CIGRE C1 ISRAELI WEBINAR

Systems and Grid Planning approaches in age of Renewable Energy & Storage growth. The Euro-Mediterranean perspective

Welcome address

ALEX LEVINZON

Chair of Isreali National Committee

June 7 , 2021

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Framework and scope of webinar

ANTONIO ILICETO

Chair of Study Committee C1 “System Developments and Economics

June 7 , 2021

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Introduction, framing and scope

- **Request from Israeli NC , very welcome by SC C1**
- **Cigre, and particularly SC C1, are deeply engaged in coping with the rapid and profound paradigm shift**
- **Cigre has adopted an End-to-End approach, encompassing the whole power sector value chain as well as neighoburing sectors to be coupled**
- **Changing system needs < > new technology options**
- **Flexibility and Resilience as keywords for grid operation, to be internalised since planning stage**
- **Market models and pricing mechanism also changing to remain usable/useful for grid/system efficient operation**

One certainty: system balance and security will become a permanent Roller-Coaster

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Impact on Grid Planning & System Development

- Many development options, wire and no-wire (demand response, energy communities, etc.)
- Uncertain load, volume and profile, including efficiency and electrification
- Uncertain generation, weather-dependent and substantially not curtailable (high Capex, low Opex)
- Large and increasing need of operating flexibility and resilience, to be internalised already in planning methodologies and assessment
- Many flexibility means to be used as optimal portfolio (performance-cost-availability)
- Need to address Sector Coupling and in particular Power-to-Gas
- In Europe, Electricity and Gas Sectors are already making joint scenarios and coordinated planning
- Hydrogen is coming into the scene, through its impact on gas infrastructures & regulation

Grid Planning is becoming an ever-increasing complex exercise, multi-actor, multi-purpose, multi-options; stochastic approach becomes paramount

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The European model

- **EU is front-runner on:**
  - **decarbonisation**
  - **energy markets (liberalisation, competition, market-based system efficiency, etc.)**
  - **shaping and uptaking new technologies, technical leadership safeguard**
- **European power governance is larger than political EU, and Network Codes have stance of primary legislation:**
  - **internal market → energy (up to intraday, almost continuous trading), ancillary services, cross-border trade, etc.**
  - **strictly coordinated operation (regional control centers, reciprocal visibility and transparency, mutual support and defence plans, very high level of interconnections, etc.)**
  - **joint planning (TYNDP, PCI, CBA, CBCA)**
  - **common Innovation Programs**

European synchronous area and their interconnected areas constitute one of the most complex interoperable systems ever built by mankind

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The Euro - Mediterranean perspective

- European power system governance already includes third countries: UK, Norway, Switzerland, Iceland, Balkans, Turkey
- Interconnections are in place also with non ENTSO-E countries (Morocco, part of Ukraine, enclaves of Russia), or under authorisation/financing phase (Tunisia)
- The next level of interconnections shall be looking Southwards: Maghreb, Mashreq, and all Mediterrenean Basin
- Several organisations addressing Euro-Mediterranean integration:
  - Med-TSO specifically targeting interconnections and cooperation
  - Med-Reg addressing the necessary regulatory aspects of cooperation
  - UfM, OME, Comelec, etc.
- Mediterranean interconnections among North, South and East shore proved to be feasible and viable
- South – South interconnections and cooperation also fundamental

Cross-Mediterranean integration is a win-win solution for exploiting complementarities

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Major trends in Planning and Cigre activities

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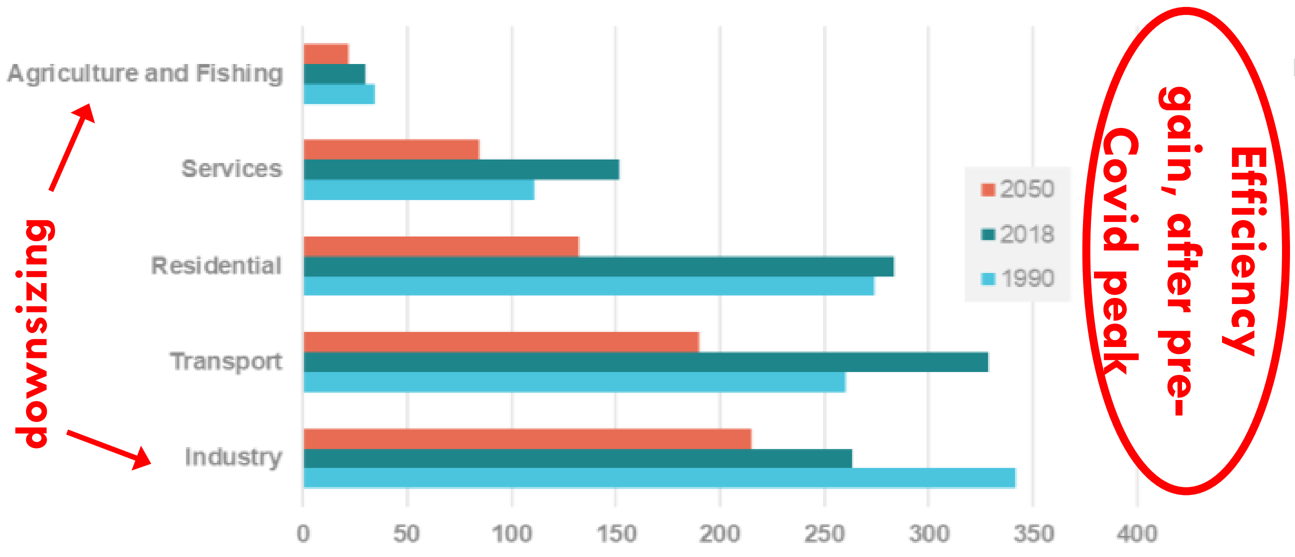
Agenda

- Overarching trends of energy transition
- Sector coupling and green
- The future electricity system
- SC C1 activities on grid planning

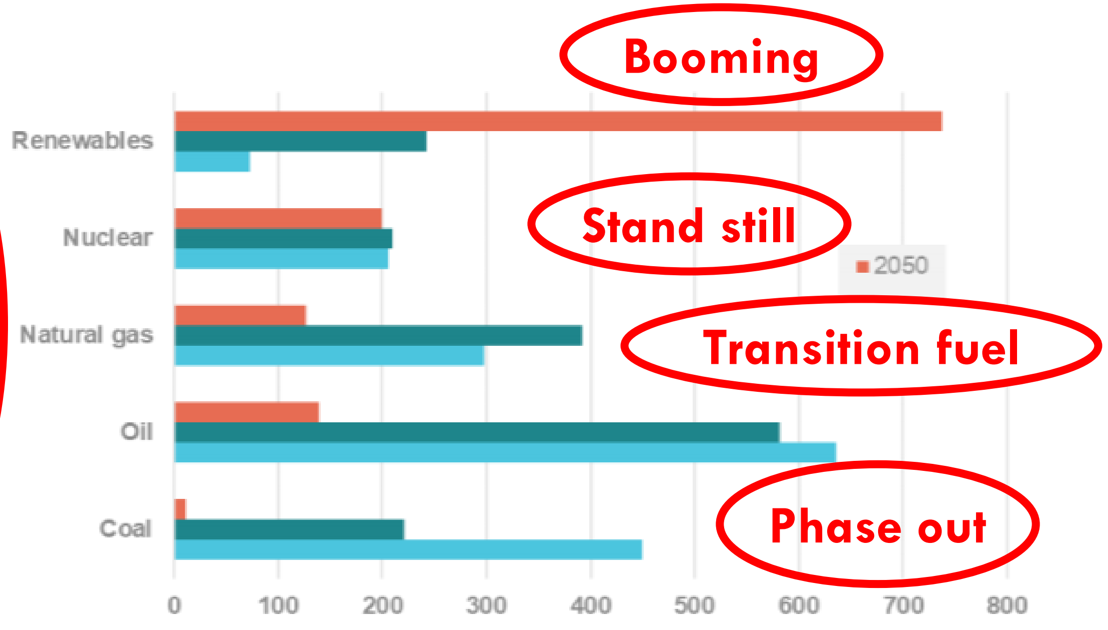
Overarching trends – EU case

Changing consumption and production patterns

Final energy demand per sector



Consumption per energy supply source



Source: EC, based on EU28 Eurostat/LTS 1.5LIFE/TECH scenarios; figures are in MToe

