System Integration of renewables

Focus on electrification

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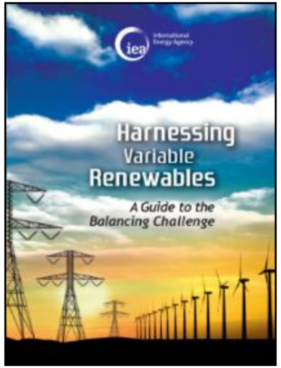
Wind Europe, Brussels, 21 March 2018

IEA System Integration of Renewables analysis at a glance

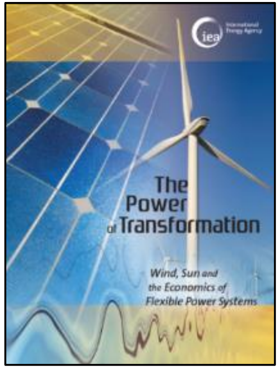
- Over 10 years of system integration work at the IEA
  - Grid Integration of Variable Renewables (GIVAR) Programme
  - Dedicated Unit on System Integration since June 2016
    - Part of delivering the IEA modernisation strategy

2011



Technical

2014

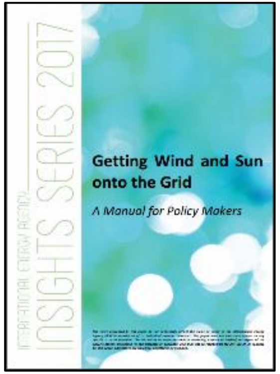


Framework, Technology, Economics

2016

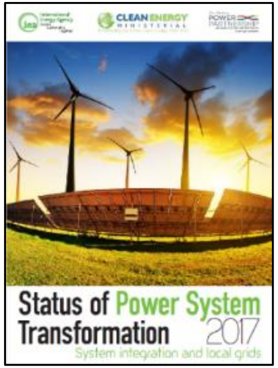
Policy

2017



Implementation

2017



Progress & Tracking

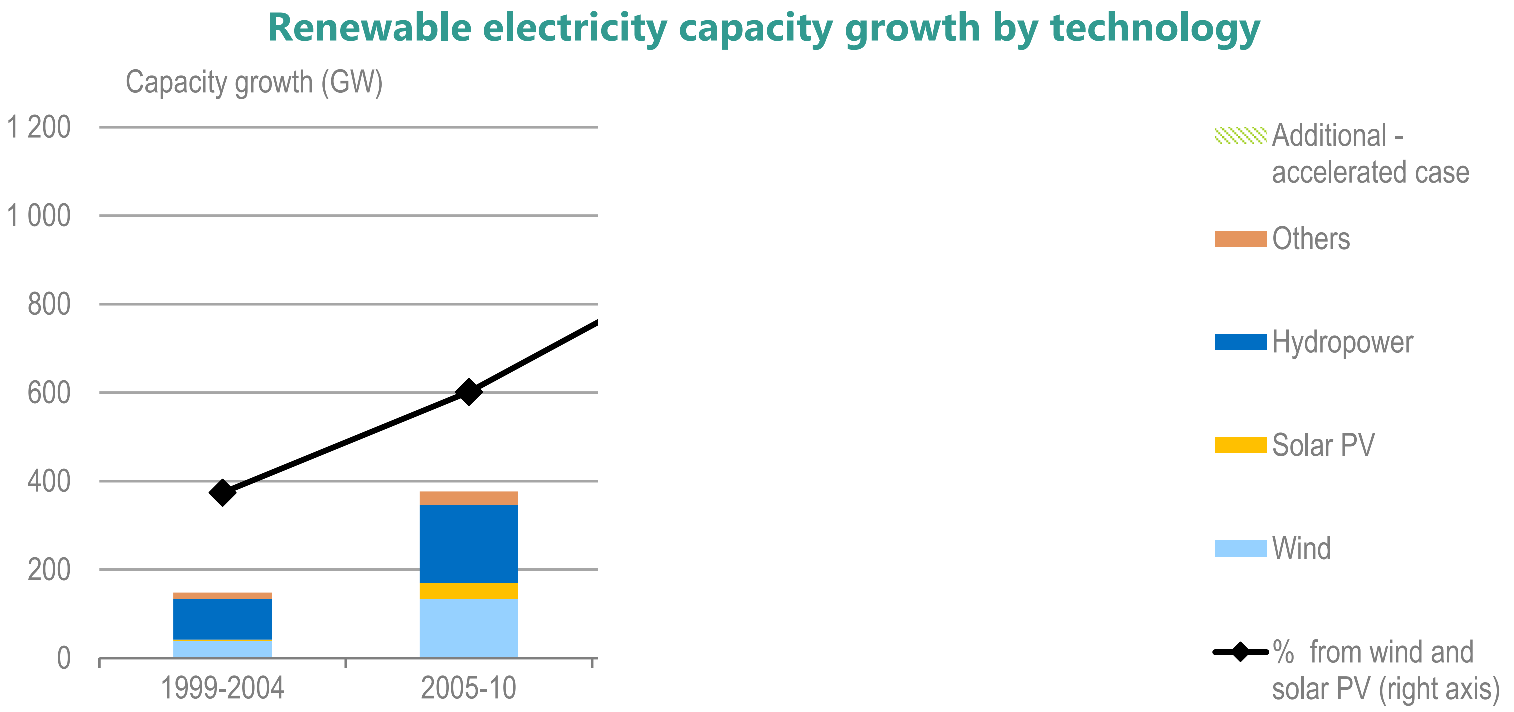
3 Questions

- What is the energy system of the future and is wind suited to it?

- Which sectors will electrify first and how will this impact load management on local, country and regional level?

- What will other sectors expect form variable renewable energy in order to use it as a source for their electrification?

