Major Challenges in Energy Regulation. Examples from European Union.

Dr. Konstantin Petrov / Dr. Viren Ajodhia

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Agenda

- Major industry trends
- Commodity markets
  - Wholesale markets
  - Gas used in transportation
  - RES electricity
  - RES gas
- Infrastructure
  - Conventional infrastructure
  - Infrastructure for gas used in transportation
  - Electricity storage
  - Infrastructure for new gases
- EU policy versus member states interest
- Conclusions
- Appendix: New Technologies

Major Trends

Major Trends / Overview

The development of the energy industry in the last decade has been dominated by political, technological and economic trends.

Political

Political trends reflect the major elements of the European energy policy.

- Liberalization, directives and related regulatory framework
- Functional competitive markets
- Regional integration and harmonization
- Climate policy
- Security of supply

Technological

Technological trends are driven inter alia by the climate policy and technological progress.

- Electricity and gas RES
- End-use energy efficiency
- Energy storage
- Network technology
- Electric vehicles
- Dispersed generation
- Smart metering / smart grids
- Digitalisation

Economic

Economic trends are driven inter alia by the general economic development, sector specifics and energy policy.

- Ageing assets / replacement needs
- New business model
- Increasing regional trade but still fragmented markets
- Convergence of gas and electricity markets
- Regional (gas) demand uncertainty
- Mergers / take-overs

Major Trends / Sector Impact

The changes driven by the sector trends require effective response from regulators and policy makers to ensure functional commodity markets and adequate infrastructure.

Commodity Markets

- Implementation of functional wholesale market / target models
- Further development and implementation market integration
- New types of use/ commodity markets
- Functional RES incentive schemes/ market integration
- Effective market monitoring
- Integration of demand response
- Innovation incentives

Infrastructure

- Investment incentives / role of cost benefit analysis
- System reliability / flexibility needs
- Strengthening regional coordination/ joined planning and harmonisation
- Potential asset stranding
- Role of unbundling in the context of new business models
- New types of infrastructure
- Network tariff reforms
- Innovation incentives

Commodity Markets

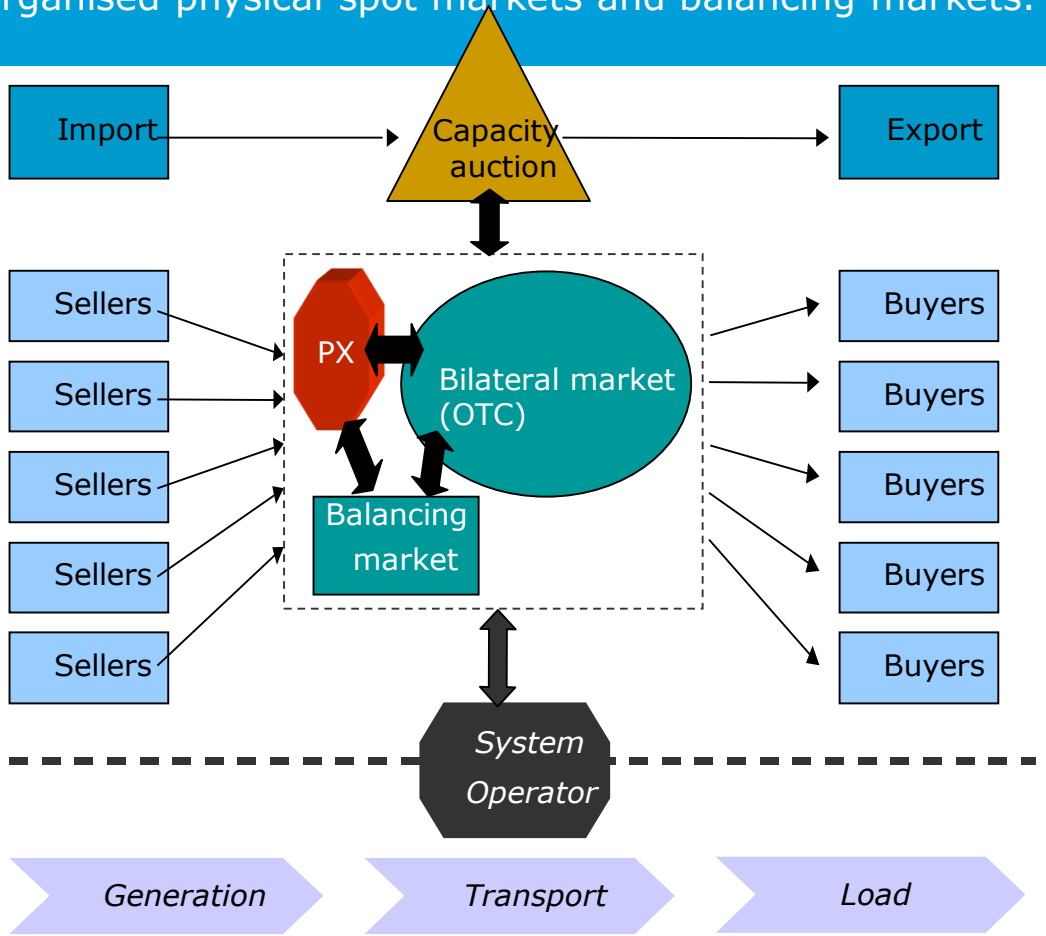
Commodity Markets / Overview

Commodity markets are in most cases competitive markets and there is no scope for a direct regulation. Regulation should continue to focus on the further enhancement of competition and removal of market distortions.

- Selected examples for the purposes of the presentation:
  - Electricity generation
  - Wholesale gas market
  - Wholesale electricity market
  - Use of gas (LNG /CNG) in the transportation sector
  - RES electricity
  - RES gas
- As commodity markets are in most cases competitive markets the role of regulation is mainly related to the further enhancement of competition including inter alia improvement of market design and tariff setting/ access arrangements of relevant related infrastructures.

Commodity Markets / Overview

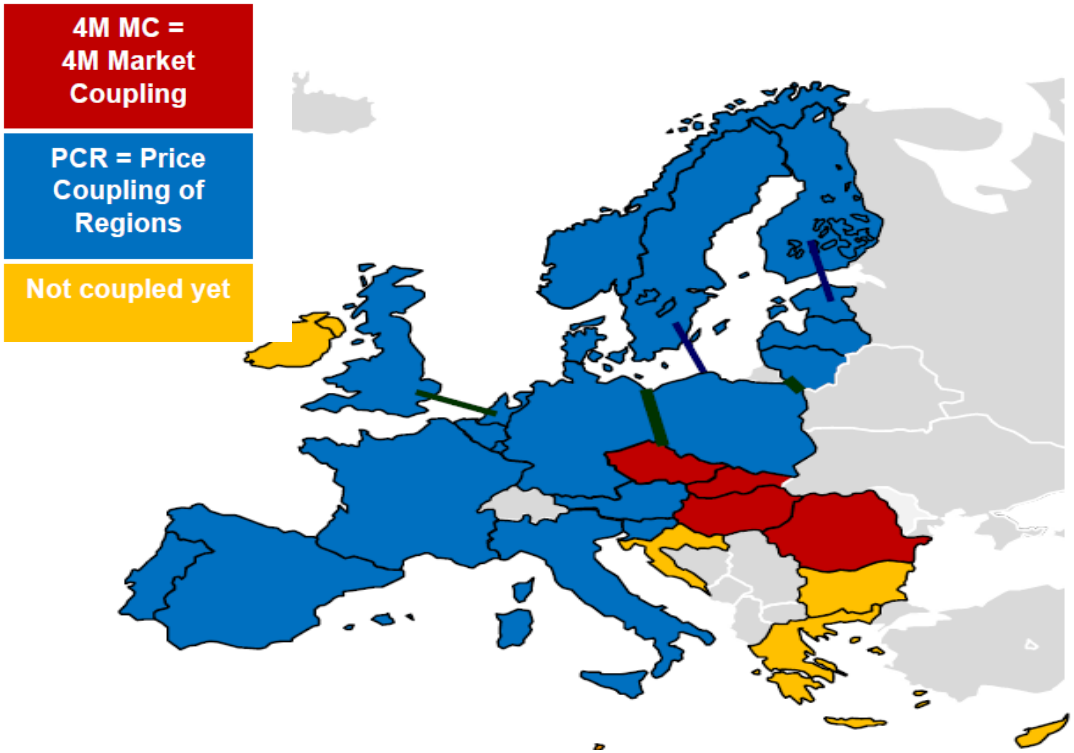
The prevailing electricity market arrangements in EU are based on physical bilateral trade, organised physical spot markets and balancing markets.