European Commission

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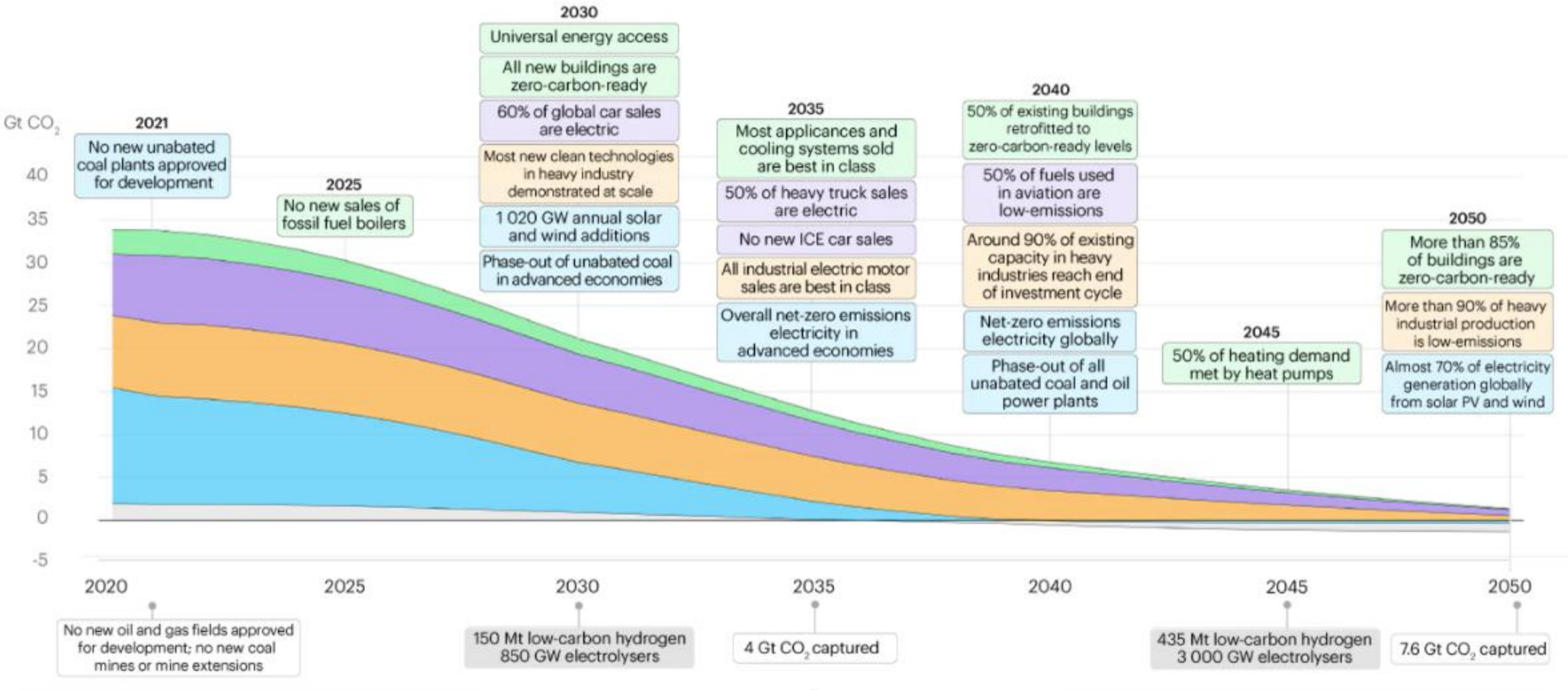
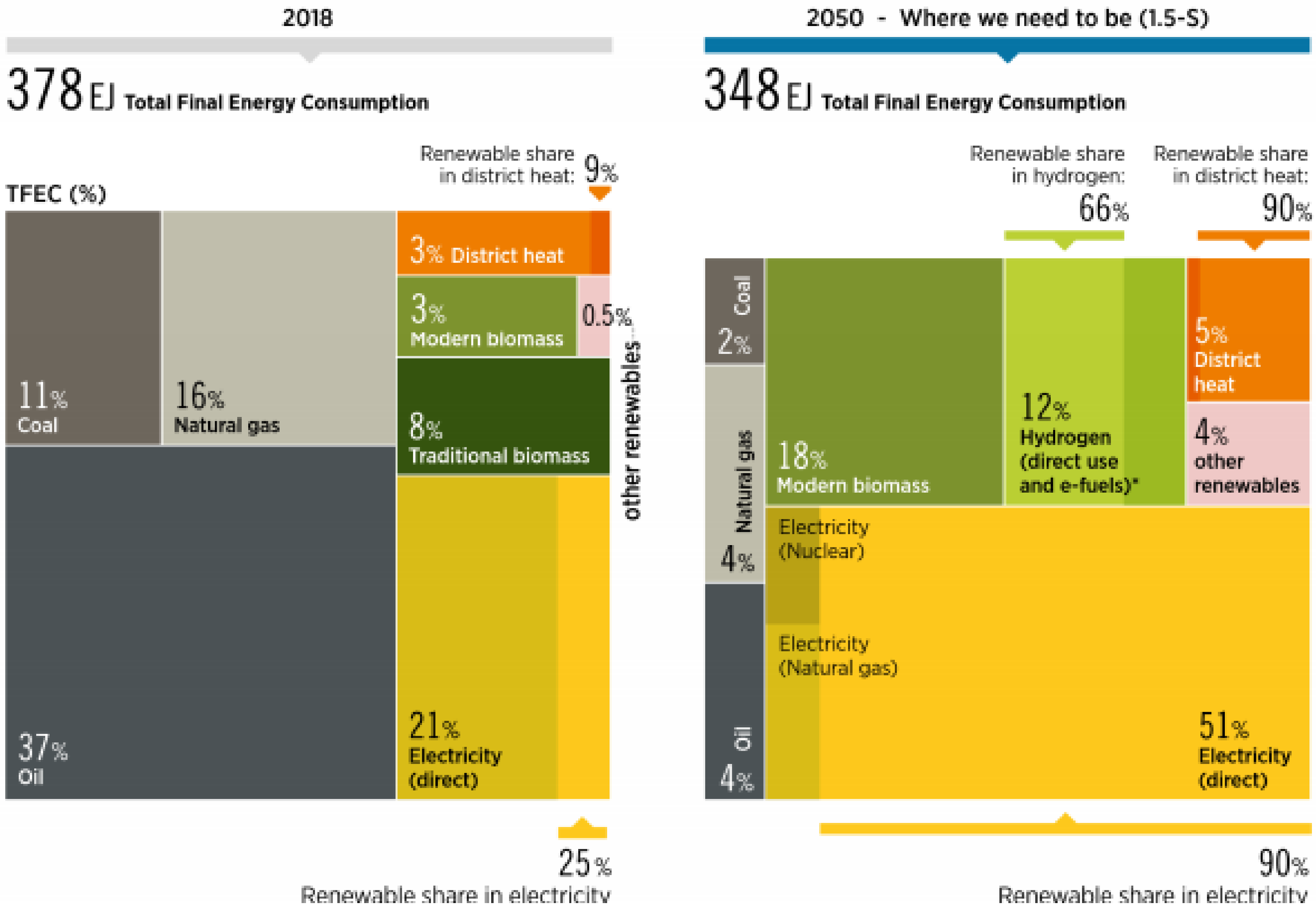
RADICAL DECISIONS HAVE BECOME NECESSARY



As the major source of global emissions, the energy sector holds the key to responding to the world's climate challenge.

Source: IEA

Energy vectors: electricity, bio-energy and hydrogen dominate



By 2050, electricity would be the main energy carrier with over 50% (direct) share of total final energy use – up from 21% today. By 2050, 90% of total electricity needs would be supplied by renewables followed by 6% from natural gas and the remaining from nuclear.

Note: The figures include only energy consumption, excluding non-energy uses. For electricity use, 25% in 2018 and 90% in 2050 is sourced from renewable sources; for district heating, these shares are 9% and 90%, respectively; for hydrogen (direct use and e-fuels), the RE shares (i.e., green hydrogen) would reach 66% by 2050. The category "Hydrogen (direct use and e-fuels)" accounts for total hydrogen consumption (green and blue) and other e-fuels (e-ammonia and e-methanol). Electricity (direct) includes all sources of generation: renewable, nuclear and fossil fuel based. DH = district heat; EJ = exajoules; RE = renewable energy.

