The roadmap to 2050 and the energy security concerns

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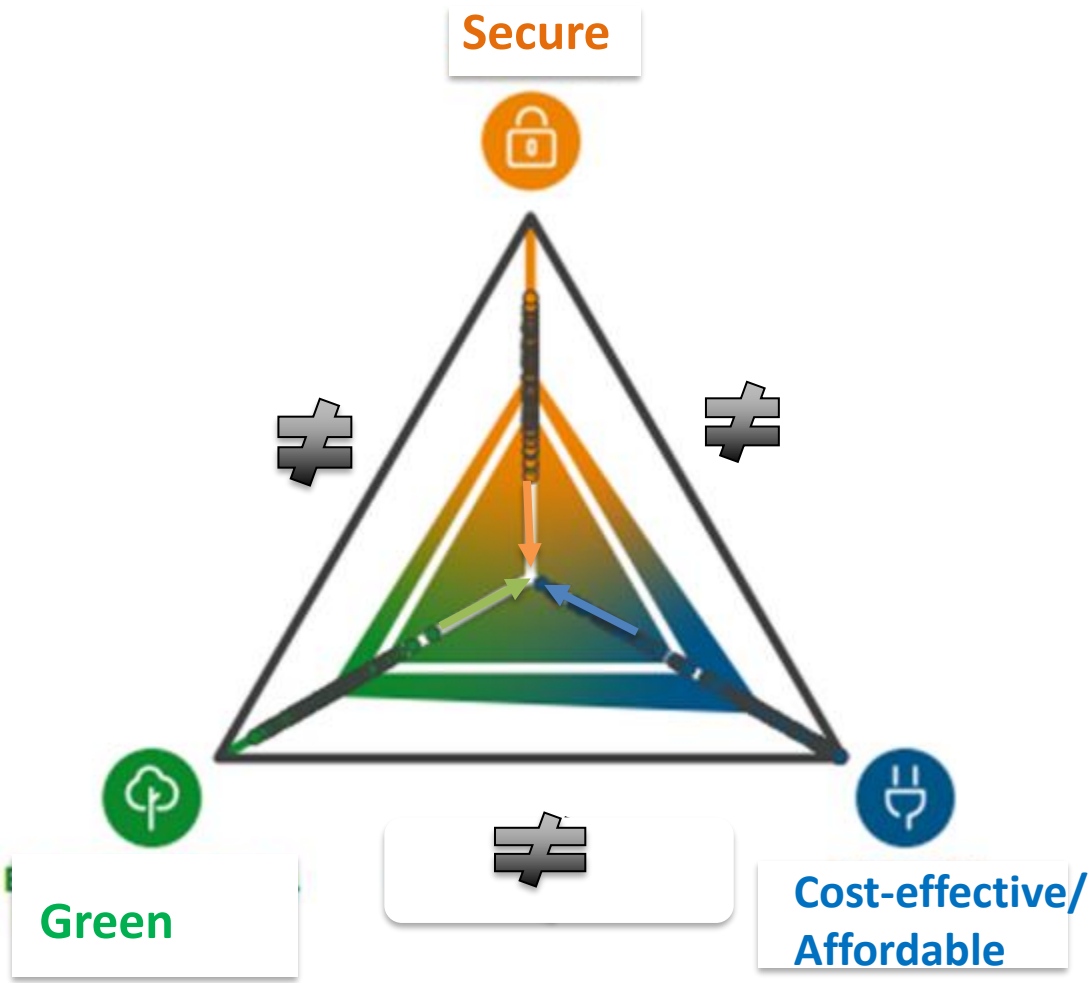