Renewables growth more and more dependent on wind and solar

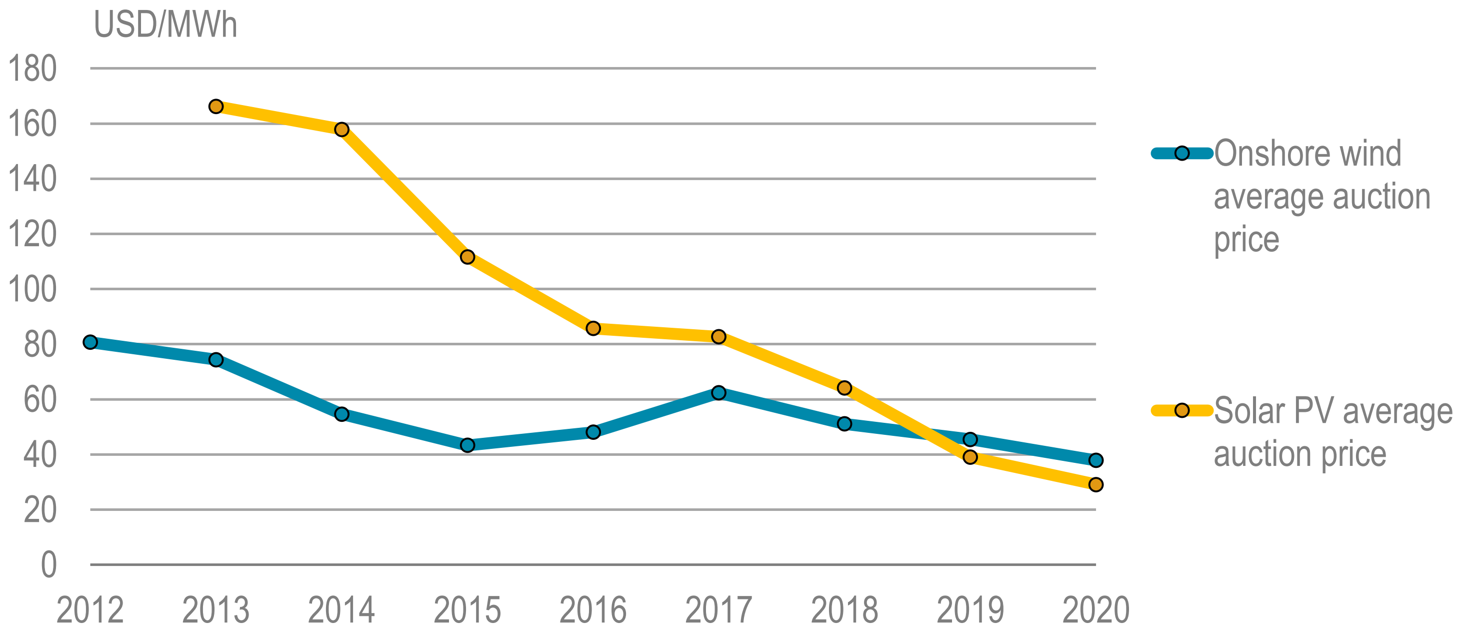


Solar PV enters a new era, becoming the undisputed leader in renewable power capacity growth; PV also accounts for 60% of