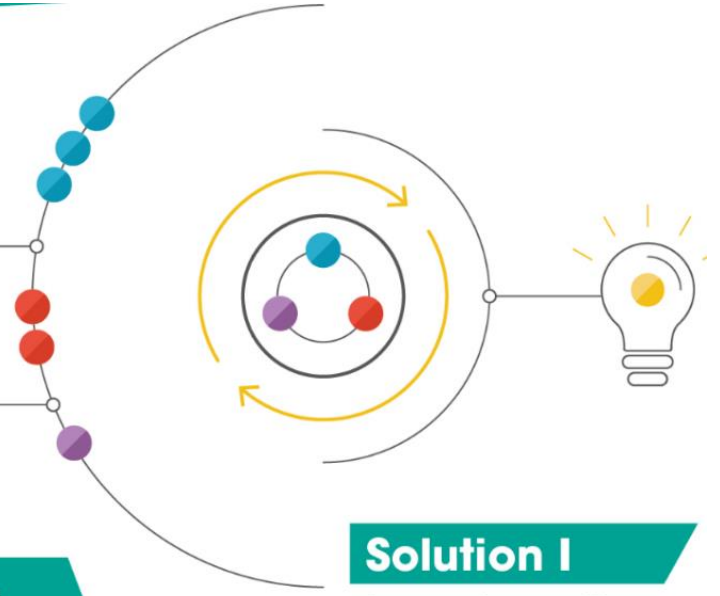
- Utility-scale batteries
- Internet of Things
- Artificial intelligence and big data

Market design

- Increasing time granularity in electricity markets
- Innovative ancillary services

System operation

- Advanced weather forecasting of variable renewable power generation



Solution I

Innovative ancillary services from both conventional and variable renewable energy sources

- 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

IRENA (2020), Innovative solutions for 100% renewable power in Sweden

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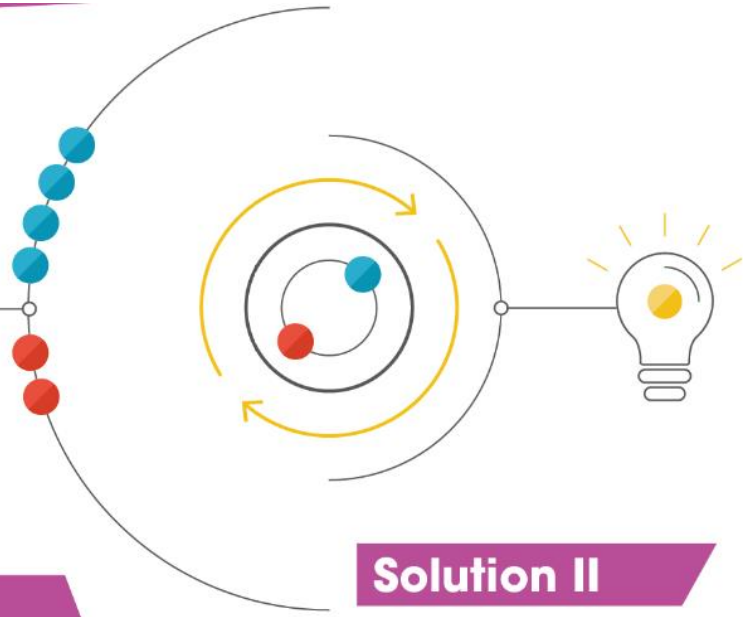
Solution II – Pan-European market as flexibility provider