Source: World Energy Transition Outlook IRENA, March 2021 preliminary

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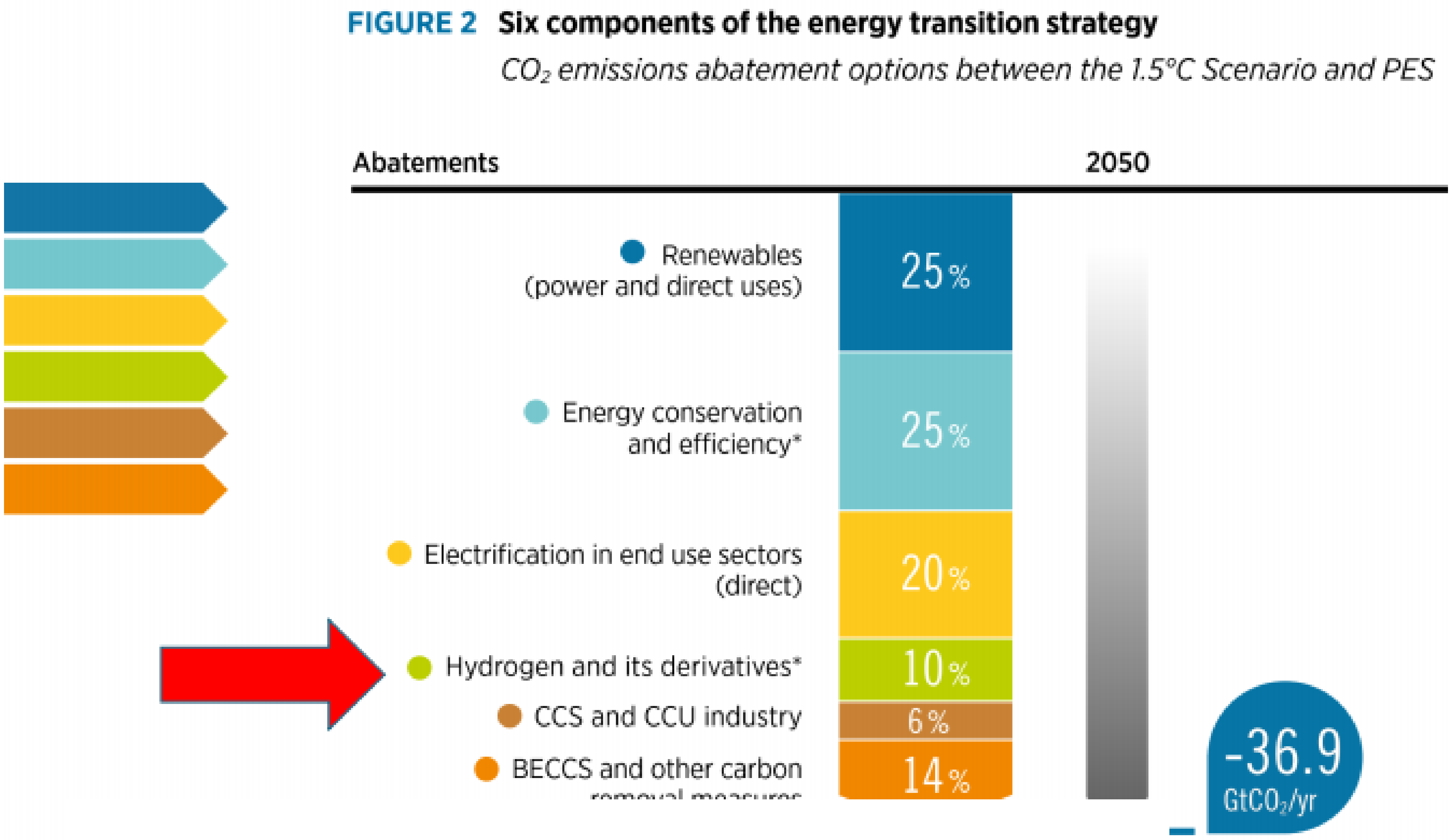
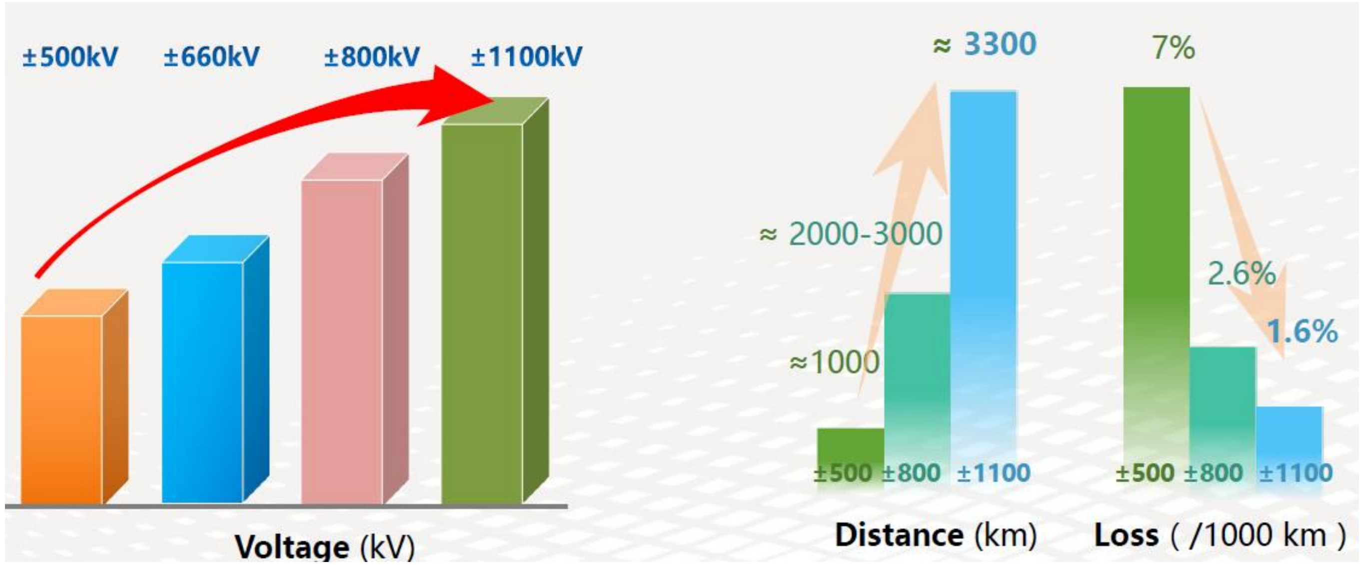
Energy transition: building blocks include hydrogen

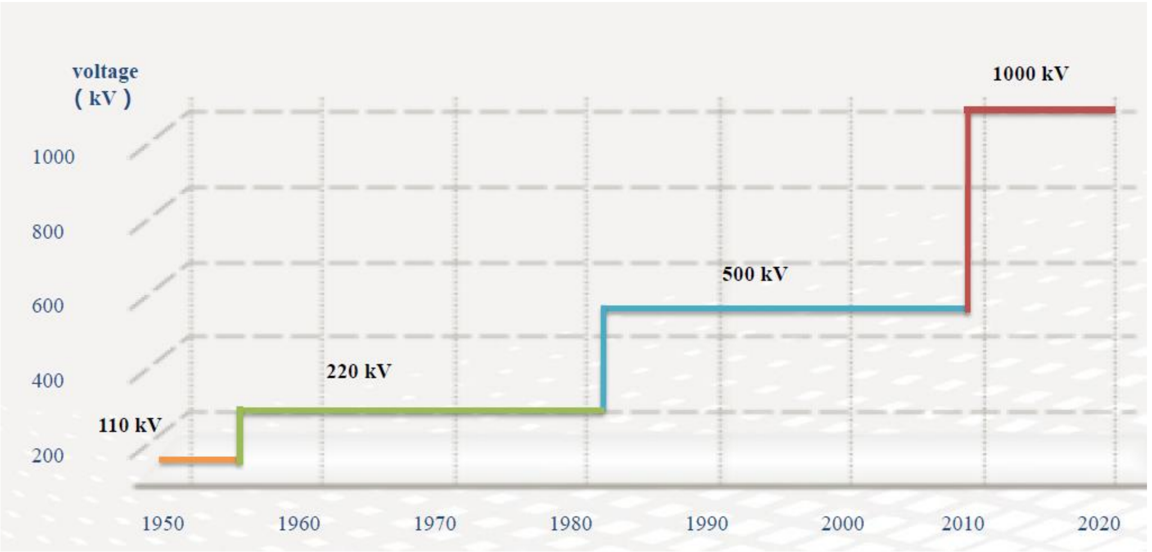


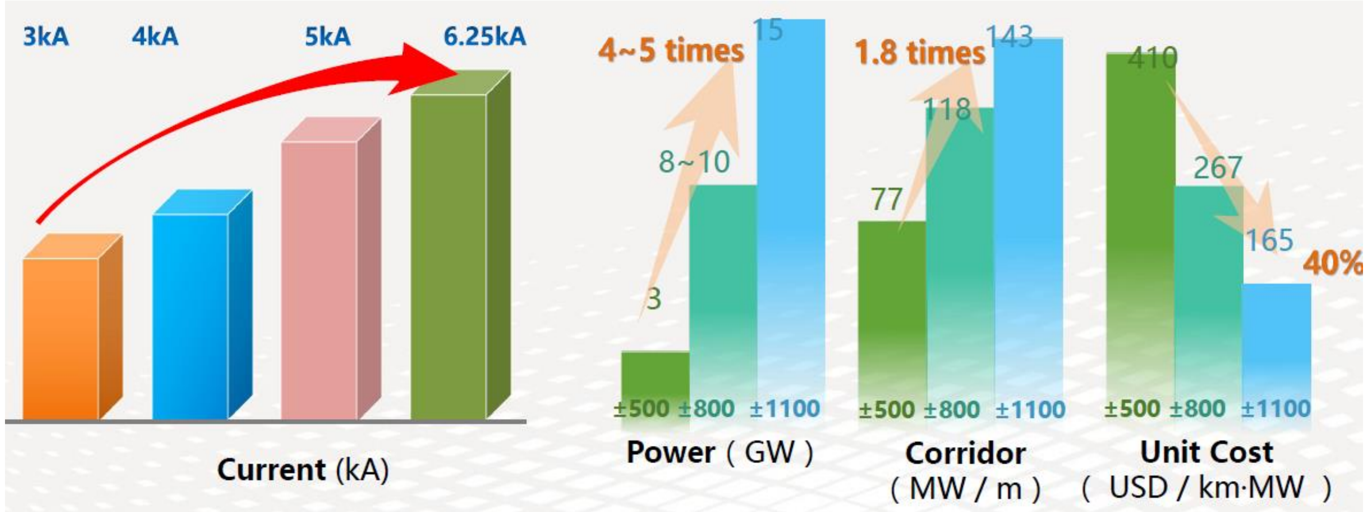
Note: The abatement estimates in the figure between the PES and 1.5-S include energy (incl. bunkers) and process-related CO2 emissions along with emissions from non-energy use. Renewables include renewable power generation sources and direct use of renewable heat and biomass. Energy efficiency includes measures related to reduced demand and efficiency improvements. Structural changes (e.g. relocation of steel production with direct reduced iron) and circular economy practices are part of energy efficiency. Electrification includes direct use of clean electricity in transport and heat applications. Hydrogen and its derivatives include use of hydrogen and synthetic fuels and feedstocks. CCS describes carbon capture and storage from point-source fossil-fuel-based and other emitting processes mainly in industry. BECCS and other carbon removal measures include bioenergy coupled with CCS (BECCS) in electricity and heat generation, and in industry and other measures in industry.
BECCS = bioenergy with CCS; CCS = carbon capture and storage; CCU = carbon capture and utilisation; GtCO2 = gigatonnes of carbon dioxide..