- Bilateral contracts markets based on self-scheduling, each producer may freely decide on the production schedule of each of its generating units
- Organised physical spot markets operated by Power Exchanges as day-ahead and intra-day markets
- Auctions for interconnection capacities
- Competitive procurement of ancillary services
- Separate balancing markets to maintain supply and demand balance in real, interacting with ancillary services
- Increasing integration of regional markets

Commodity Markets / Market Coupling

There has been a significant progress towards the completion of the internal electricity (day-ahead) market.



Today

- **80%** of borders coupled
- **46** borders coupled in a single coupling
- **3** borders coupled separately
- **12** borders still waiting to be coupled

Final goal

- EU-wide day-ahead market coupling
- with implicit auctions

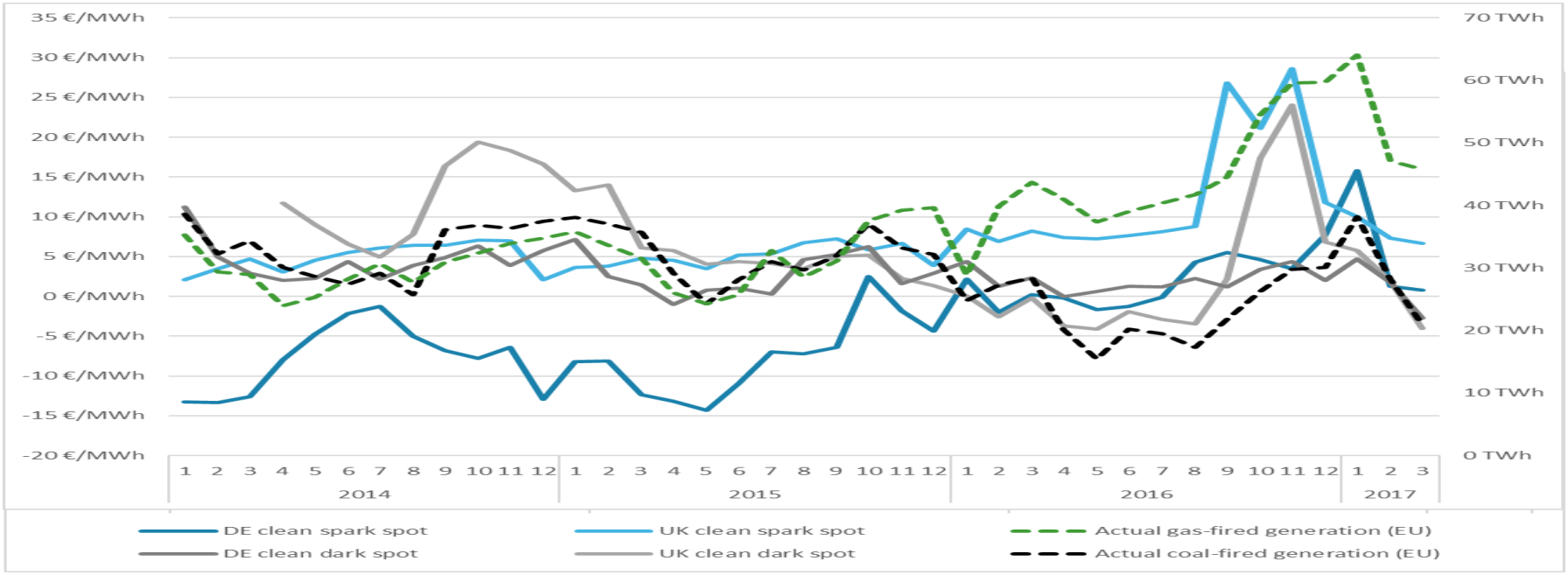
Electricity Generation / Factors Affecting Competitiveness

In the last few years, electricity producers using natural gas under-performed when compared to producers using RES and coal.

- In the last few years, electricity producers using natural gas under-performed when compared to producers using RES and coal.
- These developments were largely driven by:
  - Large promotion of RES in the EU (feed-in tariffs, feed-in premiums, tax credits and grants, auction/tender systems)
  - Shrinking production costs of RES due to the scaling-up of global production volumes and technological advances have also played an important role
  - Price competitiveness of coal supply together with low carbon prices resulting from the European emission trading scheme (ETS)
    - The competitive coal supply was largely driven by coal imports from the USA due to coal displacement with shale gas.
    - The low carbon prices were mainly due to the surplus of trade allowances allocated to companies who were the largest emitters of CO2 and therefore did not need to buy additional certificates.

Electricity Generation / Example of Producers' Performance

In 2017 the performance of gas power plants (spark spreads) has started to improve which indicates a possible change. This can be largely attributed to falling gas prices and favourable electricity prices driven inter-alia by the closure of coal-fired power plants.



Essential for the level plying field is the existence of functional wholesale markets, tariff setting/ access arrangements of the related infrastructure, improvement of the coordination between power and gas sectors, and effective emission trading scheme.

Gas Wholesale Market

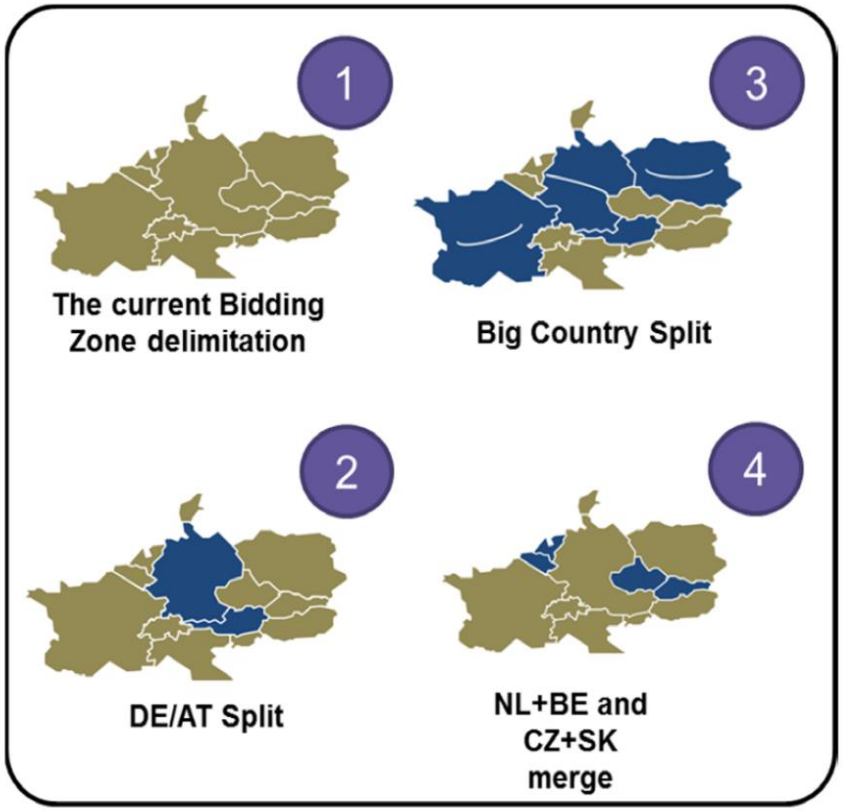
The existing market design and tariff setting/ access arrangements can be further improved.

- Wholesale Market Design
  - ACER (European regulator) revisited the gas target model (GTM) and developed a "Bridge to 2025" (wholesale market functioning, upstream competition and new developments in the gas supply chain); Quo Vadis project launched by EC aiming to assess the current market design in terms of maximising social welfare and to suggest changes to improve it
  - The GTM advocates larger markets and trading areas to pool liquidity and promote competition in upstream supply
  - Regulators may think of a series of regulatory initiatives to further develop the necessary tools for market integration across Europe.
    - A mechanism can be defined to support efficient mergers of trading hubs or markets managed by different TSOs, options including re-examination of the governance of decisions on zonal mergers, regular reviews of the gas target model
- Improve coordination of power and gas sectors
  - An improvement of the coordination of gas and power network operators is required in terms of operational decisions, time alignment also coordinated planning of new infrastructure
- Improve transportation tariffs (addressed in the infrastructure section)

Electricity Wholesale Market / Review of Bidding Zones

A question of key importance for European TSOs is the configuration and role of the bidding zones in the context of the increasing congestion in the Central European grids.