Enabling technologies

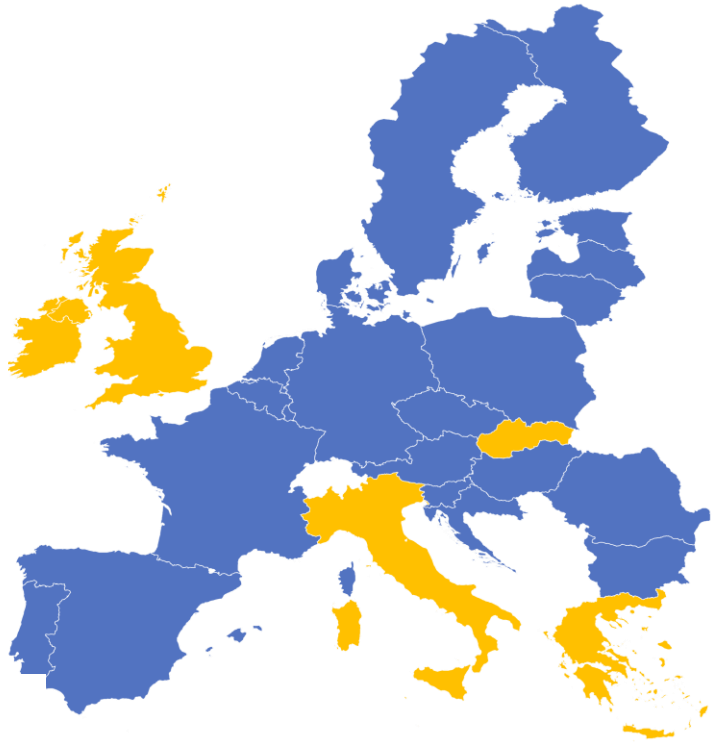
- Internet of Things
- Artificial intelligence and big data
- Blockchain
- Supergrids

Market design

- Increasing time granularity in electricity markets
- Regional markets



Intraday market coupling
21 countries



- ▹ 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

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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

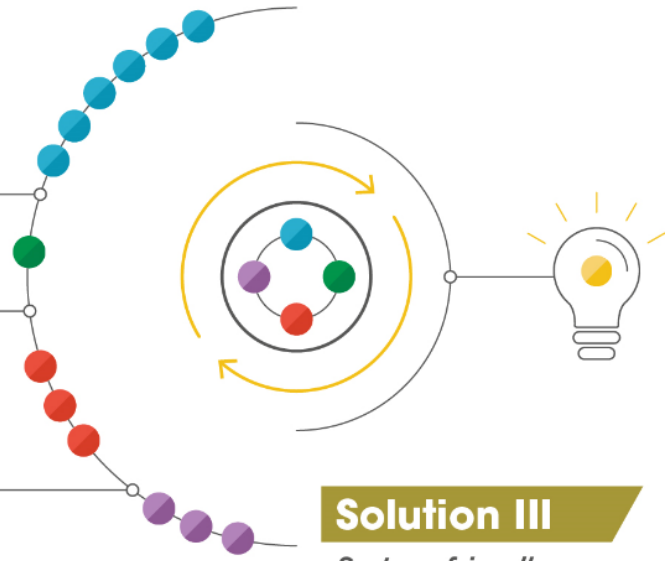
- Aggregators

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

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Solution IV – Decarbonization of end-use sector via electrification with VRE

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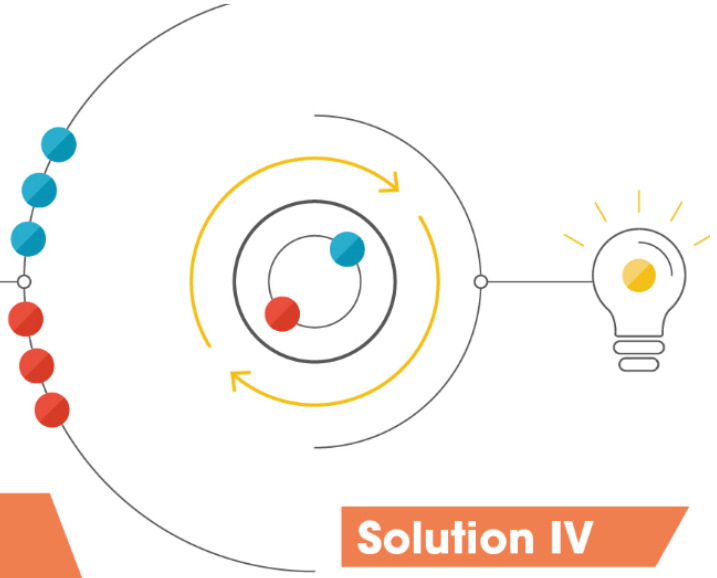
Enabling technologies

- 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.