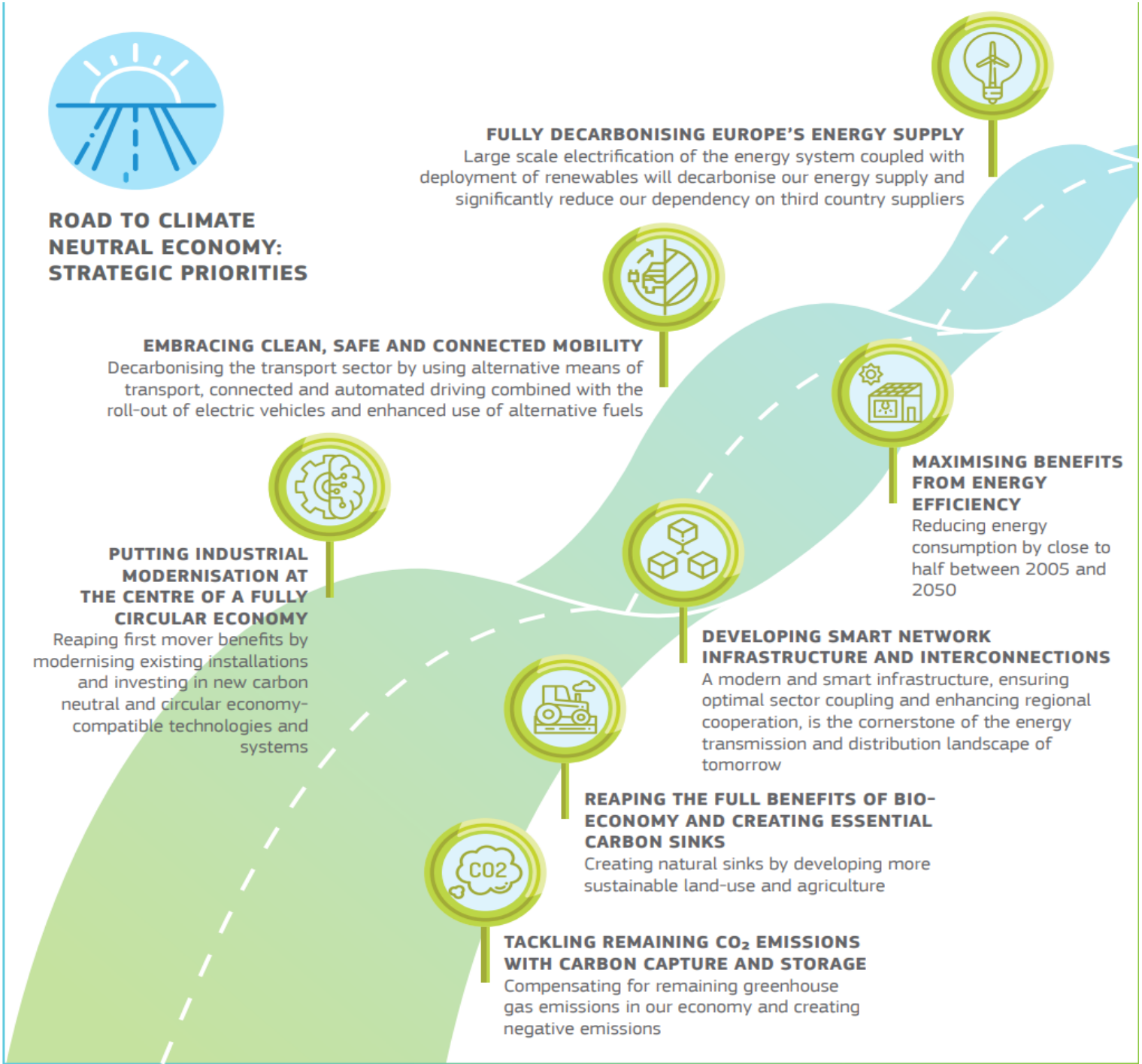
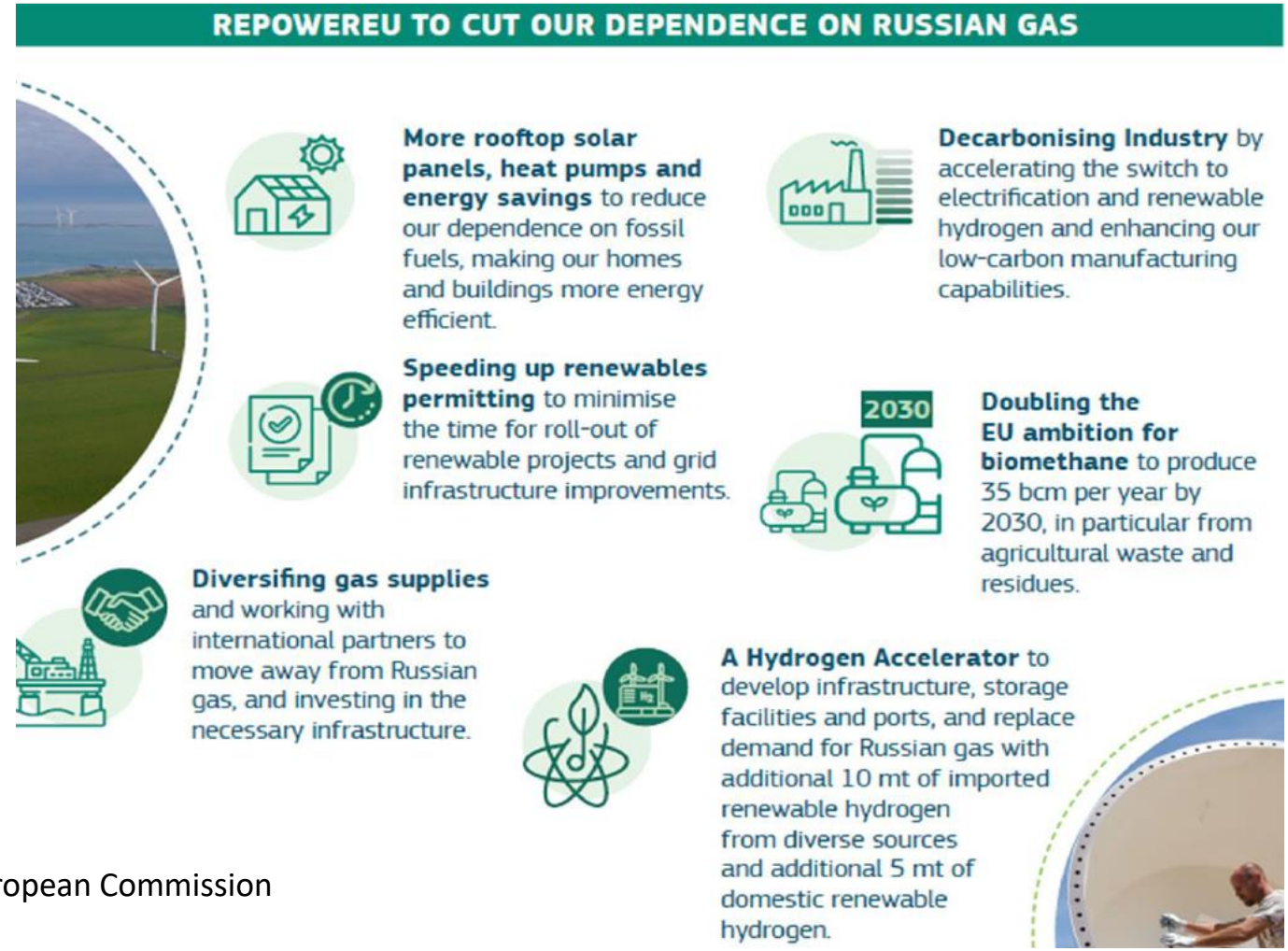
ENERGY CRISES:
EXACERBATING OR SOLVING THE ENERGY TRILEMMA?