the upside potential in the accelerated case

Source: Renewables 2017

Competition driving costs down

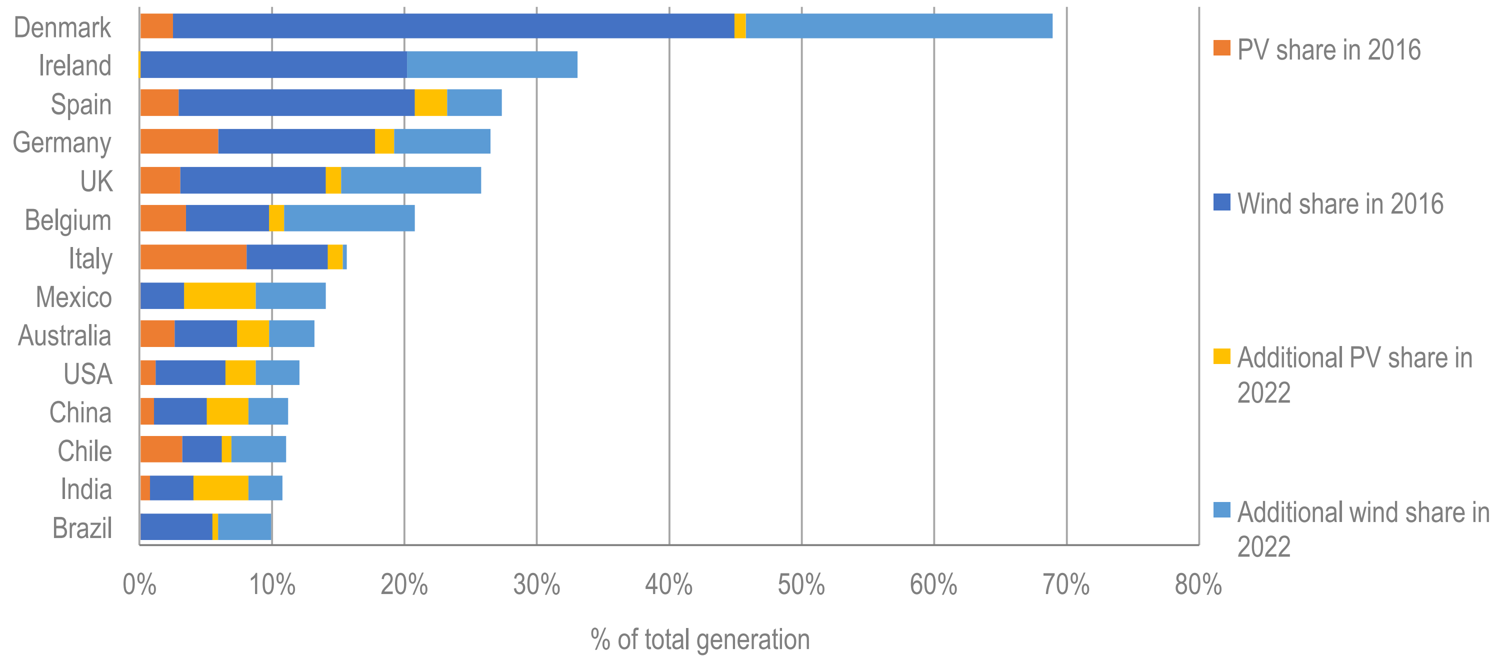
Announced wind and solar PV average auction prices by commissioning date