Solution IV

Decarbonisation of end-use sectors via electrification with renewable energy sources

Sweden – Decarbonising the building sector (blocks and houses)

Sweden – Decarbonising the iron and steel industry – HYBRIT project

Sweden – Decarbonising the heating and cooling sector – Ectogrid 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

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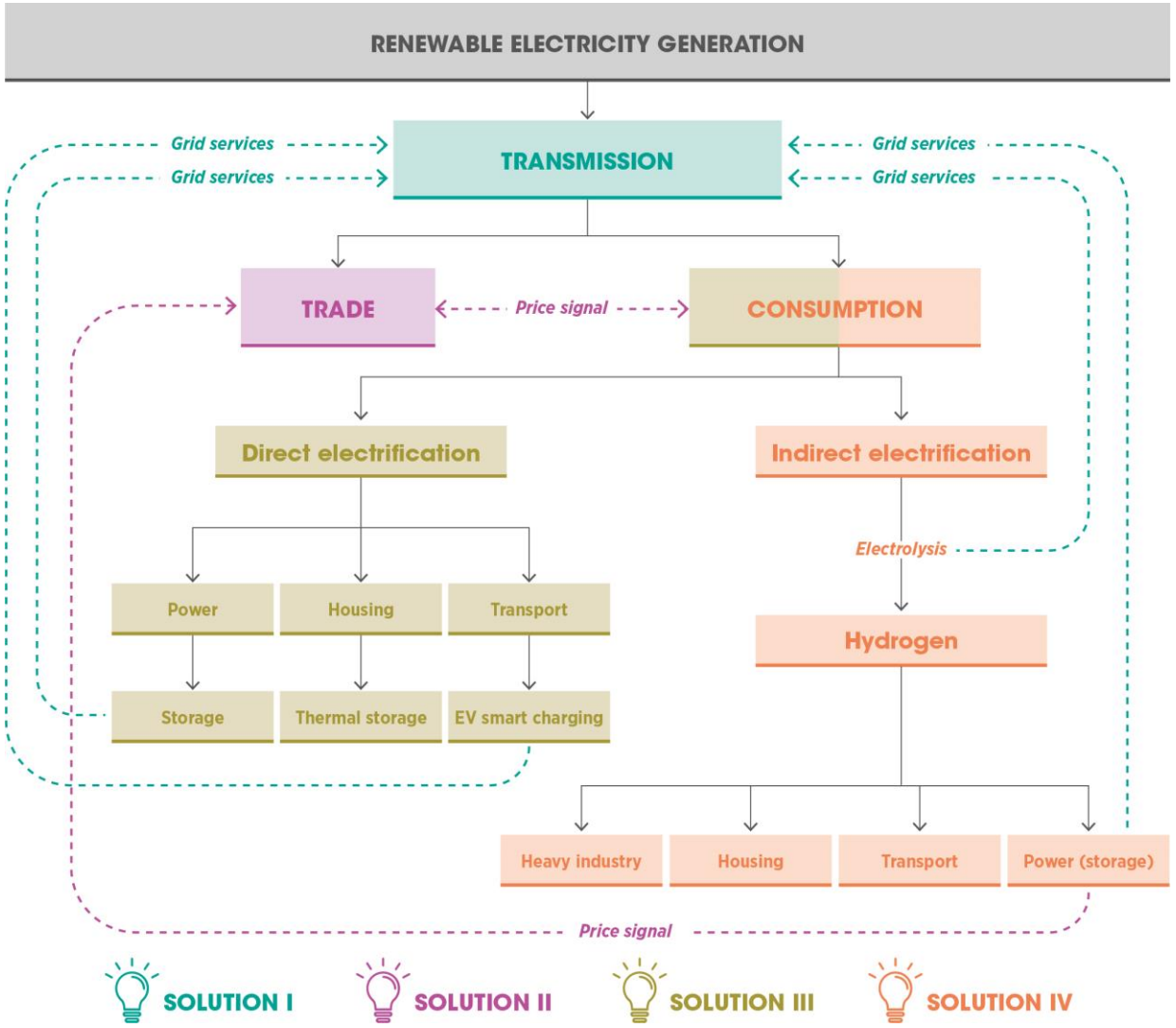
Innovative options for renewable power in Sweden



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**

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Questions & Answers

Please use the 'Questions' feature on the webinar panel

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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"

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Thank you!