EU VISION FOR A CLEAN PLANET FOR ALL



REPOWEREU:
COMPLEMENTS GREEN DEAL/FIT FOR 55 IN QUEST CARBON NEUTRALITY, WHILE REDUCING DEPENDENCY ON RUSSIA



Source: European Commission

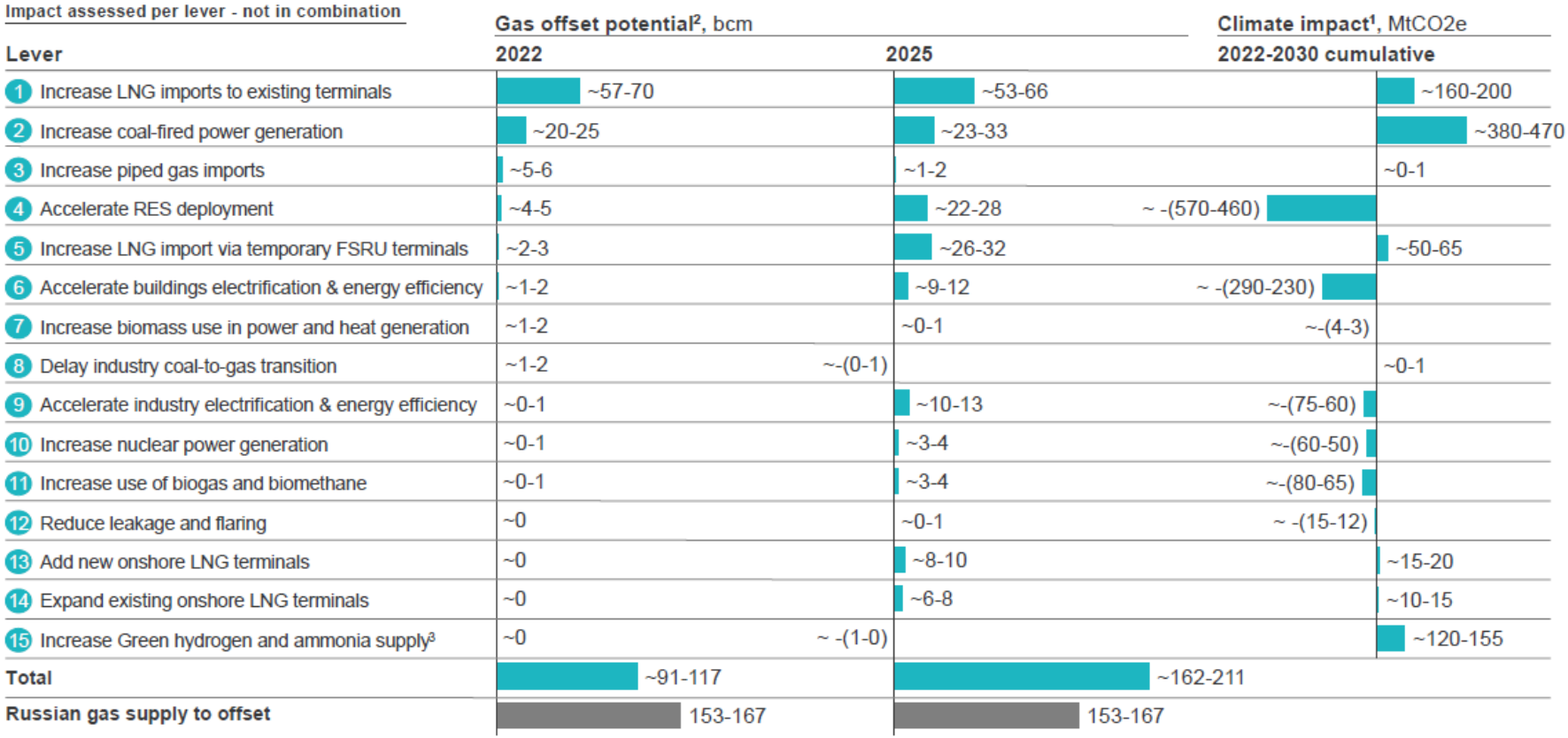
REPowerEU: affordable, secure and sustainable energy for Europe

Short-term measures

- Common purchases of gas, LNG and hydrogen via the EU Energy Platform for all Member States who want to participate as well as Ukraine, Moldova, Georgia and the Western Balkans
- New energy partnerships with reliable suppliers, including future cooperation on renewables and low carbon gases
- Rapid roll out of solar and wind energy projects combined with renewable hydrogen deployment to save around 50 bcm of gas imports
- Increase the production of biomethane to save 17 bcm of gas imports
- Approval of first EU-wide hydrogen projects by the summer
- An EU Save Energy Communication with recommendations for how citizens and businesses can save around 13 bcm of gas imports
- Fill gas storage to 80% of capacity by 1 November 2022
- EU-coordination demand reduction plans in case of gas supply disruption

ANALYSES BY THE EUROPEAN CLIMATE FOUNDATION INDICATES THAT SECURING EUROPE'S ENERGY SUPPLY AND MEETING ITS CLIMATE COMMITMENTS ARE NOT INCOMPATIBLE

There are 15 structural levers across supply and demand available for the EU to reduce gas demand or shift to alternative suppliers