Price discovery through competitive auctions effectively reduces costs along the entire value chain; Auctions with long-term contracts will drive almost half of new capacity growth over 2017-22

Variable Renewable Energy (VRE) on the rise

VRE share in annual electricity generation, 2016-22

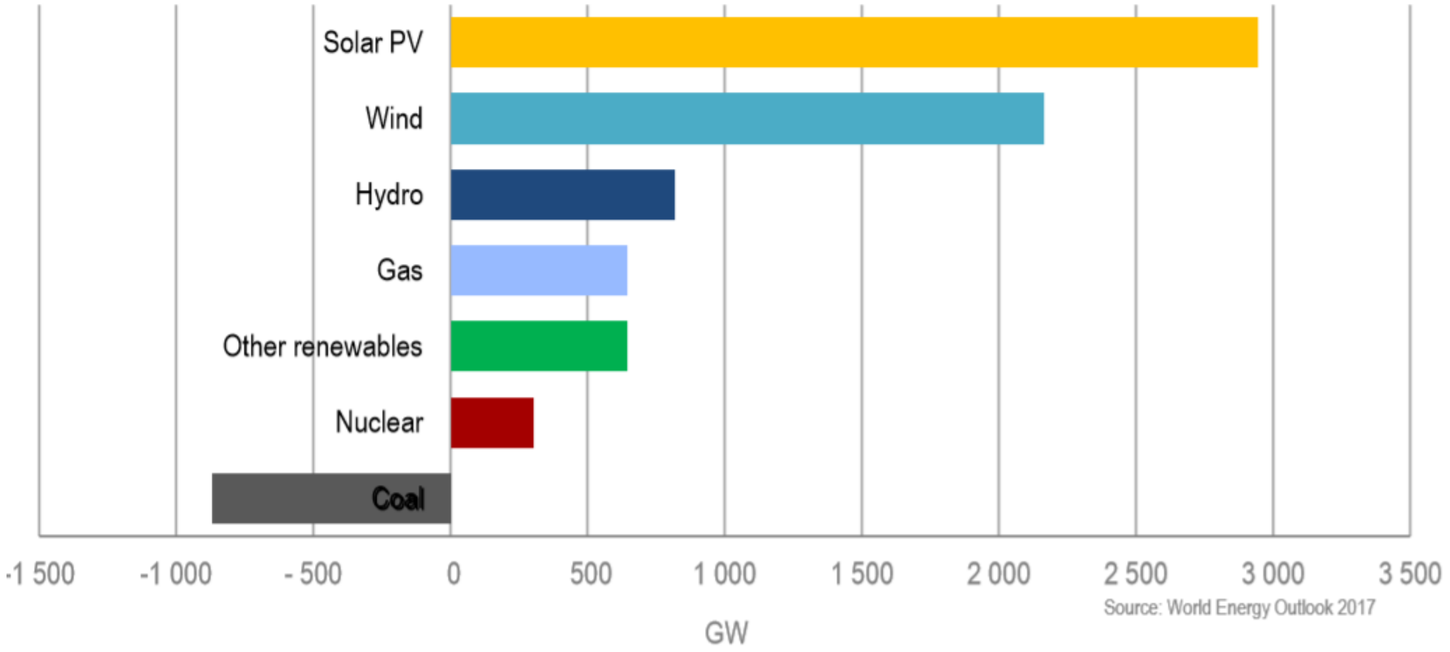


Also in emerging economies and in large power systems the share of VRE is expected to double to over 10% in just five years.