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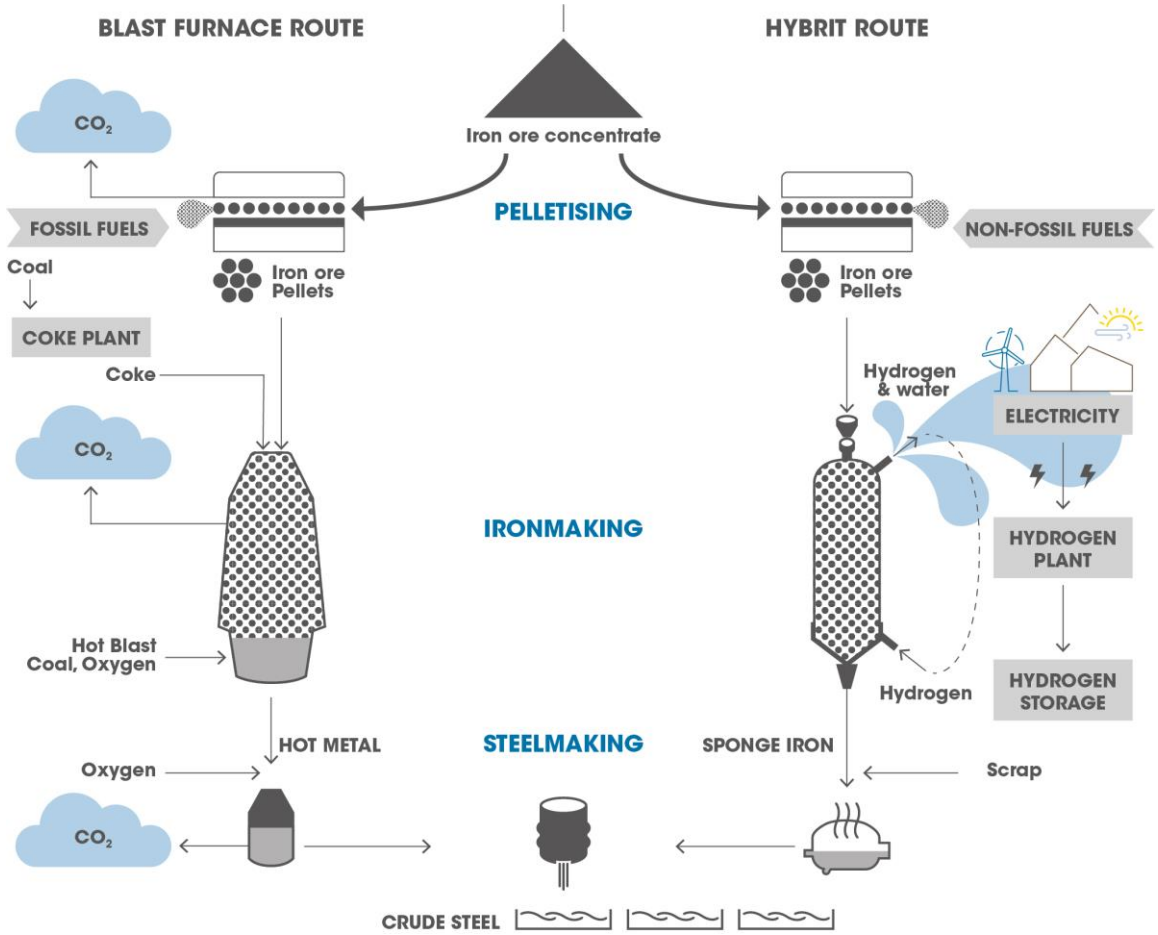
Implementation example - Sweden (Solution IV)