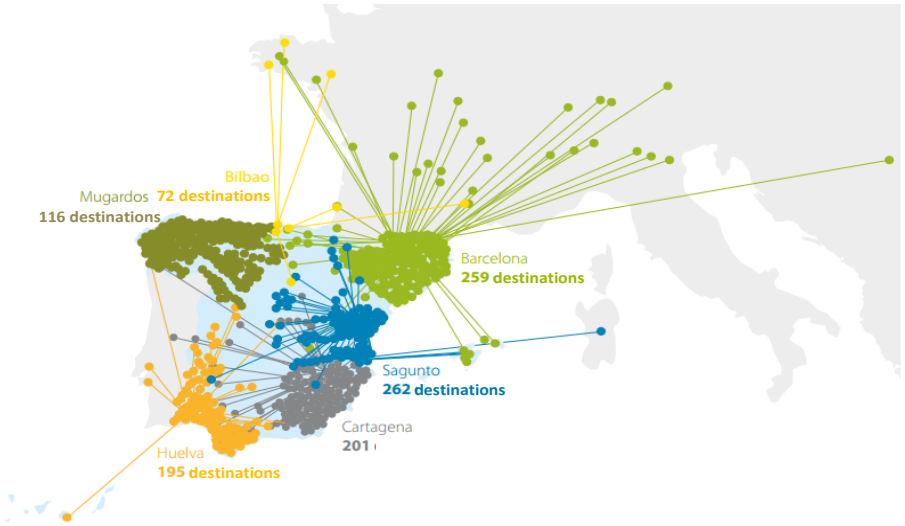
- The question has been of key importance for European TSOs, in particular in the context of the long-standing conflict about the role of single Austro-German market zone and increasing congestion in the Central European grids
- ENTSO-E has initiated a project with DNG GL, first-of-its-kind project for European TSOs, i.e. application of flow-based market coupling to most of continental European grid
  - Qualitative assessment complemented by comprehensive system and market simulations
  - Detailed simulations of continental European markets at zonal and nodal level for different scenarios and bidding zone configurations

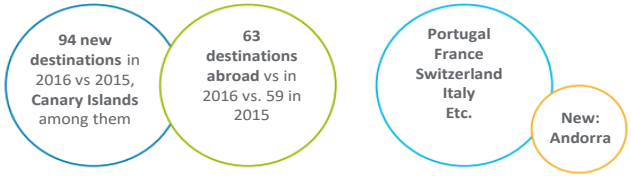


Gas in Transportation Sector / Overview

The extensive deployment of LNG and CNG technologies in the road and maritime transportation plays a substantial role in the future gas demand.

- In the last few years, gas has become increasingly important in the transportation sector, in both LNG and CNG forms.
- CNG is used in several applications including cars, buses, vans, trucks with an increasing number of vehicles being available on the market from multiple suppliers
- LNG is used in land (heavy duty vehicles) and maritime transportation (fuel for ships)
- Several initiatives have been taken both at the European and national level to foster the use of gas in transportation.





Example from Spain: The truck loading market of LNG in Spain represented 11,232 GWh/y in 2016, around 3,5% of the conventional annual demand in Spain.

Gas in Transportation Sector / Competitiveness

Natural gas can generally be considered as a competitive fuel both in land and maritime transportation.

Cost competitiveness	Gas-fuelled vehicles exhibit competitive advantages in terms of operating cost. This counterbalances the higher capital investments (however decreasing over time) to purchase them compared to regular gasoline and diesel vehicles.
Fuel availability	The availability of infrastructure for fuelling purposes (CNG/ LNG stations and bunkering facilities) still fragmented / limited. Additional investments required to increase the use of natural gas in transportation.
Emission reduction potential	In terms of environmental impact, natural gas vehicles generally have lower emissions compared to other types of vehicles, and are typically well positioned to support the achievement of environmental targets in the transportation sector.

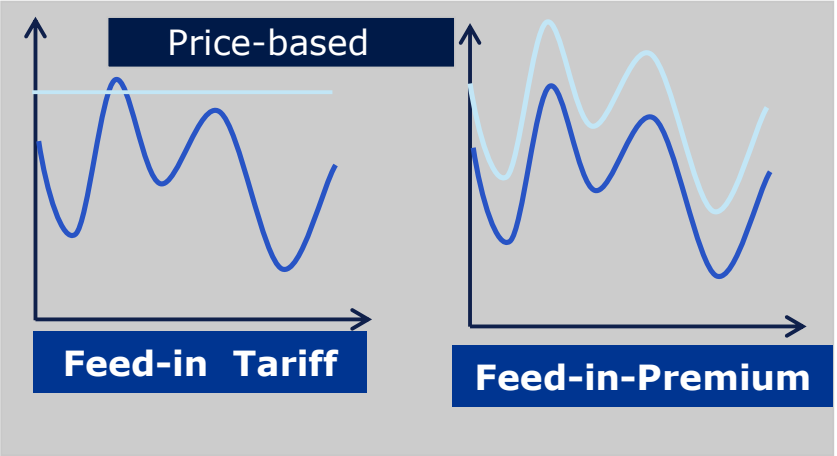
Gas in Transportation Sector / Incentive Schemes

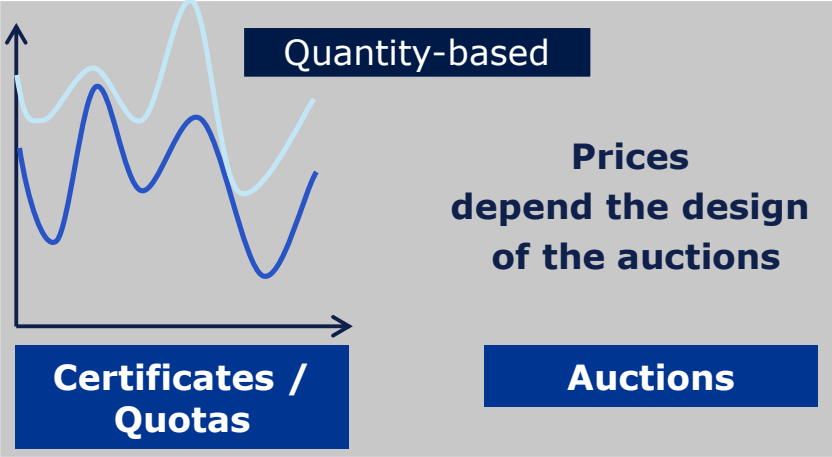
The transportation business can be considered as contestable, however explicit incentives can be considered on policy level to support the use of natural gas.

- The transportation business is largely contestable due to the presence of multiple means of transportation, fuels and different suppliers and buyers both of fuels and vehicles.
- The competition of natural gas against other fuels is, strongly affected by environmental regulation. Moreover, it is an important factor that steers vehicle manufacturers in determining the type of vehicles that they will offer to the market.
- On policy level, there are multiple measures that can be considered to support the use of natural gas. Examples for incentives on policy level may include:
  - Tax breaks for the purchasing of vehicles
  - Incentives (direct subsidies or indirect ones) for the purchase of vehicles
  - Grants for the development of fuelling infrastructure (CNG and LNG)
- Licensing requirements for the supply of natural gas (and in broader context also LNG and CNG) differ across member states. A harmonization of licensing requirements across Europe for natural gas supply may be beneficial to remove uncertainties, establish a level playing field for competing fuels and facilitate cross-border activities.

RES Electricity / Support Schemes

The majority of EU countries have been applying price-based models for RES. In the last years several countries have reviewed and changed their RES arrangements.





- Issues with price-based models
  - Limited efficiency
  - Oversized incentives for RES construction
- Issues with quantity-based models
  - Higher risk exposure
  - Setting quotas (technology neutral / technology specific)