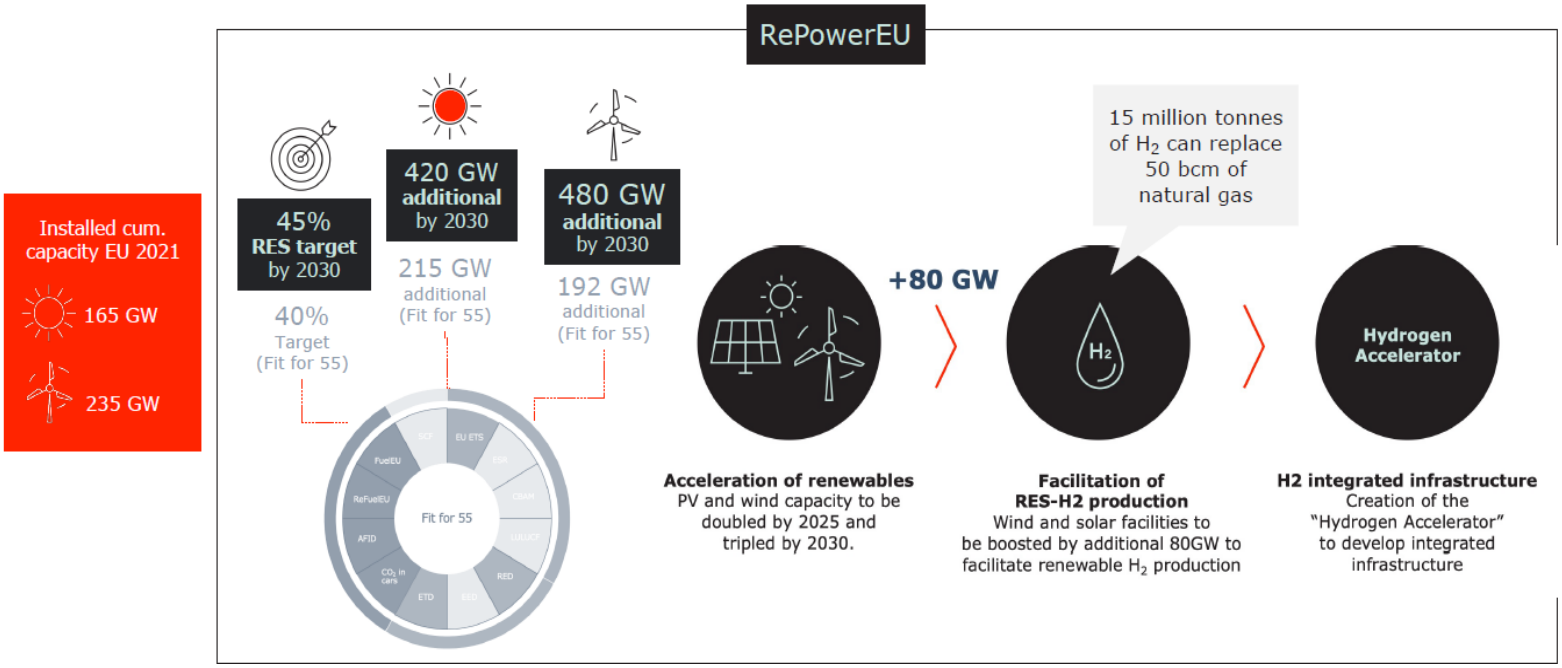


1. Net change in cumulative emissions 2022-2030 from maximum lever potential vs. baseline scenario, which includes successful implementation of Fit for 55 measures
2. Theoretical potential to offset Russian gas supply (as compared to 2021 levels for levers 1,3,5,7,8,10,11,12) or reduce gas demand (as compared to 2022/25 projections for levers 2,6,9,10,13,14,15 or compared to Fit For 55 target for lever 4 (RES)); low values indicative of +/-10% uncertainty in analysis of maximum theoretical potential; actual gas offset potential realized will depend on commitment to levers as well as external factors such as global LNG price dynamics, raw material or labor availability, and more
3. REPowerEU target includes import of 10MT of green H2 by 2030, which would reduce dependence on imported gas as well as unlock further emissions; impact here reflects production which can be ramped up by 2025; because green hydrogen relies on renewables that would otherwise be used to displace gas in the power sector, the impact on gas demand is negative until ~2030, at which point the power mix is sufficiently renewable for green hydrogen to effectively displace gas