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 steelmaker **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**

Sweden – Decarbonising the iron and steel industry – HYBRIT project

	Renewable power-to-heat
✔	Renewable power-to-hydrogen
✔	Artificial intelligence and big data
	Increasing time granularity in electricity markets
✔	Innovative ancillary services
	Regional markets



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

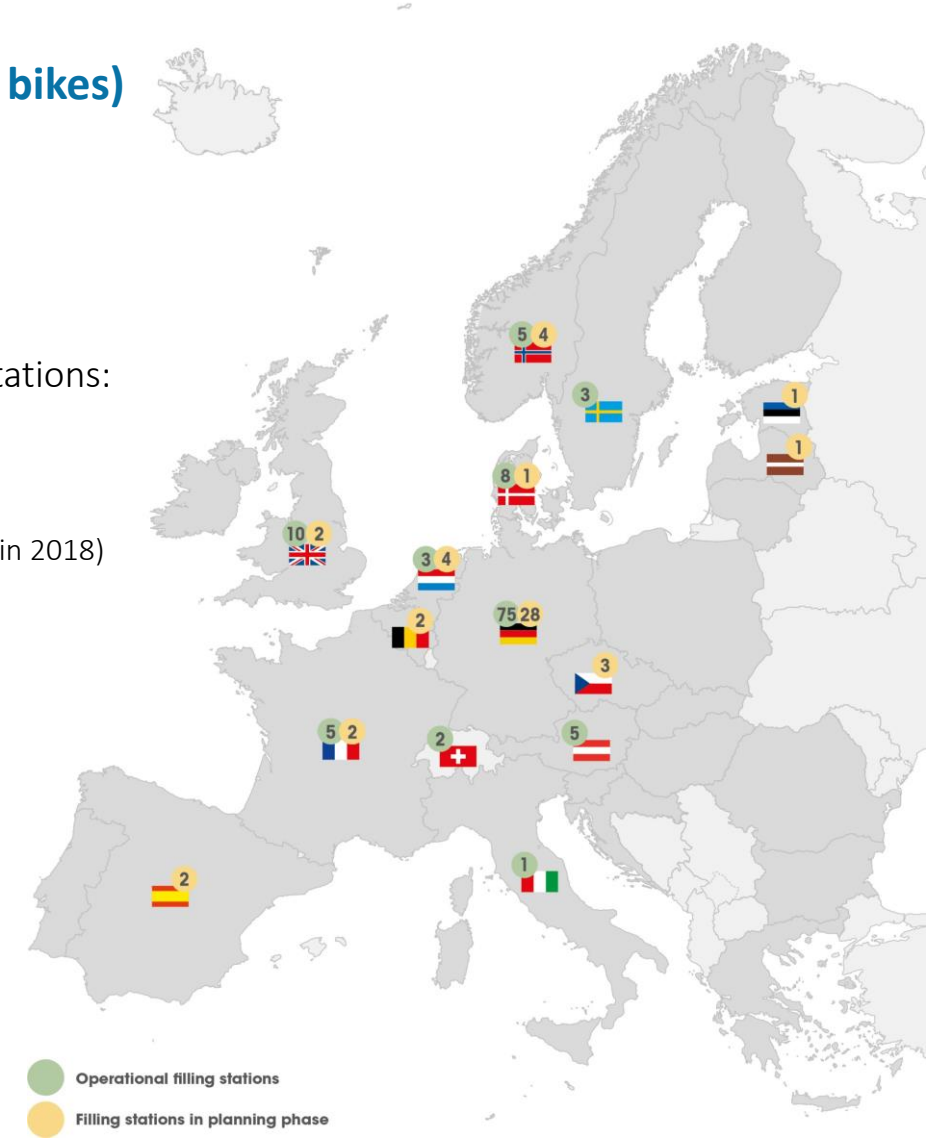
Implementation example - international (Solution IV)

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)

Europe, Asia – Decarbonising the transport sector (ships, trains, cars and bikes)