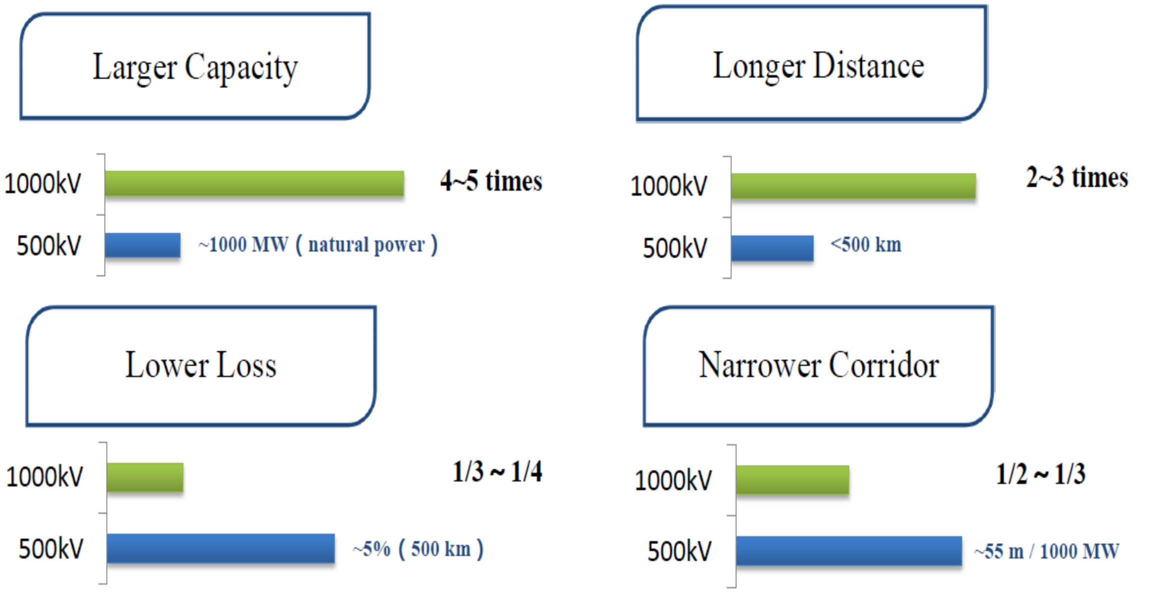
Source: World Energy Transition Outlook IRENA, March 2021 preliminary

Technological breakthroughs enable supergrids





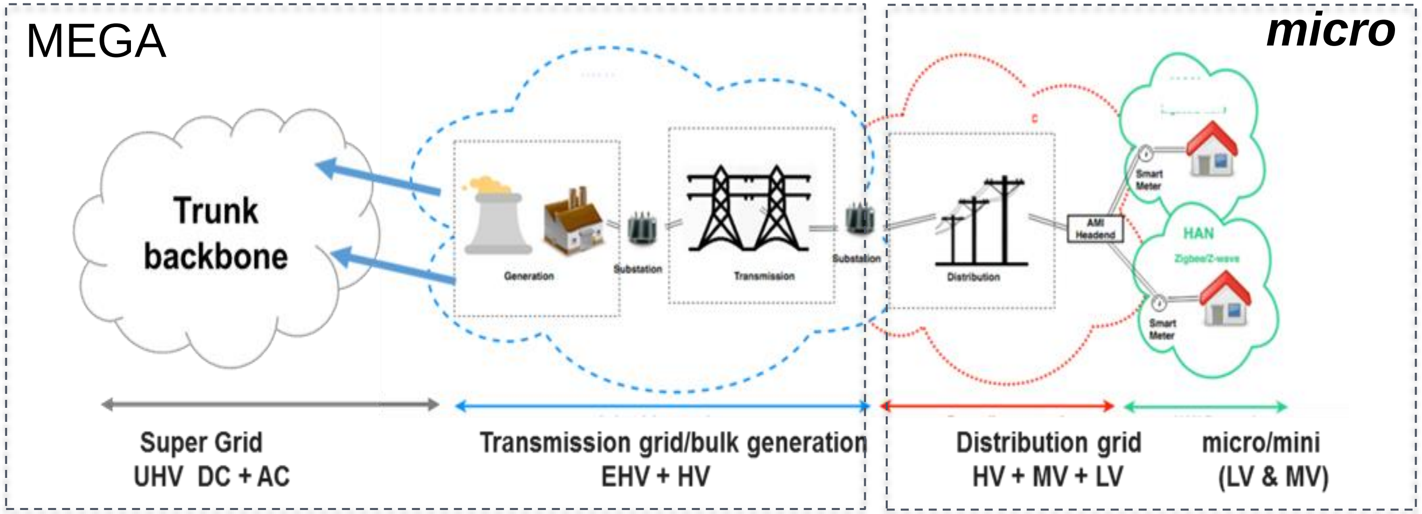


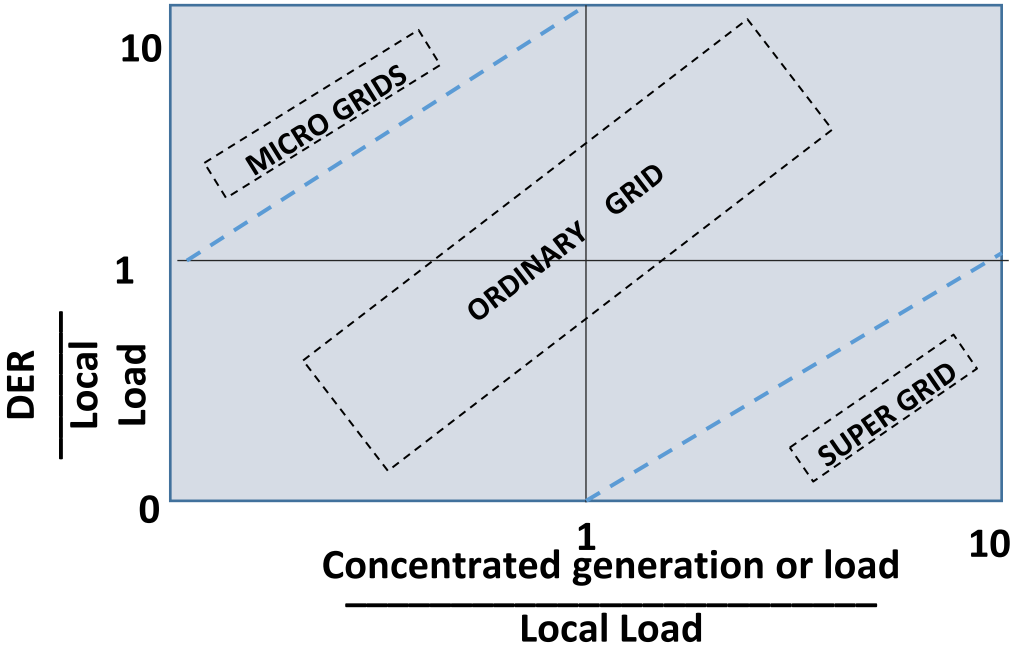


Source: State Grid of China

ONE SYSTEM, END-TO-END

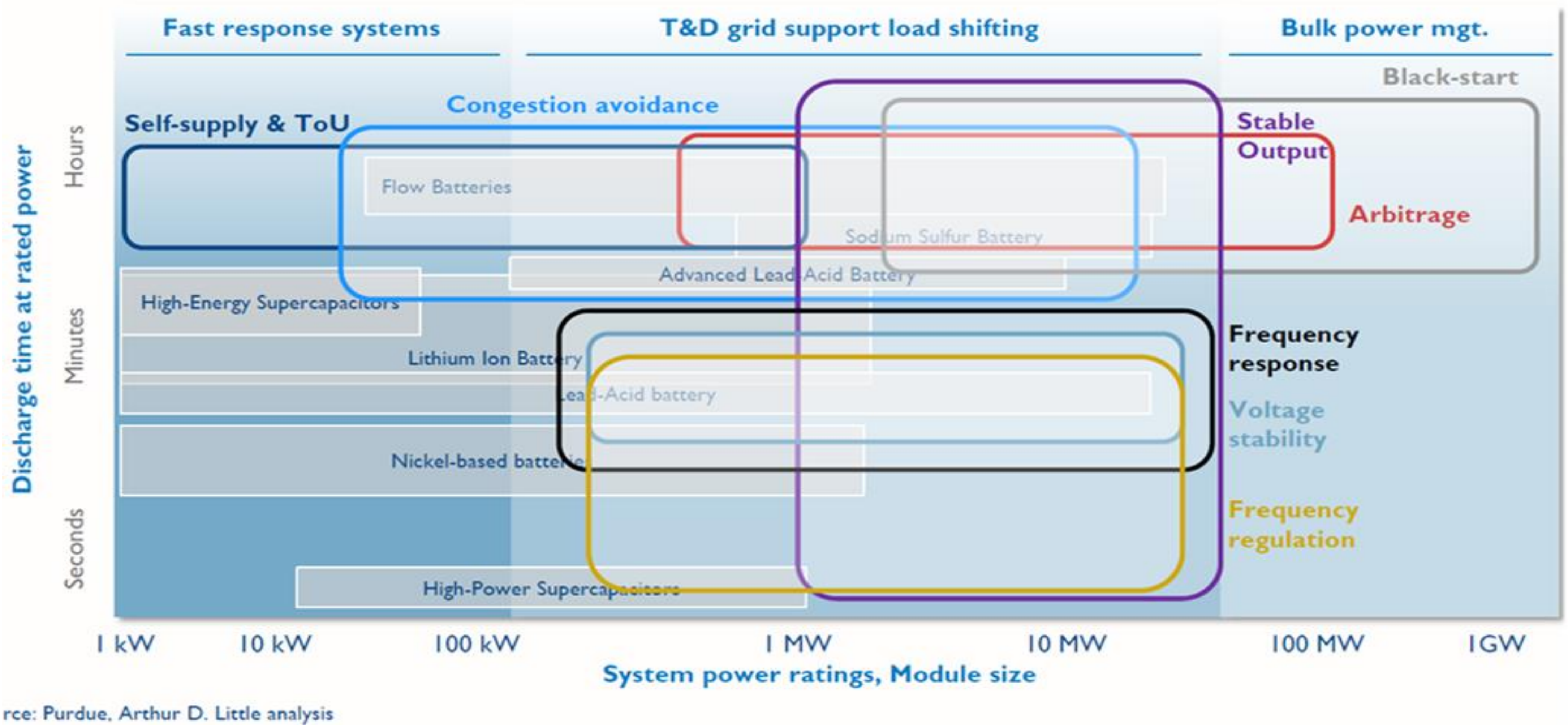
- Paradigm shift in grid operation and network expansion on two opposite fronts:
- At the lower end → microgrids, local energy communities, distributed generation, local storage, enabling the subsidiarity principle balancing the system locally as much as techno-economically feasible
- At the higher end → enlarging the integrated power system through long-distance HVAC and HVDC interconnections, for bulk-scale RES generation delivery to load centers and large seasonal storage