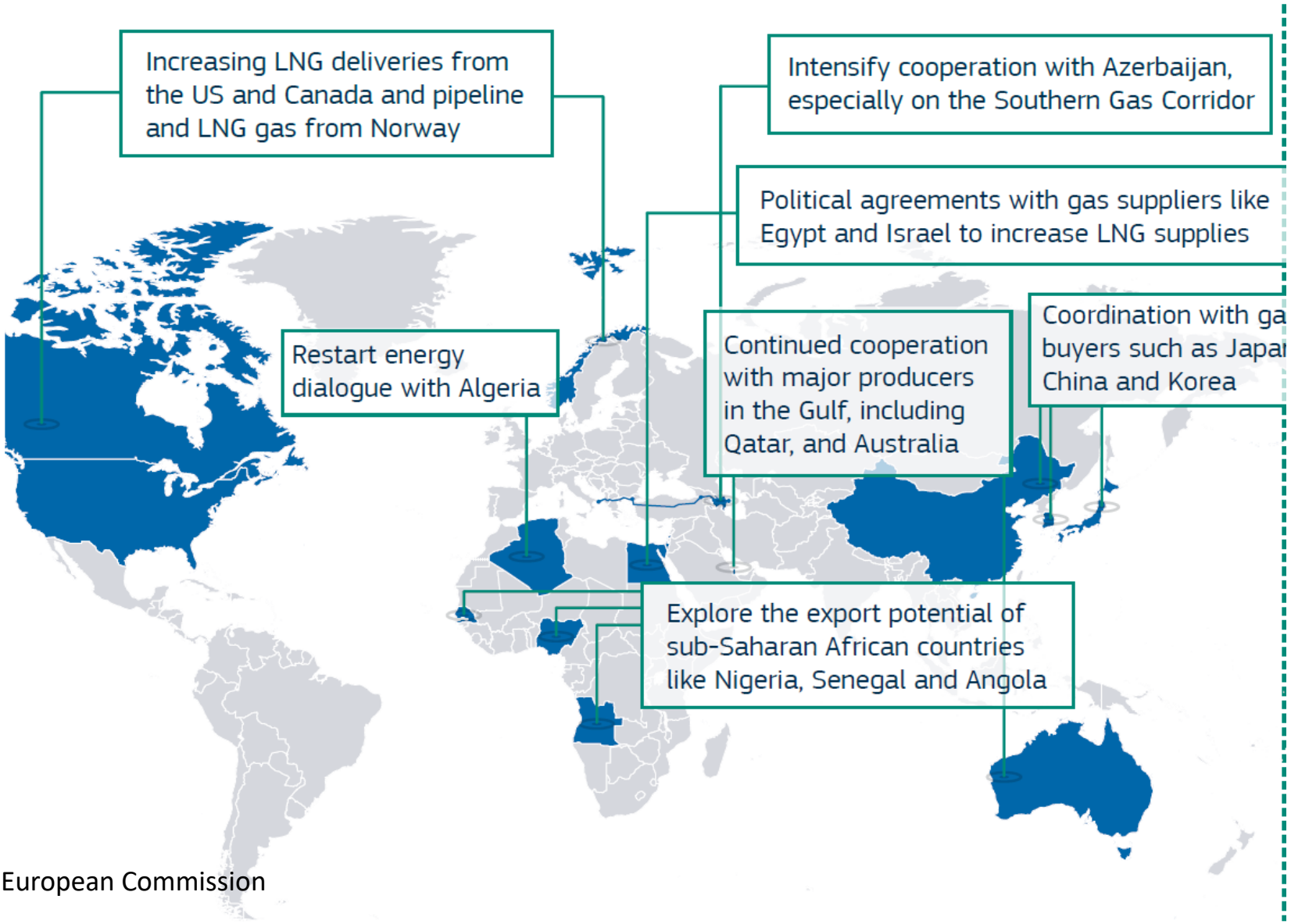
Source: Spire, European Commission, Cambridge Architectural Research, BPIE, RePowerEU, European Commission, EIA, Bloomberg, CEDIGAZ, GIIGNL, ENTSOG, Artelys, SolarPowerEurope, WindEurope, Fit for 55 package, FA Windenergie an Land, European Wind Association, IRENA, BCC Research, EurObserver 2020, EHPA, CEMAC analysis, OEC, Clepa, Reuters, World Steel Association, BDH, IEA, BP Statistical Review, Rystad, North Sea Transition Authority, Oxford Institute for Energy Studies, McKinsey Energy Insights' EUPipeFlow and LNGFlow

RES and H2 targets dramatically increased with RePowerEU

The EU Strategy will diversify supply and replace natural gas with renewable gases reducing EU dependency on fossil fuels



EU EXTERNAL STRATEGY TO ENCOURAGE PARTNERSHIPS FOR BETTER SUPPLY NEGOTIATING POWER AND SUPPORTING ENERGY TRANSITION IN NEIGHBOURHOOD



Source: European Commission

A NEW PARADIGM FOR ENERGY SECURITY:

FROM SELF SUFFICIENCY TO COOPERATION AND MARKET INTEGRATION

ENERGY SECURITY AND DECARBONIZATION

CONVERGENCE OR DIVERGENCE?

- Paris Agreement and other climate commitments require massive RE scale-up and increased electrification
- RE are usually national energy sources, so increasing the RE penetration results in a higher level of self-sufficiency. But is autarchy synonymous to energy security?
- Moreover, production of Variable Renewable Energy (VRE) is difficult to control, more decentralized and not always available when and where needed=> threat to power system reliability and to energy security
- To cope with a high RE penetration, power systems need flexibility, and regional electricity market integration is a good way to deliver that flexibility without hurting the other objectives of security and affordability

REGIONAL ENERGY MARKET INTEGRATION BENEFITS

INCLUDE ENHANCED ENERGY SECURITY AND RES SCALE-UP SUPPORT

- Enhanced energy security???? (depends on definition)
- Increased power system flexibility and reliability
- Smoothing of load duration curve
- Optimized use of infrastructure and more efficient dispatch of power plants=> lower cost of supply
- Economies-of-scale on generating plants serving multiple markets
- Reduced CO2 emissions

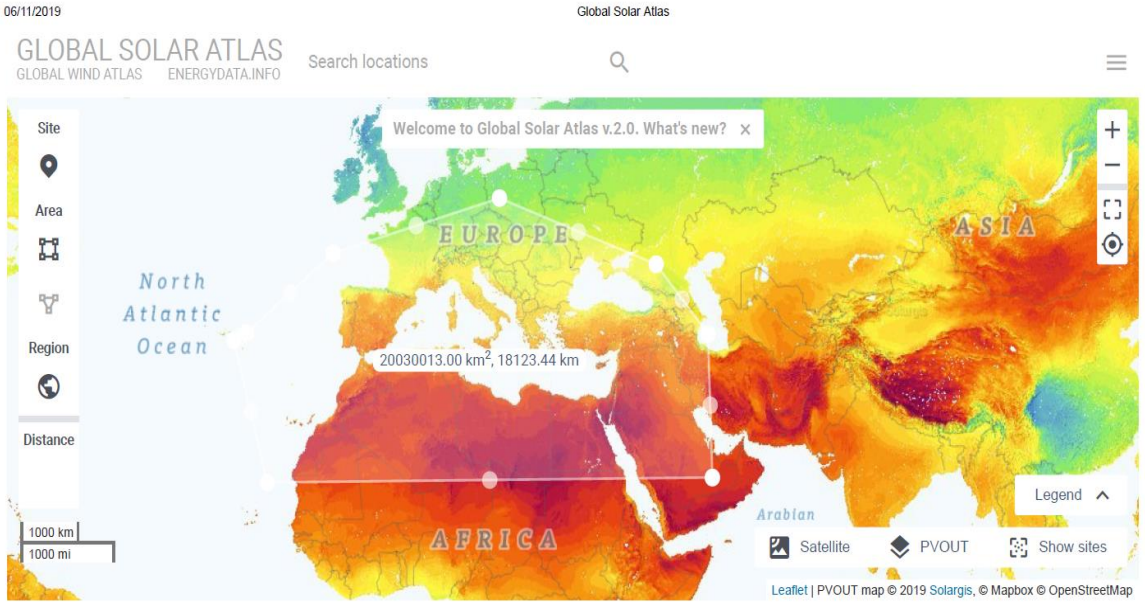
=> Increased exchanges across borders

Might be the best solution to reconcile different objectives– for a secure low-carbon energy supply at least cost. Possible threat to energy security?