Source: Renewables 2017

Renewables dominate capacity additions to meet sustainability goals

Global net capacity additions 2016 – 2040 in the WEO Sustainable Development Scenario



Renewables account for 63% of total world electricity generation by 2040 in the SDS, with wind and hydro becoming the largest sources of generation. China and India account for over 40% of net renewable additions.

Different Phases of VRE Integration

Phase	Description
1	VRE capacity is not relevant at the all-system level
2	VRE capacity becomes noticeable to the system operator
3	Flexibility becomes relevant with greater swings in the supply/demand balance
4	Stability becomes relevant. VRE capacity covers nearly 100% of demand at certain times
5	Structural surpluses emerge; electrification of other sectors becomes relevant
6	Bridging seasonal deficit periods and supplying non-electricity applications; seasonal storage and synthetic fuels

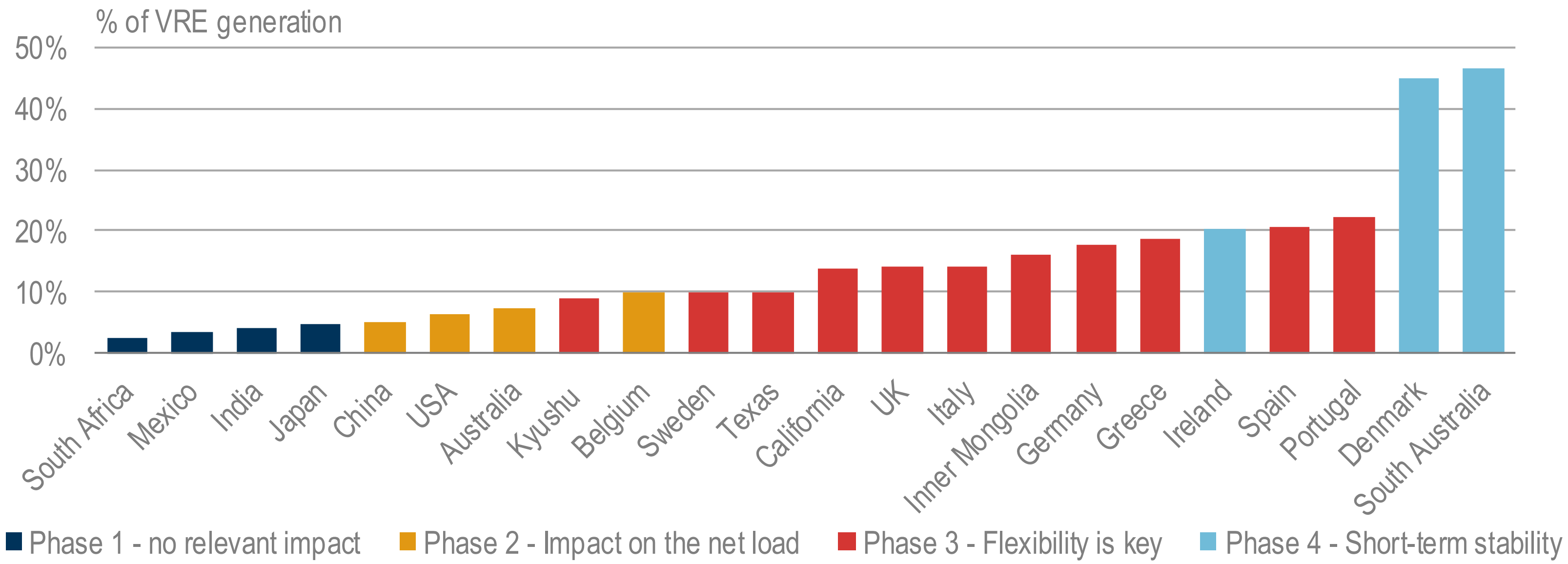
Differentiating flexibility needs

Flexibility type	Ultra-short term flexibility	Very short-term flexibility	Short term flexibility	Medium term flexibility	Long term flexibility
Time-scale	Sub-seconds to seconds	Seconds to minutes	Minutes to days	Days to weeks	Months to years