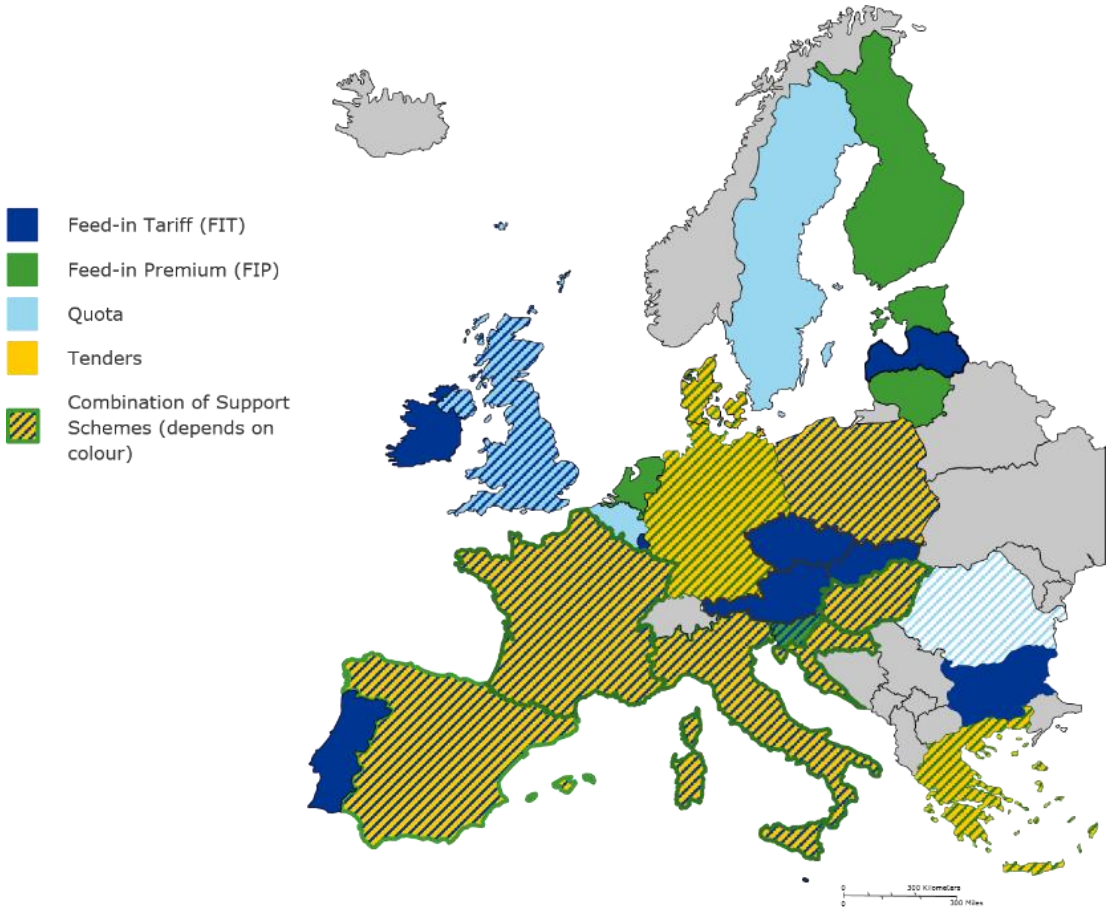
Re-design properties

- Choice of technology and location
- Regional compatibility
- Market fragmentation (RES and non-RES market) versus / one integrated market
- Degree of administrative interventions
- Overall congruence with the objective of competitive markets

RES Electricity / Use of RES-E support in the European Union today

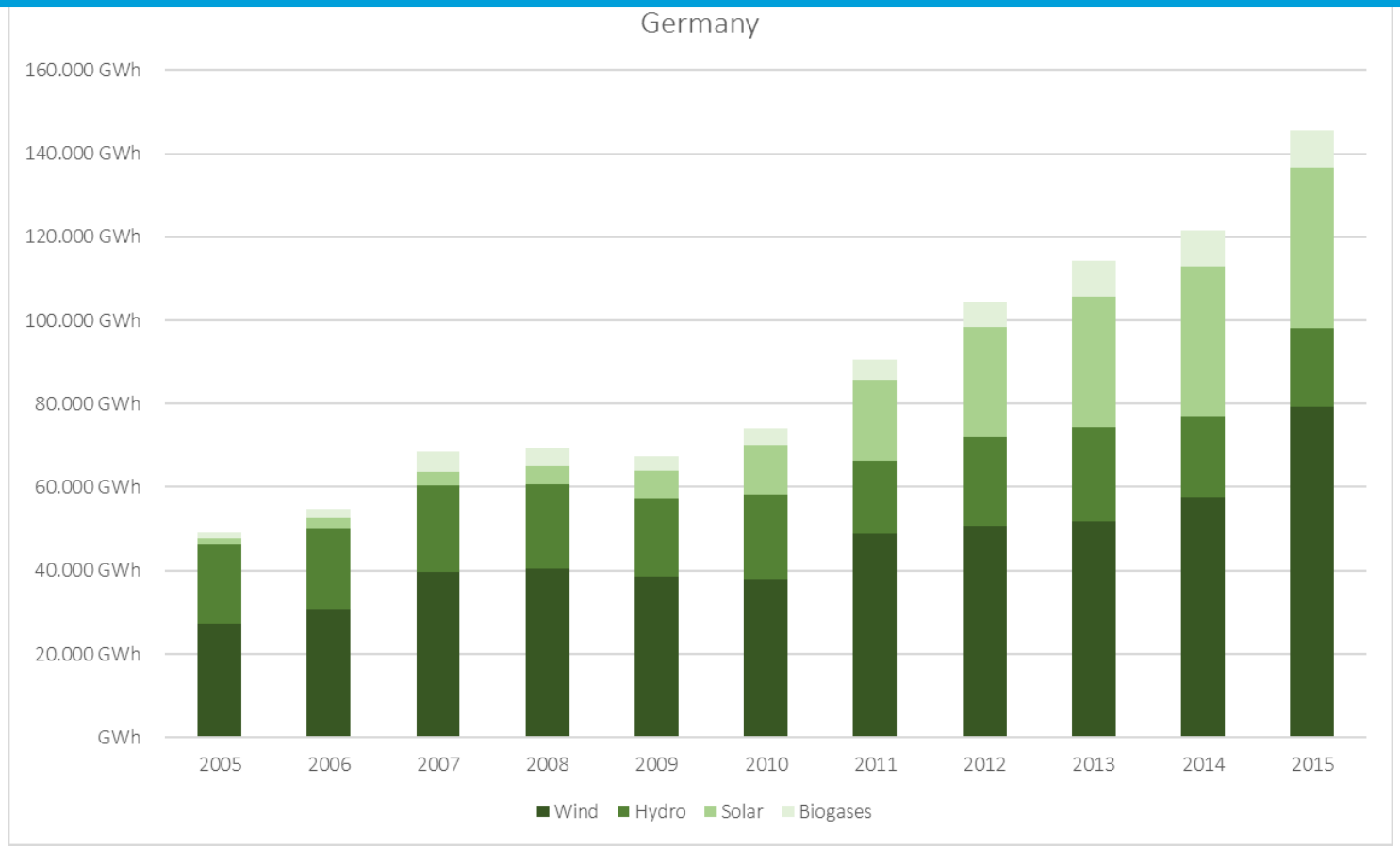
Feed-in-Tariffs were dominant support scheme for several years.

- Feed-in-Tariffs were dominant support scheme for several years, today the member states move towards market base support schemes
- EU *Guidelines on State Aid in Environmental Protection & Energy* mandate:
  - Operator responsibility for sales of electricity to wholesale market
  - Balancing responsibility for operators
  - Pilot projects for tender (auction) mechanisms



RES Electricity / Germany

From 2005-15, share of RES in net electricity consumption increased from 9% to 28%

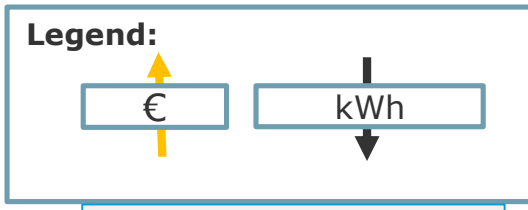


RES Electricity / Germany

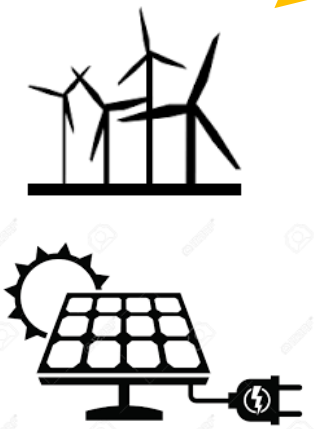
Simplified Illustration of the RES support scheme

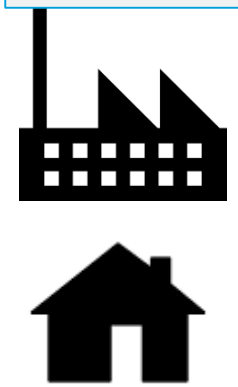
RE asset operators sell electricity in wholesale market or bilaterally