EURO-MEDITERRANEAN ENERGY MARKET INTEGRATION FACILITATES DECARBONIZATION…

Countries of the southern and eastern Mediterranean shores are rich in carbon-free energy resources and creating an integrated Euro-Mediterranean market would increase power system flexibility, thus supporting renewable energy scale-up

Key highlights of EU Green Deal are the need to increase cross-border trade and regional cooperation, to better share clean energy sources and to interconnect energy systems.



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…. AND INCREASES ENERGY SECURITY BOTH FOR EUROPE AND SOUTHERN/EASTERN MED SHORE

MEDITERRANEAN INTEGRATION REQUIRES INFRA (HARDWARE)… … AND MORE (SOFTWARE)

- Hardware: interconnectors (CEF)
  - Morocco-Spain already connected
  - Turkey connected to Greece and Bulgaria
  - Several projects, but slow moving:
    - Tunisia-Italy (ELMED PCI, TuNur)
    - Algeria-Spain and Algeria-Italy
    - Israel-Cyprus-Crete (PCI)
    - Egypt-Cyprus-Crete (PCI)

- Gas transport infrastructure underutilised, could be used for hydrogen (or blend)
  - MEG no longer used to export Algerian gas (can be used for green hydrogen?)
  - Medgaz ????
  - Trans-Med declining use trend to persist
  - Average utilisation of LNG terminals growing but not at full capacity yet

- More
  - Sector Coupling, optimize across energy forms
  - Some harmonization of market design and convergence in market operations
  - Cooperation between national TSOs (and between gas and electricity SO) and National Regulatory Authorities … and political will to work together

… in summary, think whole energy system and regionally/globally

Thank you

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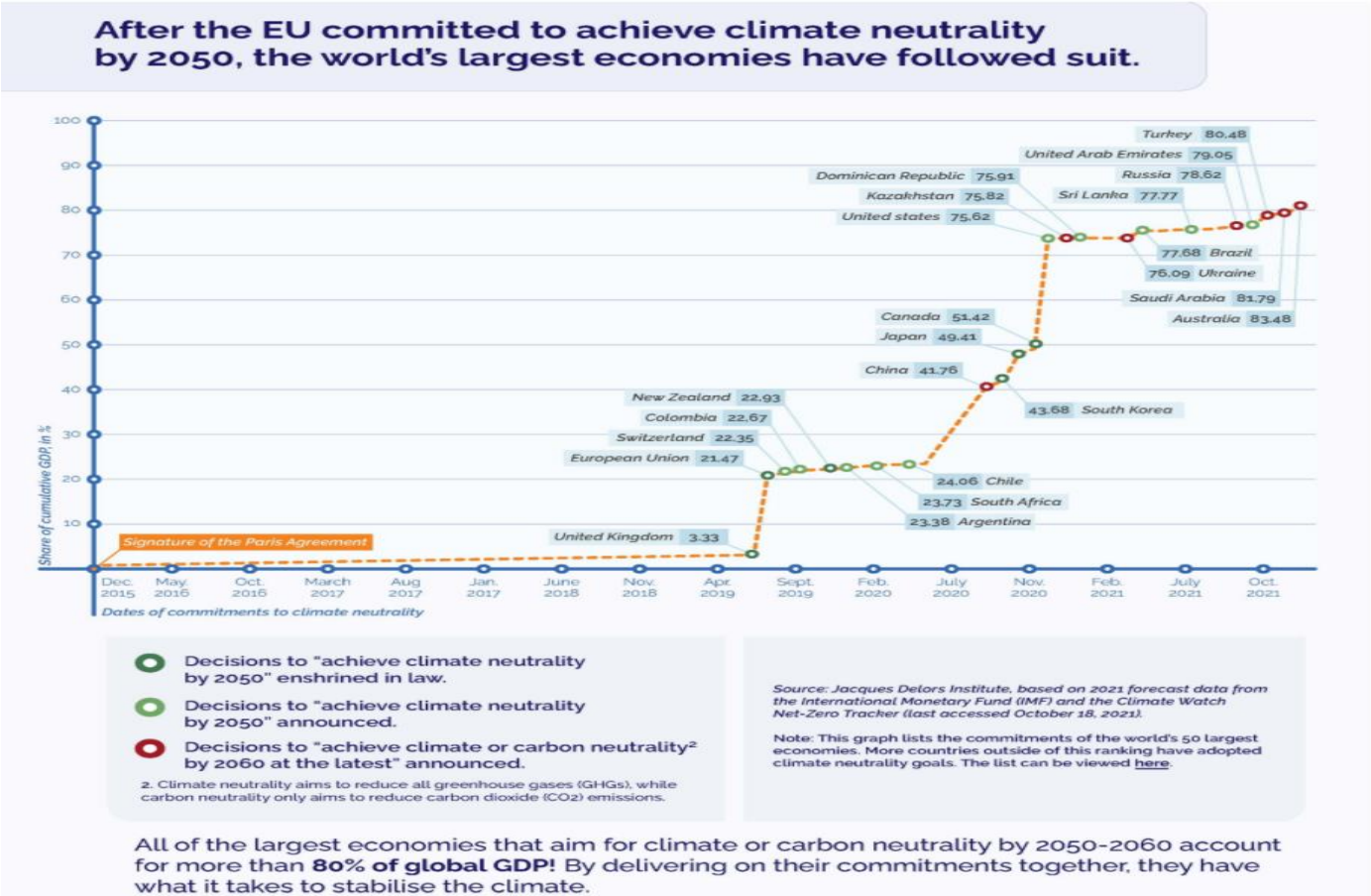
Back-up Slides

CARBON NEUTRALITY SPREADING THROUGHOUT THE WORLD



EU GREEN DEAL DRIVES CARBON NEUTRALITY
FIT FOR 55 PACKAGE IS THE IMPLEMENTATION INSTRUMENT

Interim target for 2030: -55%
In Climate Law to reach carbon neutrality in 2050

The most important endeavor since the creation of the Single Market: articulating **climate, innovation and social justice**

Beyond energy:

An industrial strategy to innovate and to develop new technologies while creating new markets.