Mega and micro pertain to very different spaces in the supply chain and serve very different needs → BOTH ARE NECESSARY

Many storage technologies for different needs

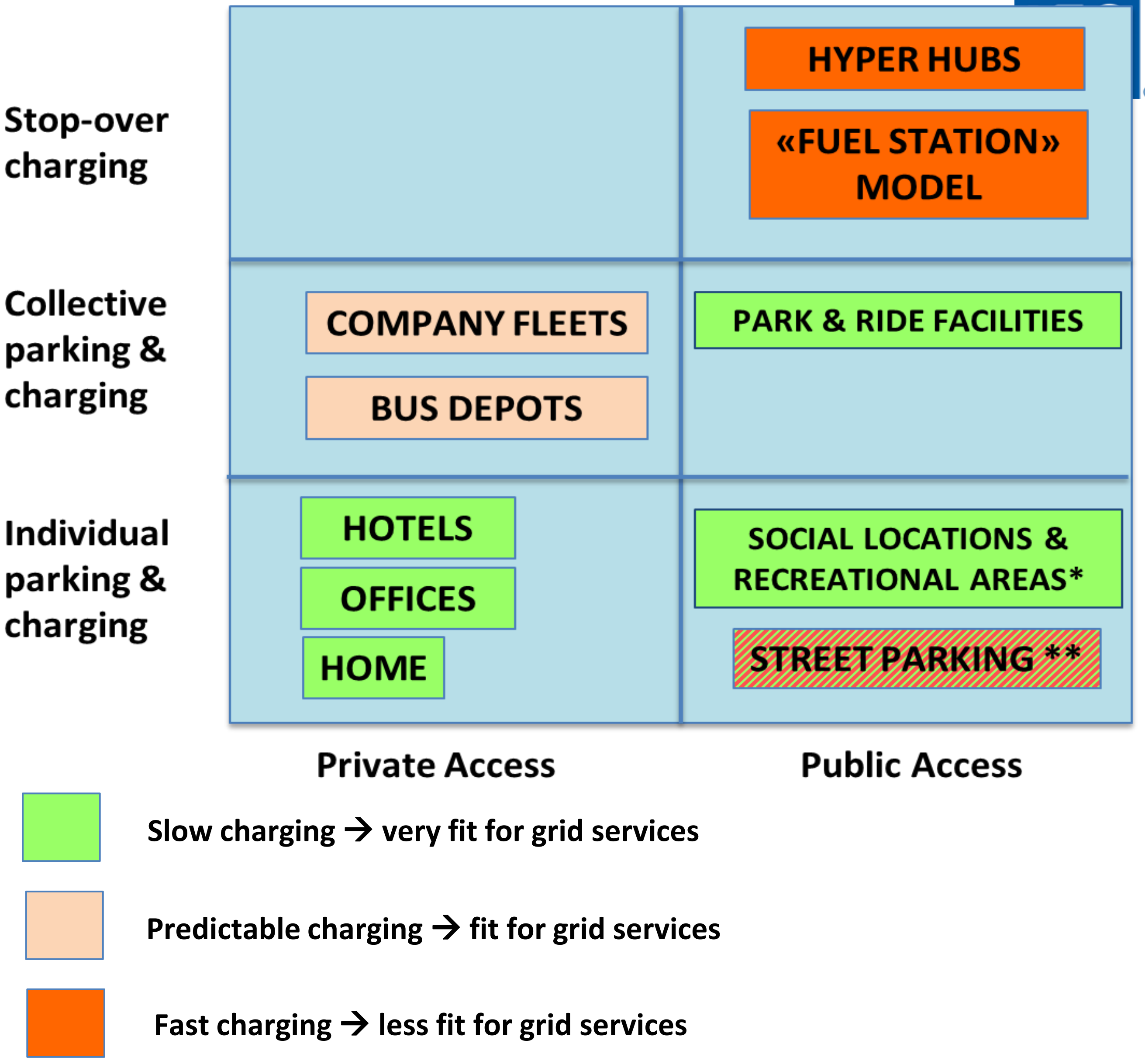


Source: Dii “battery Storage Report”, 2020

Both short term and long term storage are necessary to operate a RES-dominated system

EV CHARGING SOLUTIONS TO BE SMART BY DESIGN

- Paradigm shift: from fuelling on the move to charging while parked → Couple the **parking habits** with the **charging needs**
- Different **charging solutions for different use cases**
- Un-coordinated plugging-in would generate a fast ramp-up on top of the already existing critical evening ramp of the residual load
- Smart charging can beneficially reshape the EV load curve, shifting the power request at suitable times
- Bidirectional vehicle-to –grid (V2G) emphasizes the reshaping effect
- Potentially low user's attractiveness for **price signals** shall be enhanced through a comfortable experience and **innovative services**



All Use Cases will be deployed, and grid-supporting ones are those with slow and/or very predictable profiles

Agenda

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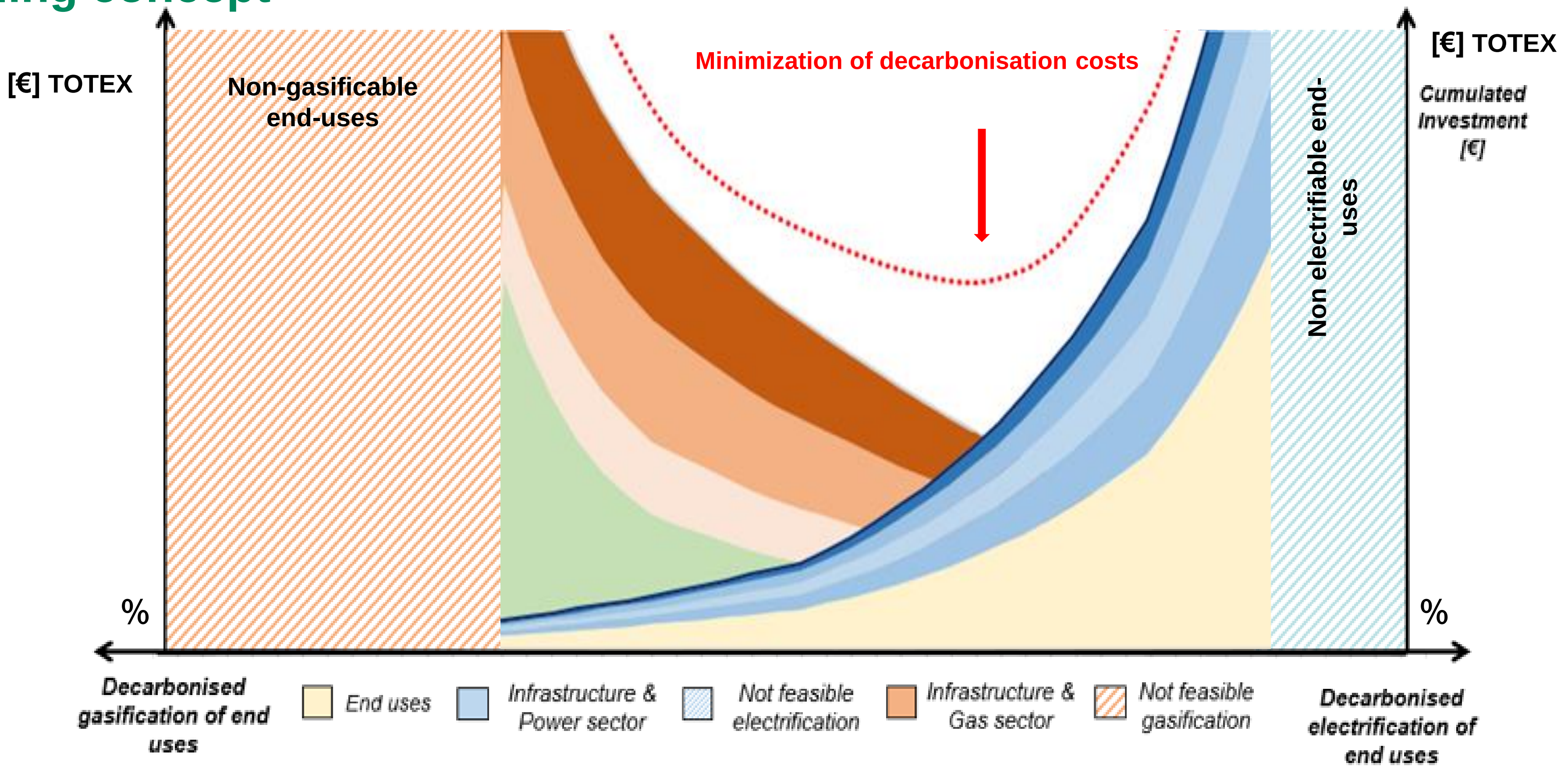
Energy molecules and Electricity are both necessary