Issue	Ensure system stability (voltage, transient and frequency stability) at high shares of non-synchronous generation	Short term frequency control at high shares of variable generation	Meeting more frequent, rapid and less predictable changes in the supply / demand balance	Addressing longer periods of surplus or deficit of variable generation, mainly driven by presence of a specific weather system	Balancing seasonal and inter-annual availability of variable generation with power demand
Priority from	Phase IV	Phase III	Phase II	Phase IV	Phase V

Flexibility is needed across different time scales.

VRE deployment phase in selected countries

VRE share in annual electricity generation and system integration phase, 2016



Each VRE deployment phase can span a wide range of VRE share of generation; there is no single point at which a new phase is entered

AU: Australia; CN: China; DE: Germany; DK: Denmark; ES: Spain; GR: Greece; ID: Indonesia; IE: Ireland; IN: India; IT: Italy; PT: Portugal; SE: Sweden; US: United States; UK: the United Kingdom; ZA: South Africa.

A system-wide approach for system flexibility (Phases 3 and 4)

Roles and responsibilities / Planning — Architecture

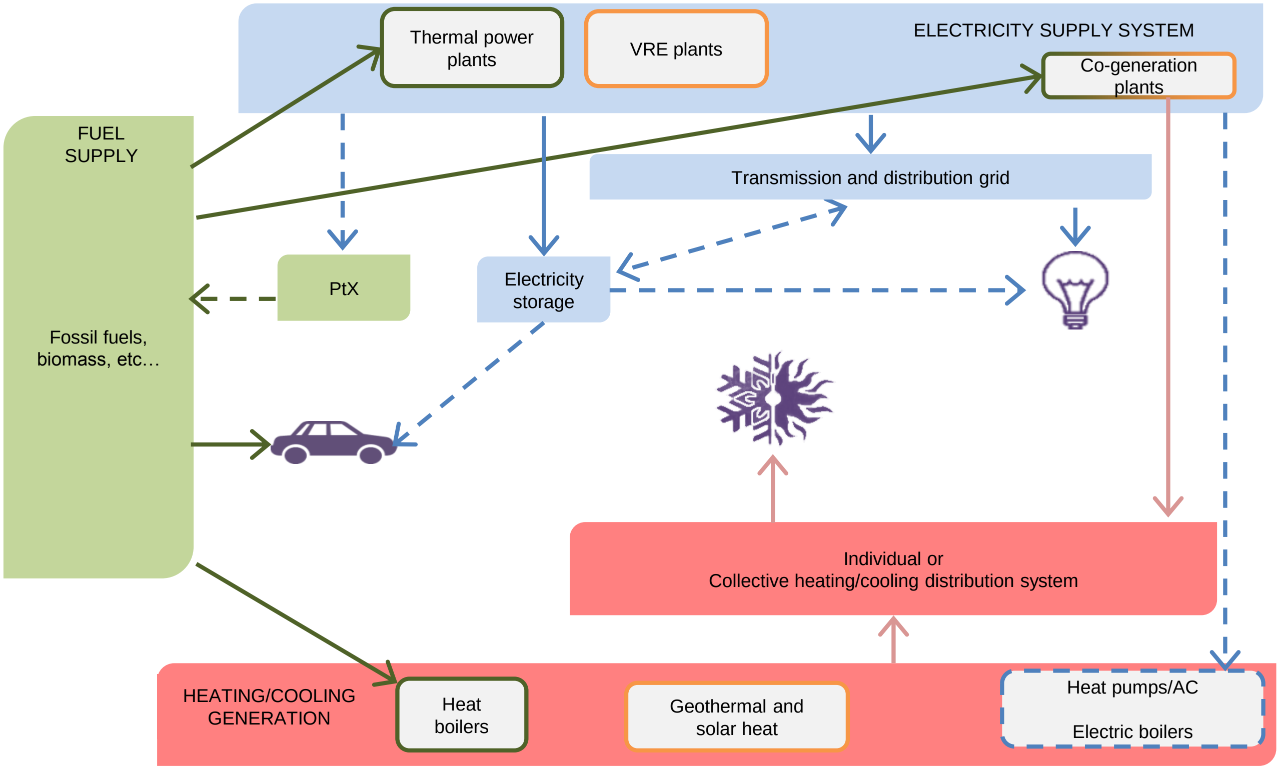
System operation and market rules
System services, spot markets, resource adequacy — Software