Making Europe a leader in low carbon technologies. Hydrogen Alliance

CBAM to prevent carbon leakages

Beyond Europe:

Green Agenda for Western Balkans

New Agenda for Mediterranean

New strategy on international energy engagement being prepared by EC

Source: EC

EU Hydrogen strategy for a climate-neutral Europe (8 July2020)

September 2019

hiip://profadvanwijk.com/hydrogen-the-bridge-between-africa-and-europe/

March 2020

hiips://hydrogeneurope.eu/sites/default/files/Hydrogen%20Europe_2x40%20GW%20Green%20H2%20Initative%20Paper.pdf

TU Delft

The path towards a European hydrogen eco-system step by step :

From now to 2024, we will support the **installation of at least 6GW of renewable hydrogen electrolysers in the EU**, and the production of **up to 1 million tonnes** of renewable hydrogen.

From 2025 to 2030, hydrogen needs to **become an intrinsic part of our integrated energy system**, with at least 40GW of renewable hydrogen electrolysers and the production of **up to 10 million tonnes** of renewable hydrogen in the EU.

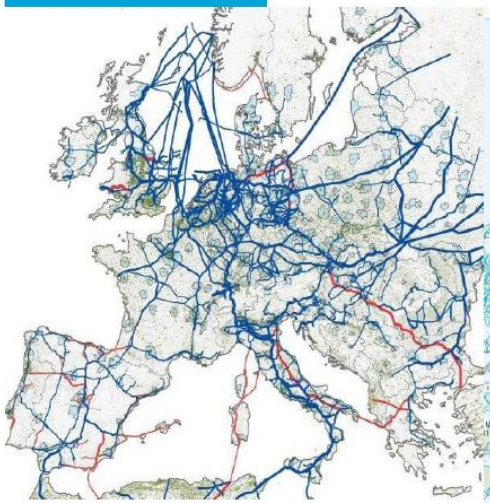
From 2030 onwards, **renewable hydrogen will be deployed at a large scale** across all hard-to-decarbonise sectors.

hiips://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

Gas Infrastructure in Europe can be reused for hydrogen

Gas Pipeline Capacity 5-20 GW, Electricity cable capacity 0.5-2 GW

Gas transport cost roughly a factor 10 cheaper than electricity transport



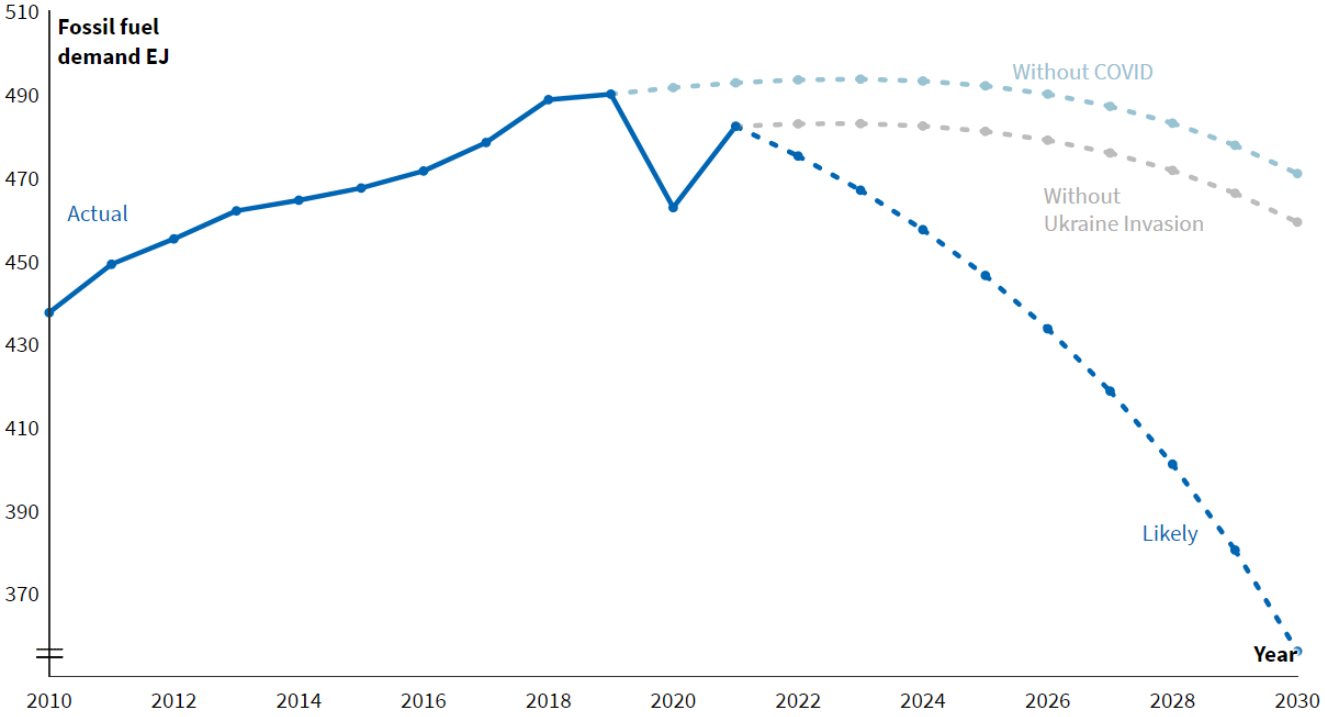
Gas Pipelines Europe
Transporting gas from gas fields at North Sea, Norway, Russia, Algeria, Libya to Europe