Traders



Consumer pay for electricity purchased





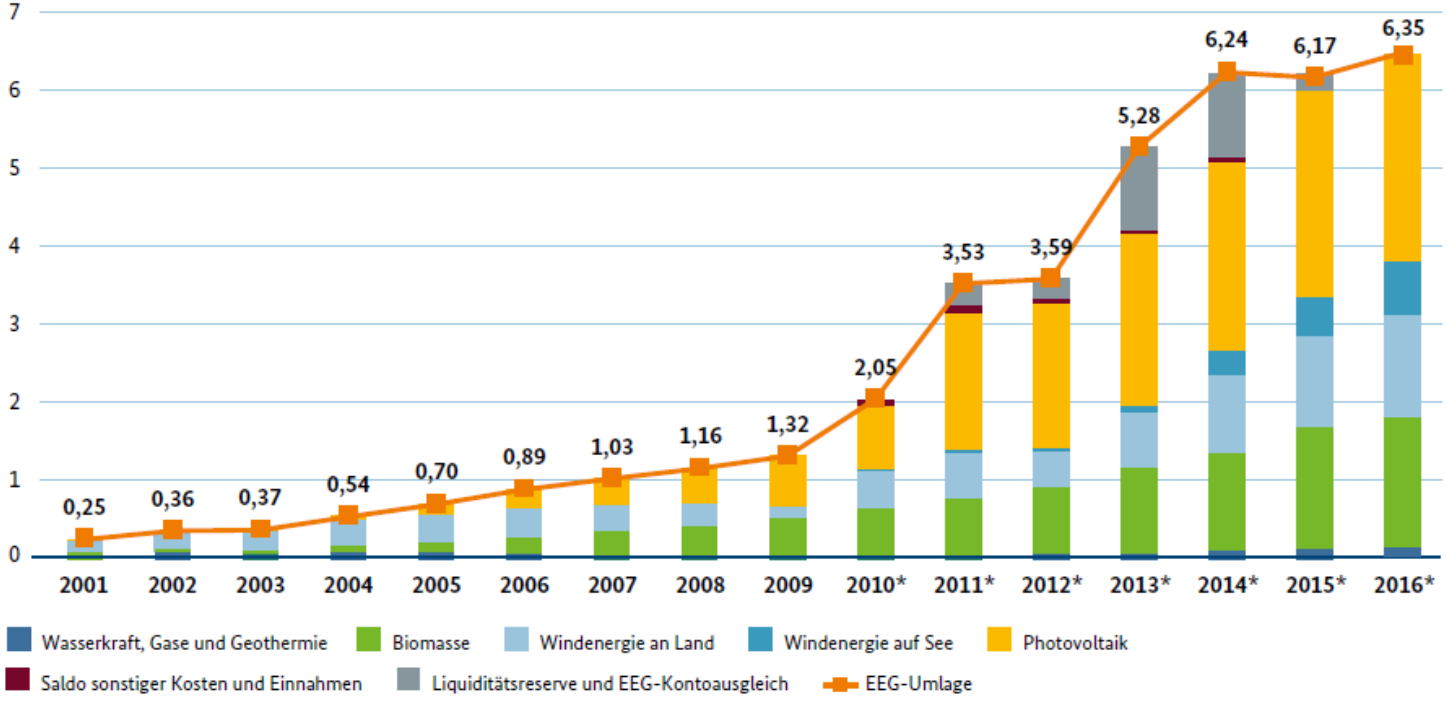
Grid access & priority feed-in for RES-E; support from DSO/TSO

Consumers pay a levy for RE to the DSO/TSO

RES Electricity / Germany

Development of the support cost in Germany

Development of unit EEG support cost 2001-2016



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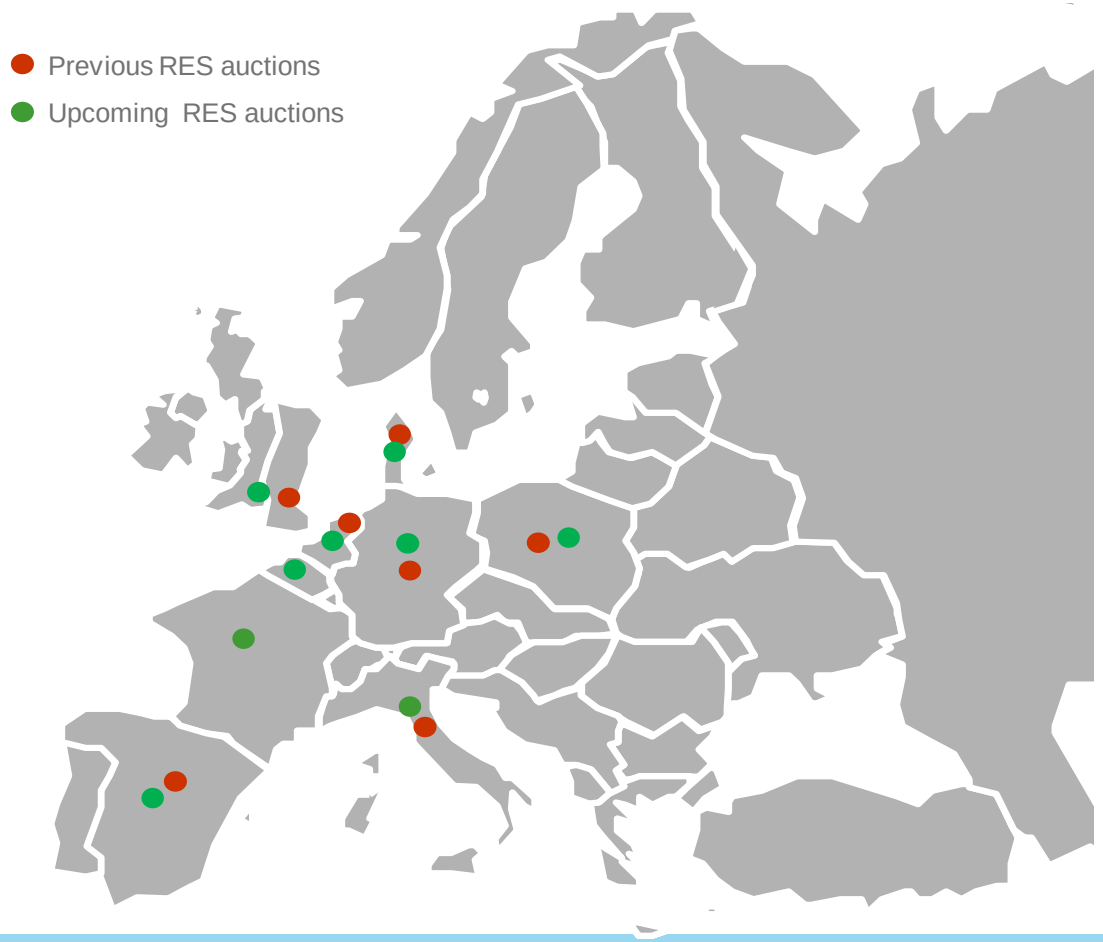
RES Electricity / Use of Auctions

Auction processes for RES deployment is becoming a widespread trend along Europe.