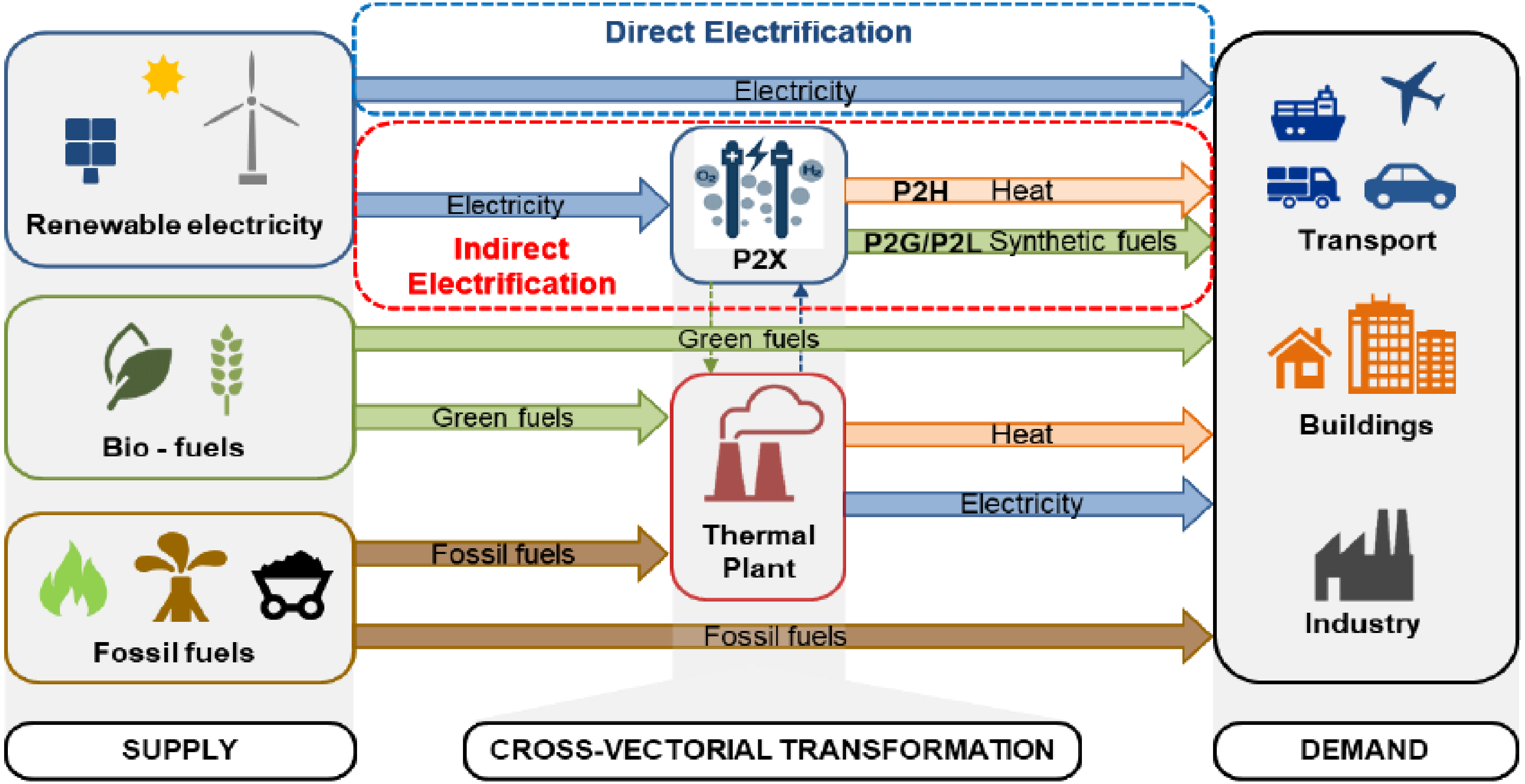
We need also molecules as bulk energy carrier to decarbonize at minimal cost → Sector Coupling concept



Source: Terna.

- ✓ Electrons / Molecules ratio in overall energy consumption will change, according to their respective decarbonization patterns
- ✓ The optimal mix will depend on several drivers, also country-specific

Power-to-Gas in the broader framework



Sector Coupling and P2G assets in particular are required to decarbonize those sectors that struggles to be electrified. The potentiality of such assets to work as storage systems, in relation to the electricity system flexibility needs, has to be assessed.

Source: Terna

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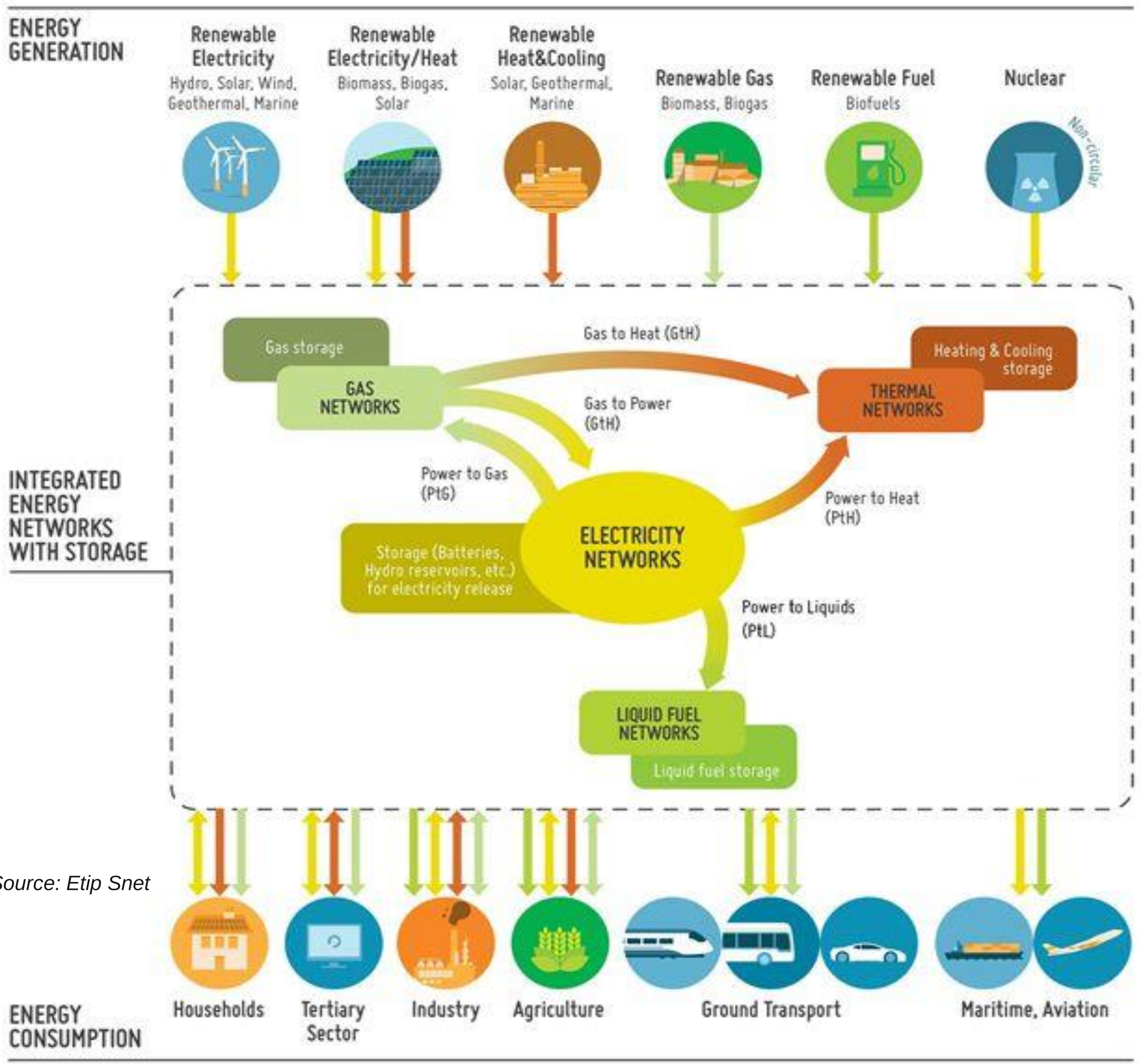
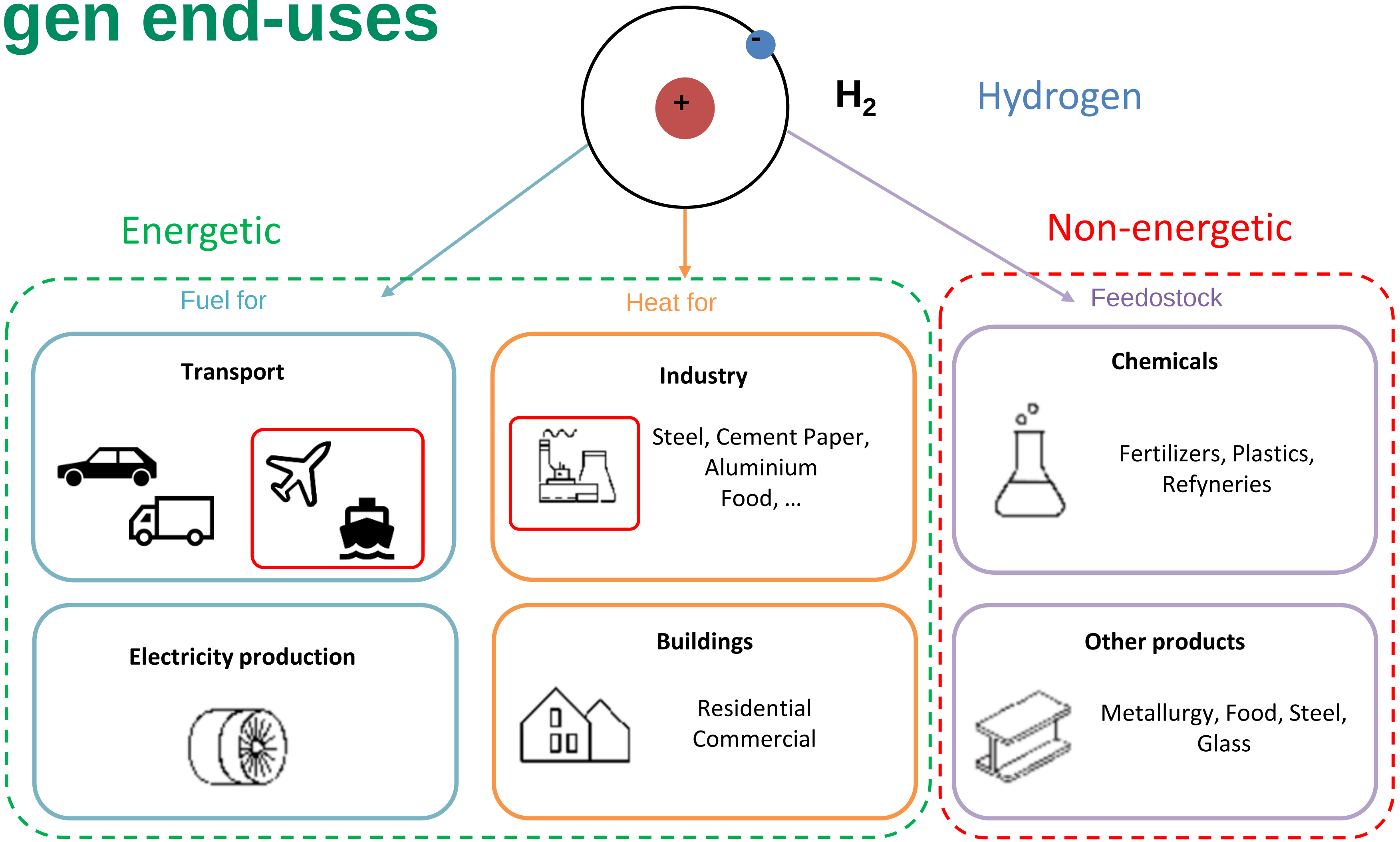
Power system and grids as backbone of the energy transition