Gas from North-Sea
2017 production
190 bcm = 1.900 TWh

Gas from North-Africa
60 GW Natural Gas Pipeline
2x0.7 GW Electricity Cable

European Hydrogen Backbone
75% re-used gas pipelines
25% new hydrogen pipelines
40.000 km pipelines

Exhibit 1: Global fossil fuel demand (EJ/y) under different scenarios



Source: BP, illustrative RMI estimates

WHAT IS ENERGY SECURITY?

- A polyseme (a concept widely used, but no consensus on its meaning or precise definition)
- According to the IEA (which was created in 1974 to address the first serious security concerns following the first Arab oil embargo): the uninterrupted availability of energy sources at an affordable price, irrespective of economic or political instability
- This definition of long-term security of energy supply has increasingly been complemented recently, due to the rapidly increasing RE penetration, with concepts specific to the electricity system: power system reliability and grid stability
- Typical energy security indicators include:
  - Self sufficiency (or the opposite, degree of import dependency)-- overall and by fuel
  - Number of external suppliers, and market share of dominant supplier
  - Primary energy mix
  - Etc……

POWER SYSTEM FLEXIBILITY

THE PROBLEM AND THE SOLUTIONS

Dispatchable power plants

Demand side Response

Energy storage facilities

Interconnection with adjacent markets

Gas-fired power plant

Industrial

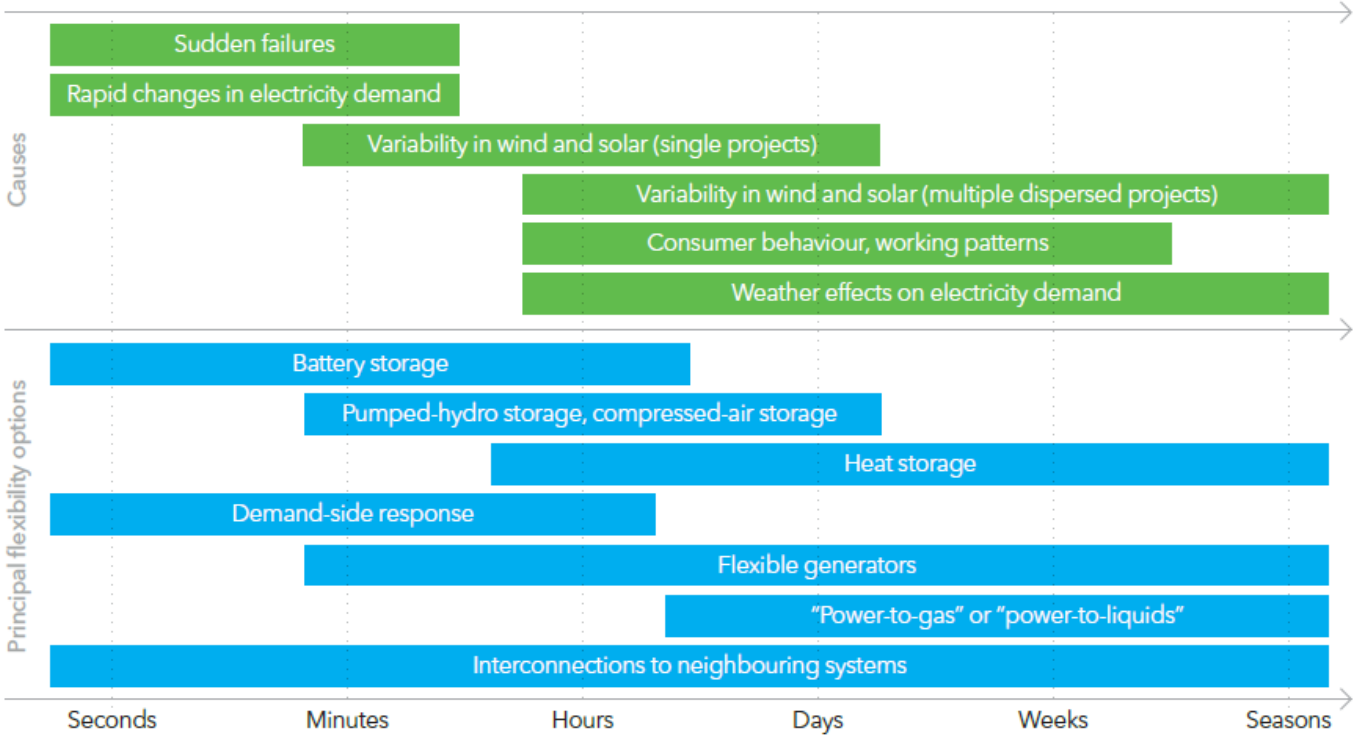
residential

Pumped hydro facility

Scandinavian interconnections

Numerous definitions but flexibility can generally be defined as the ability of the power system to cope with sudden and unexpected changes in demand/supply

Flexibility issues by timescale



Sector coupling, also a source of flexibility (DSR, storage)

- Concept initiated with the coupling of the transport sector with the power sector: use electric vehicles (EV) as batteries and let power flow from EV to the grid (V2G)– since cars are parked 95% of the time

- Massive electrification of end-use sectors create new loads high in capacity but low in energy, if not properly managed. But if end-use sectors are coupled with each other and with power sector, DSR potential and storage solutions are increased

- Coupling electricity and gas (incl green gas and hydrogen) sectors is also a source of flexibility