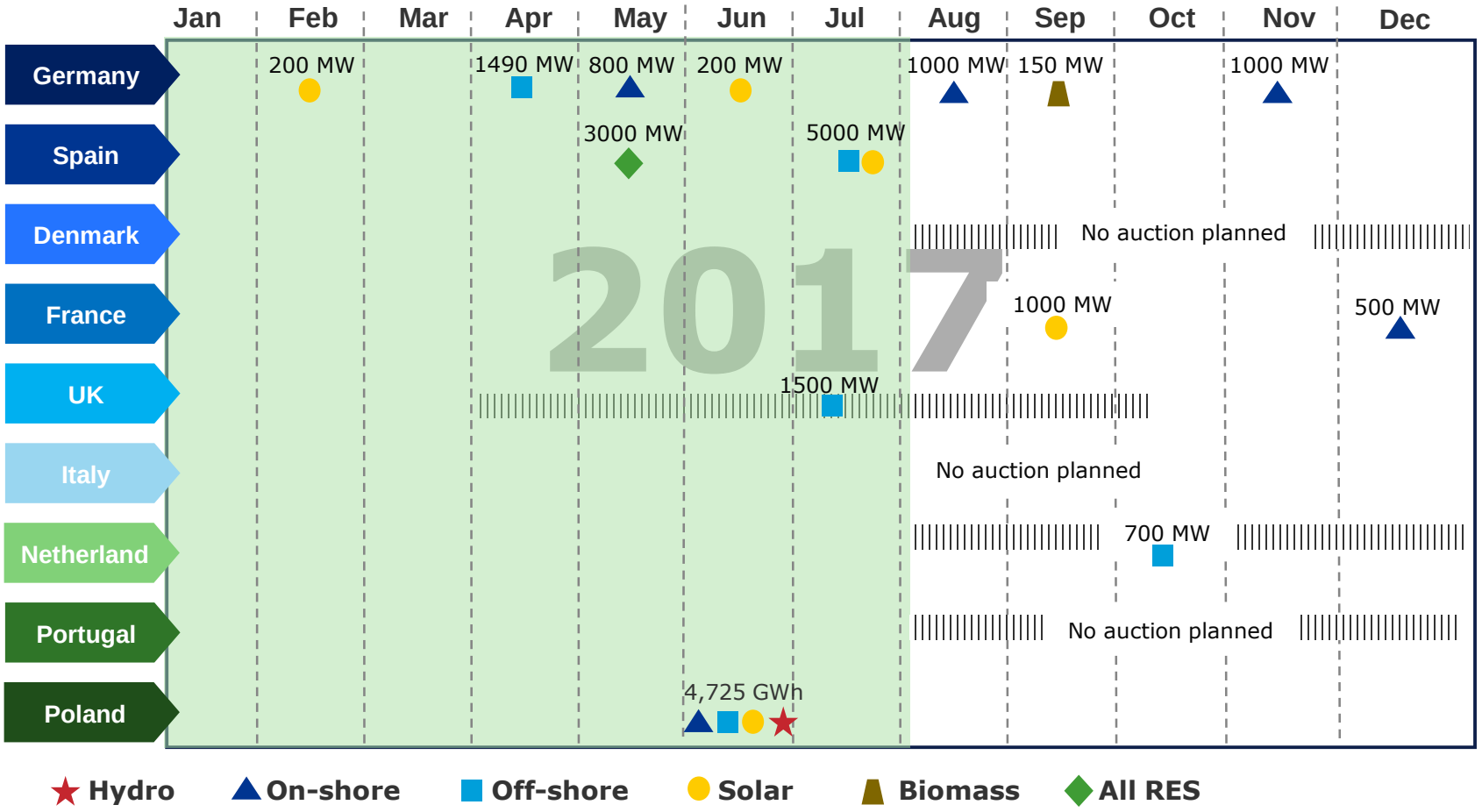


Examples

- Denmark and Italy were the first countries to introduce RW auctions
- Germany has scheduled various technology specific auctions that will continue over the next years
- France and Netherlands have introduce tender systems with strong focus on wind energy
- Spain has recently introduced the first large scale (3 GW) auction scheme and new tenders will follow

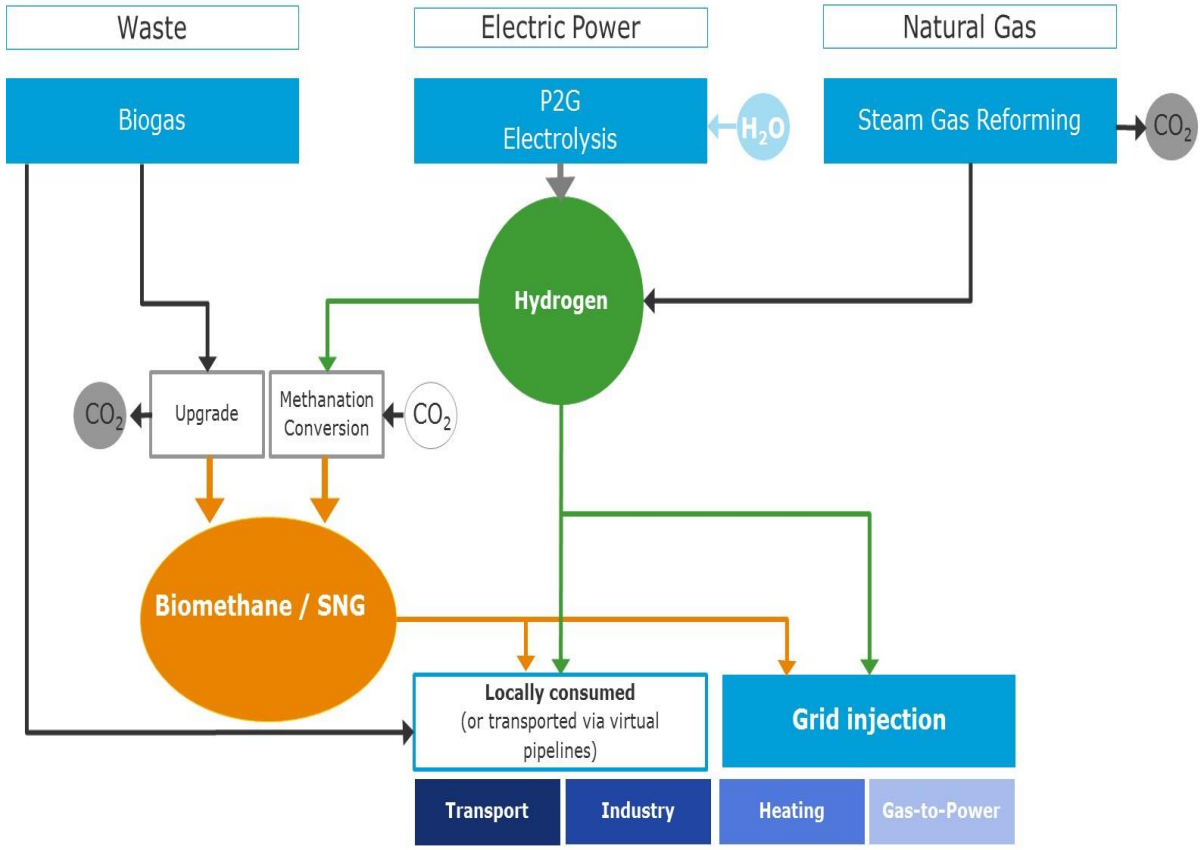
RES Electricity / Use of Auctions

Examples of auction schemes from EU



RES Gases / Overview

Because of their low CO2 content, the role of renewable gases as well as their processes have been increasingly emerging as technologies with a high potential for decarbonisation.



Renewable gases are gases produced from renewable sources.

They are able to substitute natural gas and include biogas upgraded to biomethane and synthetic natural gas (SNG) produced in methanation process.

Currently blending of small hydrogen proportions exists, blending of larger quantities still under development.

Production cost still high and development of renewable gases depends on policy and regulatory support.

Renewable Gases / Regulatory Measures

Production of new gases is potentially contestable, however regulatory and policy interventions to address positive externalities is often used in practice.

- Production of hydrogen and biogas production are potentially contestable activities and there is no normative need for regulation if functional markets exist.
- However, similar to RES in electricity sector, policy interventions to address positive externalities related to renewables gases are common and often used in practice. They aim to support commercial viability and to encourage supply of such gases as environmental benefits resulting from their use are not adequately reflected in in the respective output prices.
- The policy interventions can be implemented through methods ranging from feed-in tariffs, to tax breaks and investment support etc.
- Green certificates can be used to support the establishment of regional markets for biomethane.
- Regulators in some jurisdictions (for example UK, Ireland, France) have provided funds to support the research and development of these new technologies.
- This has included pilot projects for possible injection of biogas and hydrogen into the gas network and exploring gas quality specification of biogas, hydrogen blend for example.