System-friendly VRE | **Dispatchable generation** | **Demand shaping** | **Storage**

Grid and connectivity — Hardware

Technical, economic and institutional policy layers mutually influence each other and have to be addressed in consistent way

Sector coupling – conceptual map (Phases 5&6)



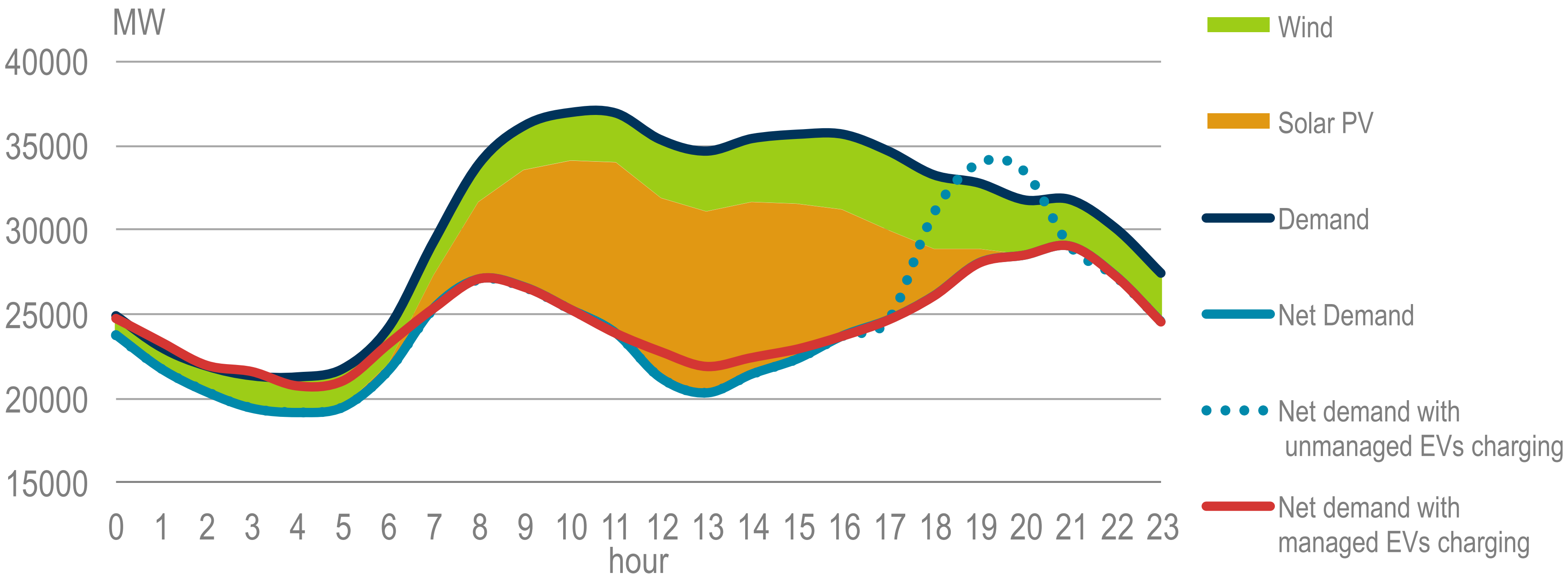
Electrification: what sectors will go first and what will be impact?