- A very extensive electrification of (nearly) all sectors of the energy system
- Europe to target global leadership in Renewables deployment
- Deep energy efficiency improvements in all sectors
- Extensive use of carbon neutral fuels
- Adoption of a widely circular approach
- Sustainable buildings
- Progressive societal changes
- Widespread digitalisation



Source: Etip Snet

Hydrogen end-uses



Source: Bloomberg New Energy Finance.

Green Hydrogen/synthetic fuels are good candidates (in some cases the only feasible) to decarbonize high temperature industrial processes, heavy transports and non-energetic end-uses

WHAT CAN WE DO WITH MASSIVE AND AFFORDABLE HYDROGEN

Clean feedstock

Replace hydrogen produced via Steam Methane Reforming by water electrolysis.

Example: ammonia plant

Clean fuel

Replace diesel and gasoline by hydrogen produced via water electrolysis.

Example: fuel cells truck

Alternative energy carrier

Use hydrogen as energy carrier for bulk, long distance energy transport

Example: hydrogen pipeline

Seasonal storage

Use hydrogen as bulk, long duration storage medium for balancing variable renewables

Example: salt cavern

Hydrogen can help to achieve multiple goals of energy transition and energy security

Source:
HITACHI ABB

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Beyond present concept of ‘residual load profile’

- **Evolution of electric system operating philosophy:**

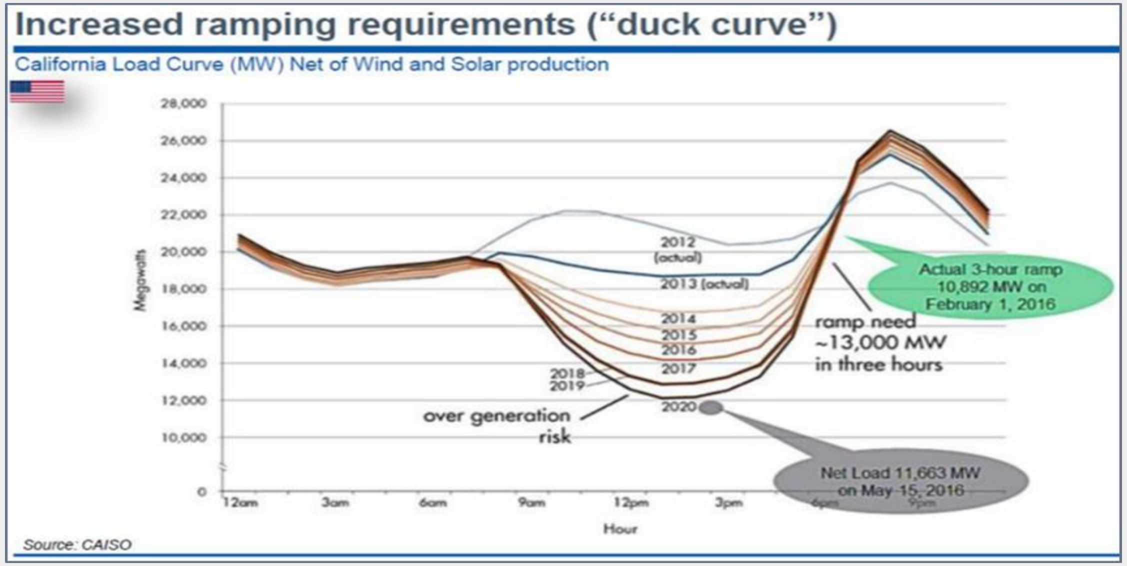
Generation follows Load

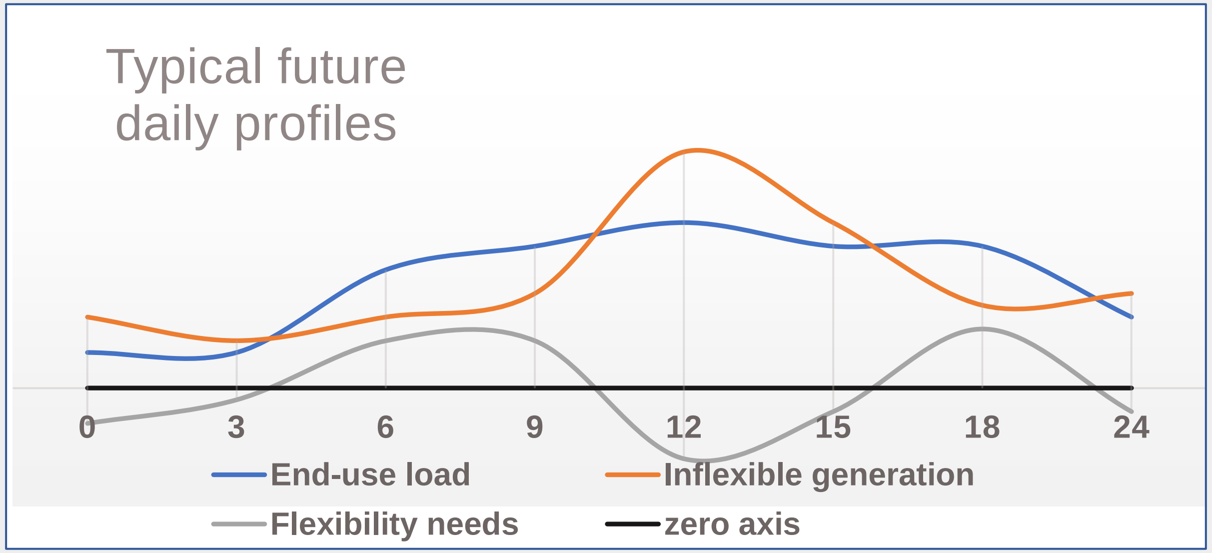
THE PAST → Load profile given as independent variable (inflexible load), generation has to follow the load

THE PRESENT → Residual load profile (total load minus variable RES generation) covered by traditional flexible generation + pioneering flexibility means

THE FUTURE → Generation profile given as independent variable (inflexible generation), so grid and load have to become flexible through a wide portfolio of flexibility means

Load follows Generation

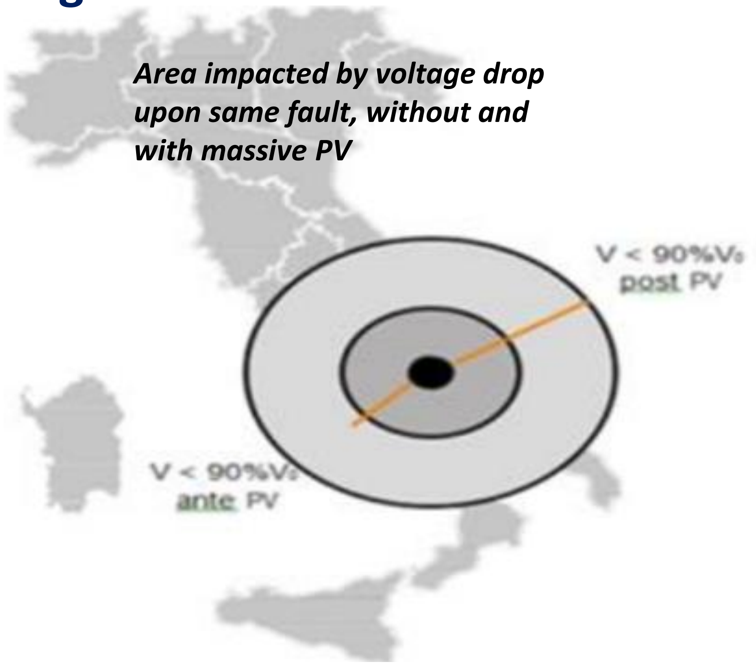




RES MAINSTREAM: NEW PROBLEMS, NEW SOLUTIONS

➢ **Grid Operation:**

- ✓ **Weather-related predictability → more reserves (capacity and duration, i.e. in power and in energy)**
- ✓ **Steeper ramps → flexible generation (hydro, gas open cycle, adaptable RES)**
- ✓ **More balancing actions → smarter processes, enlarging balancing providers (aggregators, demand response, cross border),**
- ✓ **Modified control & protection → new grid services: fast reserve, sector coupling**
- ✓ **Low inertia, instability → synthetic inertia, grid forming**
- ✓ **Observability → TSO-DSO coordination, digitalisation**



➢ **Grid Planning:**

- ✓ **Holistic view → joint planning TSO-DSO and other energy sectors**
- ✓ **Proliferation of variables and combinations for scenarios definition**
- ✓ **Assessment methodologies → stochastic criteria, multi-criteria CBA, no-regret real options methodologies**

Grid operators proved very adaptive and resilient to fast changes

DEEP ELECTRIFICATION & SMART SECTOR INTEGRATION

- Electrification → higher load, **new load profiles, peak power increase (adequacy**), stressing distribution grids (and transmission as well)