Infrastructure

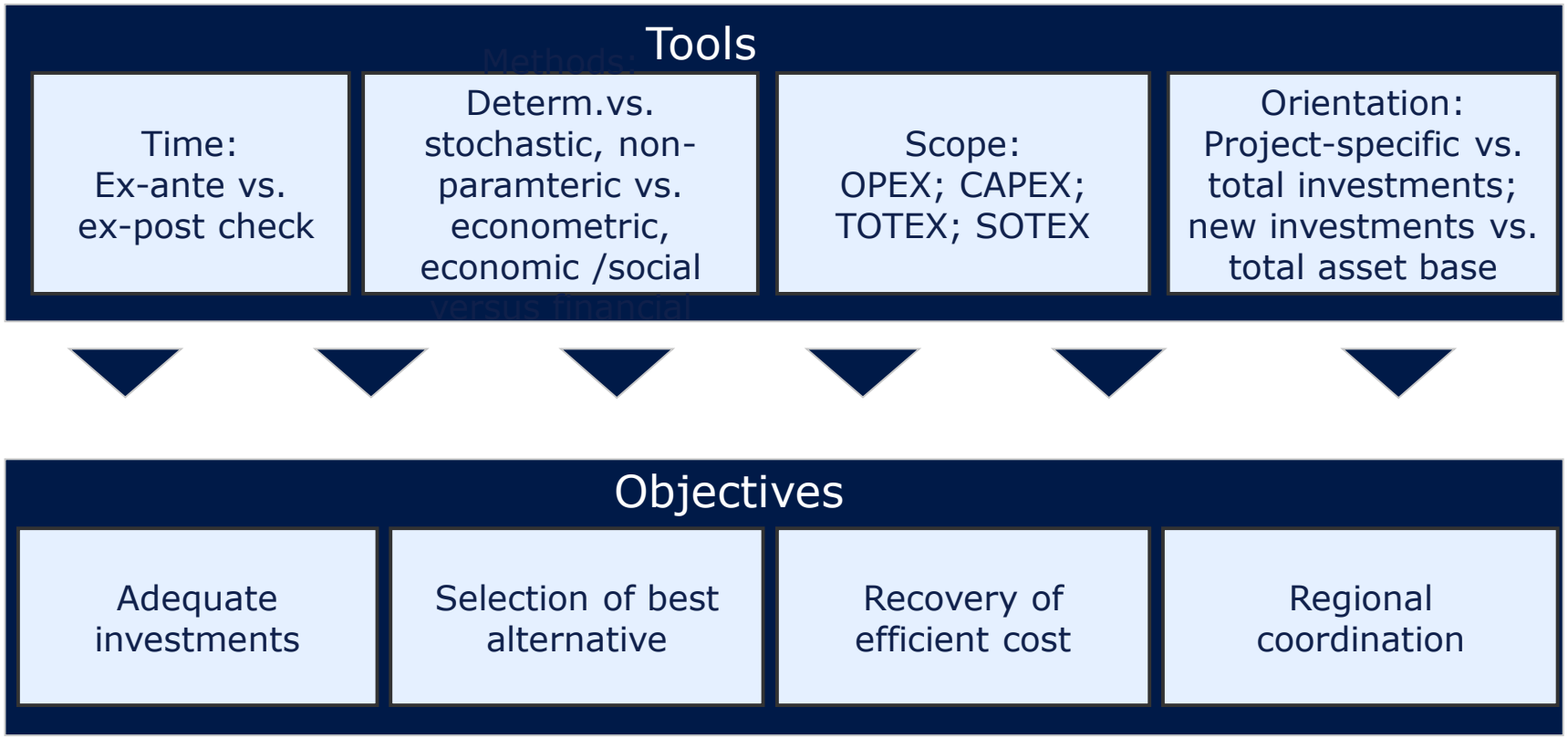
Conventional Infrastructure / Overview

In the EU electricity and natural gas networks are typically regulated, however member states may opt for negotiated or regulated access regime for gas storage facilities.

- Energy networks are also characterised by high initial and irreversible investments, and has a relatively long asset, they are considered natural (regional) monopolies
- Other activities like gas storage, which are principally contestable, can become de-facto monopolies due to various limitations.
  - For example, the provision of storage services may be limited due to operational or physical constraints or requirements of the permission rules. Limitations may also appear due to the limited market size of the relevant market that may hinder the establishment of functional competition. In such circumstances, these activities will require regulation including access and capacity allocation rules.
- In the EU electricity and natural gas networks are typically regulated, however member states may opt for negotiated or regulated access regime for gas storage facilities
- Majority of regulators apply incentive regulation using different forms of efficiency analysis
- There are explicit incentive schemes for specific revenue components including inter alia losses, ancillary services

Conventional Infrastructure / Role of Regulation

Regulation should provide a robust analytical and coordinated framework to support the selection of adequate and efficient investments on national and regional level.
Cost-Benefit Analysis (CBA) should be applied for evaluation of new investment projects.



Conventional Infrastructure / Asset Stranding

A continuous and structured decline of demand could potentially lead to under-utilisation (and potentially stranding) of infrastructure assets and require specific regulatory reaction.

- The development of future demand affects the traditional energy infrastructure. While a stable and high demand requires to maintain and extend the networks, a continuous decline of demand could potentially lead to under-utilisation and stranding of network assets.
- For example in gas industry, demand in the residential sector can fall due to energy efficiency programs. Furthermore, gas demand in the power sector may decline, after 2020, when the power sector reaches full decarbonisation.
- Regulatory approaches typically presume future consumers will meet a substantial proportion of the capital costs of investments made today in the energy infrastructure. Yet changes in demand, technological innovations and climate policy targets have made this presumption less certain resulting in potential for asset stranding.
- In the future regulators will need to address the questions for potential asset stranding and develop appropriate compensation schemes for adjusting allowed revenues of the regulated network companies.

Conventional Infrastructure / Gas Transmission Tariffs

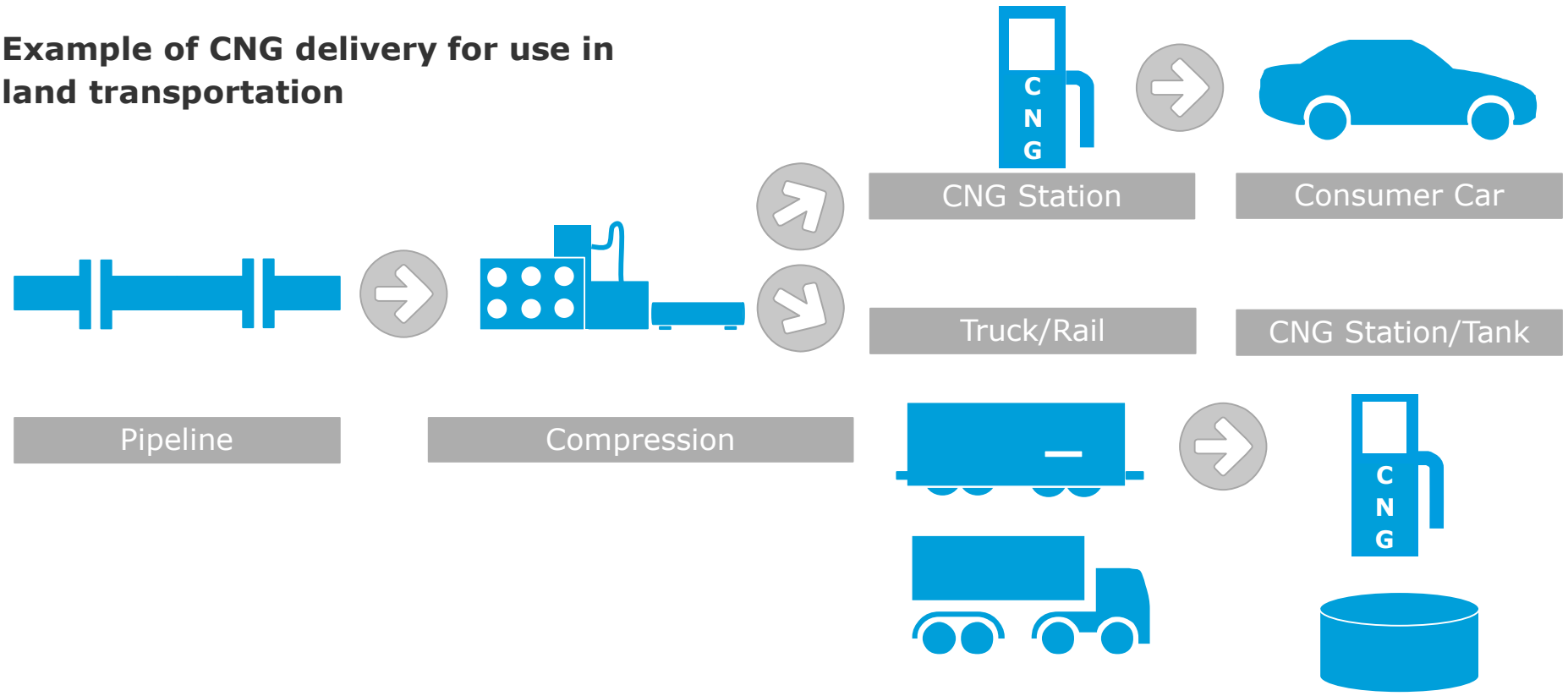
Regulators may consider revisiting elements of the tariff design of the gas transmission networks.

- The transmission tariff design is set out in the Network Code Tariffs (TAR NC) which was adopted in March 2017 and now is being implemented. The code deals with tariff design at interconnection points, and not at domestic network points.
- A steadily declining demand and excess transportation capacity may necessitate a basic rethinking of the network tariff design.
  - Role of auctions for capacity allocation
    - With decreasing gas demand in some regions/routes, the auction prices would fall. Auctions can play a role to allocate uncongested capacity, however auction revenues may not be sufficient to recover the cost.
  - Role of reserve prices and their structure/ level, aiming to continue providing efficiency signals and cost revenue recovery
- The current design of network tariffs can discourage the efficient use of gas-fired power plants in some cases by creating excessive costs for such plants in accessing the gas network and gas supplies. Regulators may consider revisiting elements of the tariff design, e.g. adequate short-term capacity charges that will not discourage users to book this capacity.

Gas Infrastructure in Transportation / Example

There are multiple options to deliver CNG / LNG to users. Often the transport is based on virtual pipelines, i.e. transport by rail or track.