- Political / societal pressure to electrify
  - E.g. passenger cars / short-haul trucks
  - Impact: depends on how it is used (next slide)

- Options to make use of abundant VRE / provide flexibility
  - First: use of existing assets with low CAPEX retrofit possibility
  - Prime example: electricity boilers in CHP plants / district heating networks

- More cost-effective than current fossil options
  - Substitution of fossil fuels thanks to cheap electricity
  - Impact: could create a rather inflexible load, depends on capital costs

Potential impact of electrification on electricity demand

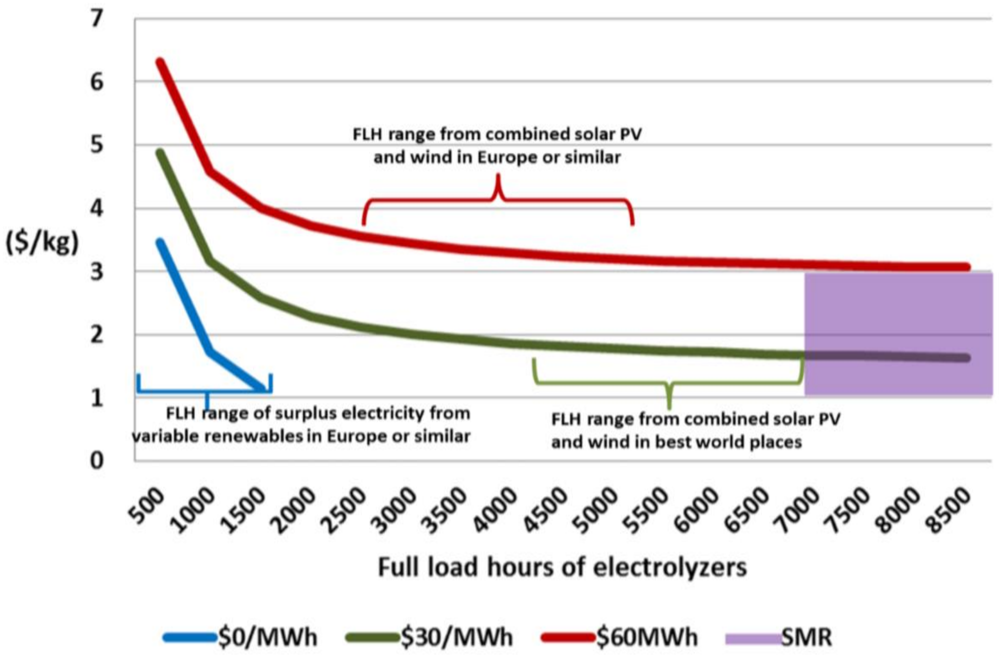


Smart sector coupling will need to take VRE deployment into account to avoid exacerbating net demand load changes

Expectations from the electricity source: sufficient utilisation

- Capital costs put pressure on per unit costs proportionate to
$$\frac{1}{Utilization}$$
- Possible to have 'layered' approaches to electrification
  - Options that run only a few 100 hours will need to be *very* cheap, but can be inefficient
  - Longer utilization range with higher capital cost
- Don't assume that electrification serves to deal just with surplus from variable electricity supply

Cost of Hydrogen from alkaline water electrolysis



Capital efficiency" as a paradigm to guide electrification

- Old efficiency paradigm driven by: effect of capital utilization buffered by fossil fuel flexibility
  - Value of energy savings dominated by offset fuel type, best time and location follow simple patterns
    - Flexibility of fossil fuels (storability and transportability) -> capital savings (upstream oil + gas)
  - Peak demand defines moment of most expensive supply
    - This reflects possible inefficient use of power plants and grids in electricity system

- New efficiency paradigm: capital utilization directly coupled across energy system
  - Value of energy savings depends on offsetting cost of match making, best time and location have a complex pattern and optimum changes with innovation
  - Most costly match making defines moment of most expensive supply
    - This reflects possible inefficient use of flexibility assets in electricity system

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