- Deep electrification → higher complexity of the networks → more difficult **modelling (digital twins) and scenarios definition (assumptions, storyline), co-optimization of different sectors (many variables and reciprocal interactions, with viable combinations growing exponentially)**

- **How to apply different market rules (or just introduce market concept) to properly valorise energy conversions and provide price signals**

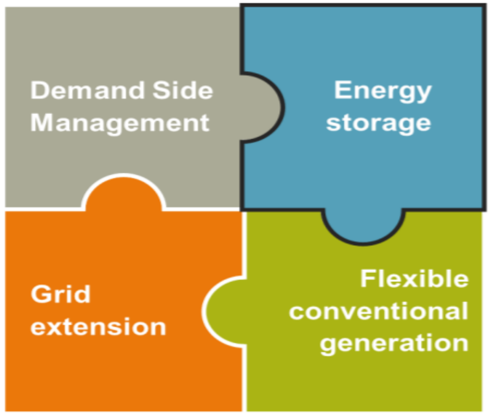
- How to design and plan the infrastructures considering flexibility options from Sector Integration (no wire options) and how to **avoid stranded assets→ networks flexibile-by-design**

- **How to exploit flexibility also for improving resilience→ efficient asset management**

- Future role of hydrogen & green gases, also as energy carrier in place of electricty

EFFICIENT ENERGY TRANSITION FOR A SUSTAINABLE AND RESILIENT SYSTEM OF SYSTEMS

- ❑ **Sustainability** and TSO CO2 footprint, direct and indirect emission reduction
- ❑ Resilient system: **optimal mix** among preventive, mitigation, adaptation measures (e.g. accept higher risk in presence of fast and reliable restoration options)
- ❑ **Pivotal role of TSOs in tackling efficiency trilemma:**
  - ➢ Energy efficiency → reduce losses, but also best use of energy primary resource mix
  - ➢ Infrastructure efficiency → best use of existing assets and optimal planning of future assets
  - ➢ Decarbonisation efficiency → identification of optimal options for each emission source (switch to electricity, switch to green fuels, decarbonise fossil fuel, etc.)
- ❑ **Managing v-RES penetration → optimal mix among:**
  - ❑ grid reinforcements
  - ❑ Interconnecting neighbouring areas
  - ❑ demand response and more in general, **elastic demand**
  - ❑ storage, both short term (e.g. batteries) and long term (pump hydro, molecules)



- ❑ **Evolution of projects' assessment criteria and evaluation tools (LCOE, CBA, investment analysis) with cross-sector footprint and externalities**
- ❑ **Governance of energy plans with coordinated deployment of RES, storage, Power-to-X**

SOME FUTURE-LOOKING QUESTIONS - 1

Energy sectors integration, a movie with unwritten end

Efficiency First, is energy efficiency also infrastructure efficient?

Deep electrification, is it ok for peak capacity / grid congestions?

EV require fast charging, but grids prefers slow charging…

Power-Heat integration is it only a local (DSO) issue?

Will TSOs be so flexible to use many flexibility means for many flexibility needs?

System-of-System is attractive concept, but cannot stay without central governance like instead internet

Smart Sector Integration, are other sectors' stakeholders excited as we are?

H2, the new charming prince

Hydrogen, an unexpected decarbonisation ally or a competitor for power lines?

Hydrogen shall be deployed supply-driven (excess RES) or demand-driven (deficit RES) ?

Are we sure electrolyser cost shall decrease like PV did? Why is not the same for all other technologies?

Striving for grid growth or happy de-growth?

Shall we need more grids (electrification, DER scattered in location and time) or less grids (H2, efficiency gain, web-of-cells architecture)?

SOME FUTURE-LOOKING QUESTIONS - 2

DC revenge

Offshore HVDC grids, a world pioneer or a solution for one-of-a-kind situation?

Grid Forming, does the problem (Power Electronics) also contains the solution?

DC applications peeping in MV and LV: going back to Edison-Tesla derby?

Smarter or stronger?

AI, self-learning, digital twins, how much smarter can still evolve our grids?

More extra-European interconnections or more energy autarky?

Grids, going macro or going micro? Will the fans of DER succeed in marginalizing big brother TSO?

A harder job …

With Adequacy becoming more stochastic, and system complexity increasing esponentially, how shall we update our grid planning & operating methodologies?

Resilience, can we limit reserve costs, counting on mitigation/recovery support from non-wire solutions?

Is TSO-DSO re-merging the natural solution? Is asset-based tariff suited to drive TSO efficiency and innovation?

Paradigm shift. Or not?

How long can last a market model designed for fossil plants competition and for generation pooling, while RES are zero variable cost and are bankable with PPA?

Impact on TSOs future role

TSO-DSO

- ❑ Transmission & Distribution interfaces, joint planning & coordinated operation
- ❑ TSO-DSO, a blurring boundary → re-merging / re-bundling?

Micro & Macro grids

- ❑ Role of micro-grids, active consumers, local energy communities
- ❑ Role of macro interconnections and bulk imports from RES hubs (North Africa, Middle East, Ukraine and Central Asia, Iceland/North Atlantic) or **energy autarky goal**?

Business & Remuneration

- ❑ **New TSOs business models, regulated vs non regulated activities**
- ❑ Tariff schemes / Regulation suitable for future system?

Governance & Role

- ❑ **Role in planning / investing / operating of strategic storages, electrolysers, large interconnections**
- ❑ **Governance of multi-sector system and TSO relations with decision-makers/operators of other systems**

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C1 new WGs

- C1.45 Consistent long-term scenarios and metrics for benefits assessment for interconnections and sector integration projects (Pierluigi Vicini)

- C1-C4.46 Optimising power system resilience in future grid design (Christian Schaefer)

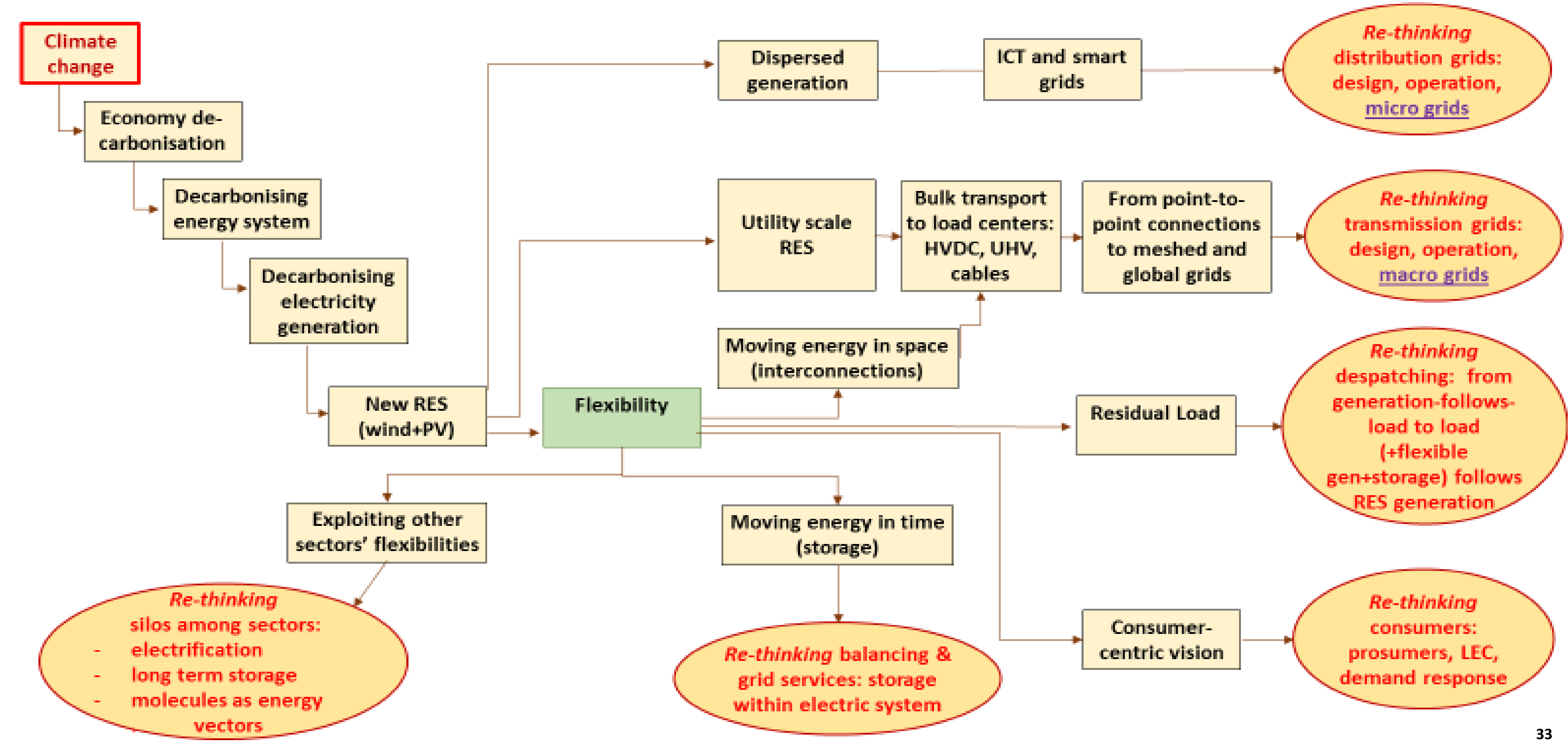
C1.47 Smart Sector Integration: potentials & perspectives for flexibility solutions at transmission system level (Ning Zhang)

C1.48 Hydrogen, Green Molecules & Power-to-Gas: potential, perspectives and barriers (Alexandre Oudalov)

In pipeline:

- Offshore grids: system planning guidelines and compatibility with future system expansion
- New WG on an Euro-Mediterranean relevant topic?

Energy transition IMPLIES RETHINKING MOST OF LEGACY SYSTEM AND MINDSET



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Q & A session

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