	Renewable power-to-heat
✔	Renewable power-to-hydrogen
	Artificial intelligence and big data
	Increasing time granularity in electricity markets
✔	Innovative ancillary services
	Regional markets



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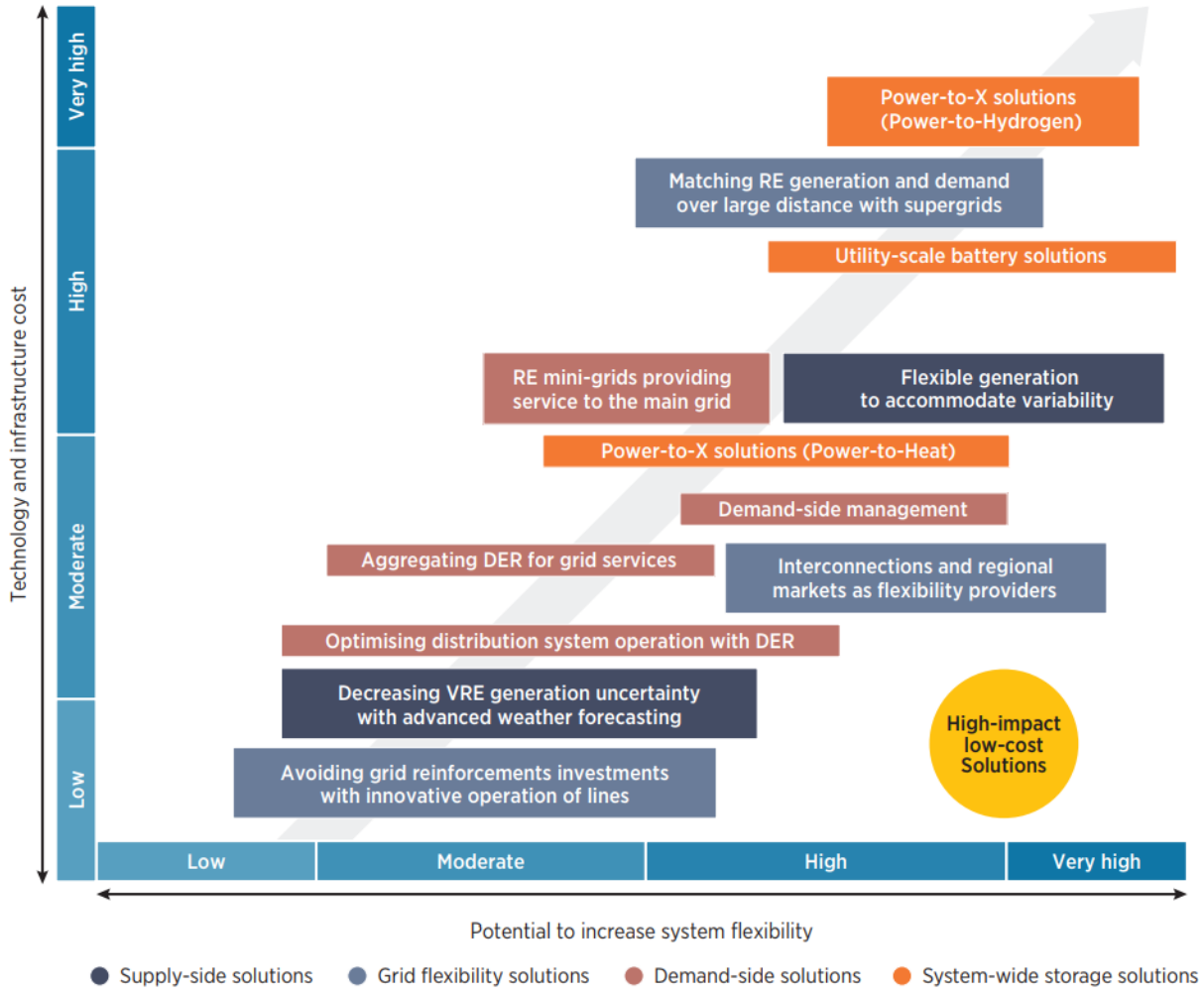
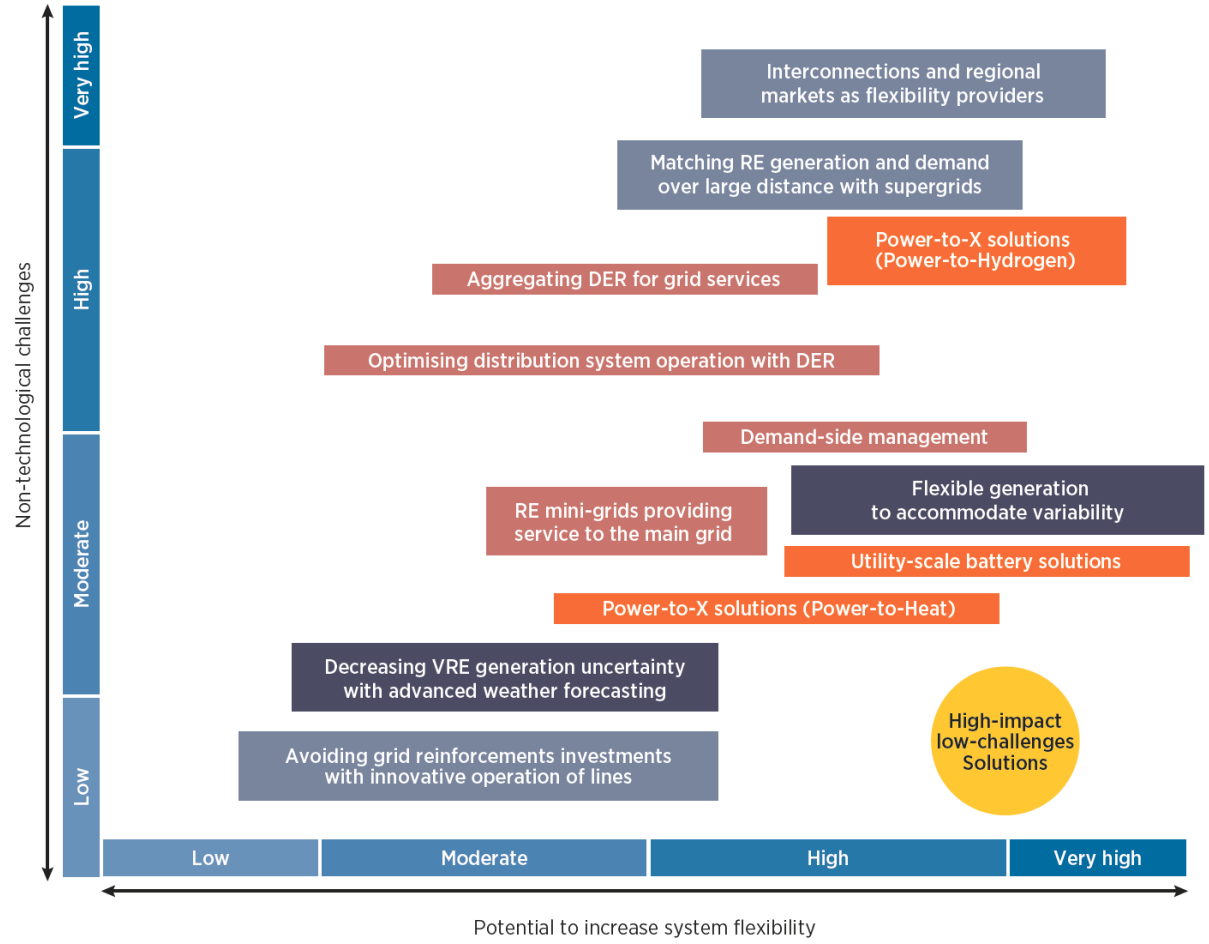
IRENA (2020), Innovative solutions for 100% renewable power - Swedish case study, H2 2019

Priority solutions based on country/system context

Flexibility vs Cost



Flexibility vs Implementation Complexity



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

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