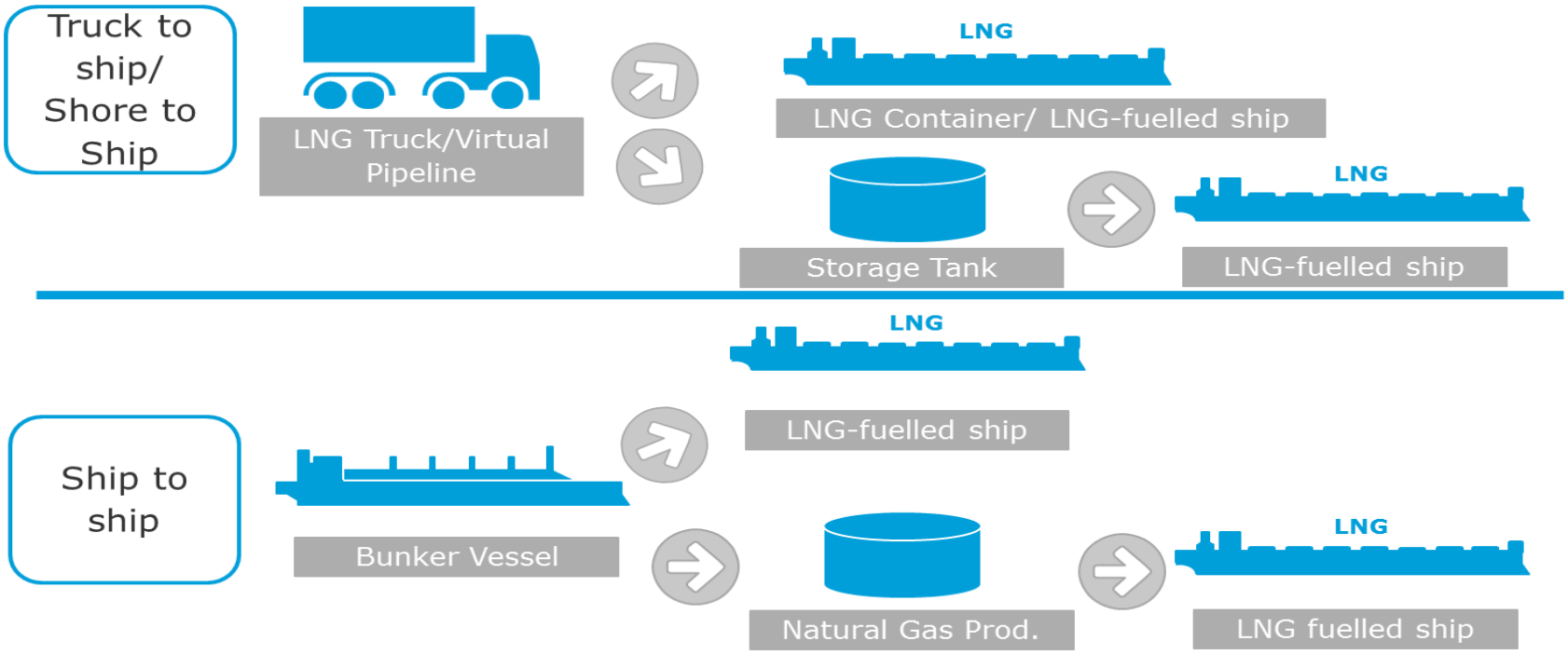
Example of CNG delivery for use in land transportation



Gas Infrastructure in Transportation / Example

There are multiple options to deliver CNG / LNG to users. Often the transport is based on virtual pipelines, i.e. transport by rail or track.

Example of LNG delivery for use in maritime transportation



Gas Infrastructure in Transportation / Nature

The increased use of CNG/LNG in transportation determines the important role of the infrastructure for these emerging markets.

- CNG and LNG infrastructure makes CNG and LNG available for use as a fuel in transportation
- Infrastructure comprises:
  - Physical pipeline and non-pipeline transport (virtual pipelines) / connection to the gas networks
  - CNG and LNG refuelling stations including compression equipment to convert natural gas in CNG or LNG
- Contestability
  - Specific parts of the value chain like physical networks to transport gas to the CNG refuelling stations constitute a natural monopoly and should be regulated
  - Other activities like gas storage, which may not be natural monopolies, can become de-facto monopolies due to physical or operational limitations
  - Transportation via virtual pipelines (LNG/CNG) or provision of refuelling station services are contestable activities and can be provided in a competitive environment
  - Monitoring specific segments to prevent from distortion of competition /abusive use of market power (for example LNG and CNG refuelling stations)

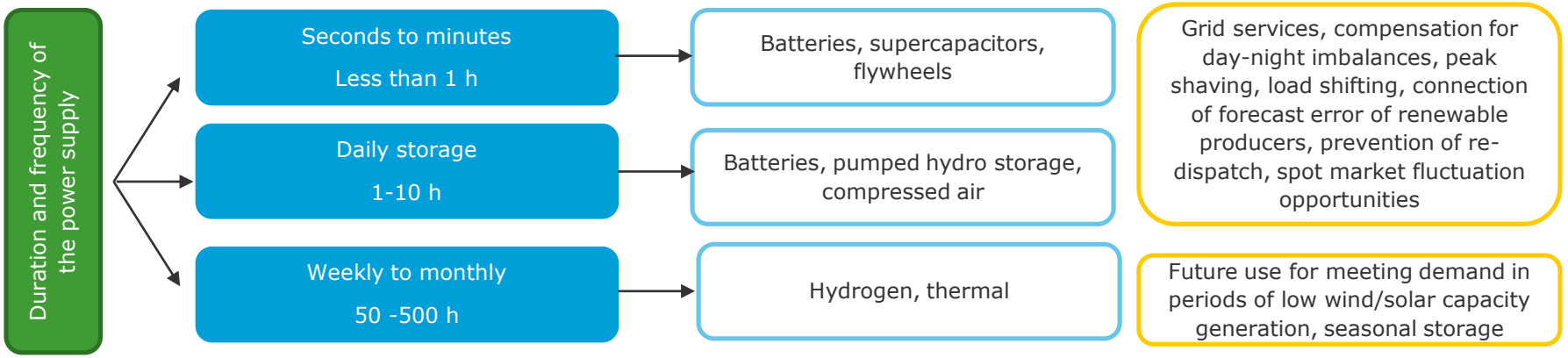
Gas Infrastructure in Transportation / Role of Regulators

The changing business environment and new business models require adequate regulatory reactions.

- Network operators may opt to diversify their business models towards contestable activities (P2G, CNG/LNG)
  - Complementary to the traditional transmission / distribution (diversification and scope effects)
  - Contribute to the commodity demand which in turn may encourage network demand (scale effects)
- Such involvements can provide various benefits in terms of infrastructure development, network security and increase competition
- Role of regulators
  - Should not create a barrier and should ensure that customers and market participants benefit to the largest extent possible from the range of services
  - Should recognise the existing advantages of network operators due to the experience and knowledge in development and management of gas infrastructure
  - Should prevent (unintended) interactions between the regulated and contestable sectors
  - May consider adapting the existing unbundling rules, by recognising explicitly the specific circumstances and the motivation for such involvements

Electricity Storage / Overview

Different type of storages have the ability to intervene in different sections of the electricity market as they meet different needs of the power system.

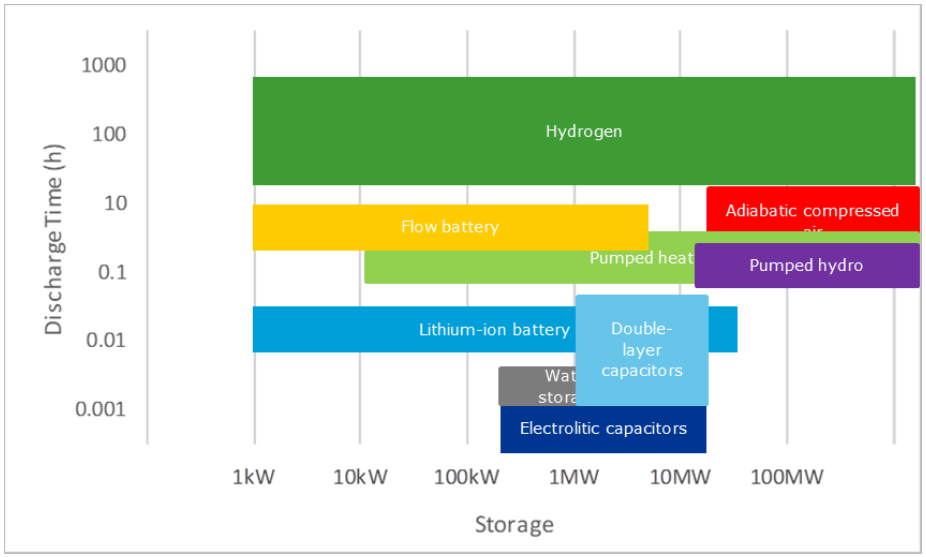


The role of storages is determined firstly by their discharge and response times, or duration and frequency of the power supply they can deliver. Different sections of the electricity market will in fact require different discharge times by storage providers and different response times.

Batteries / Properties

Batteries have several competitive advantages and their costs have significantly decreased in the last years.

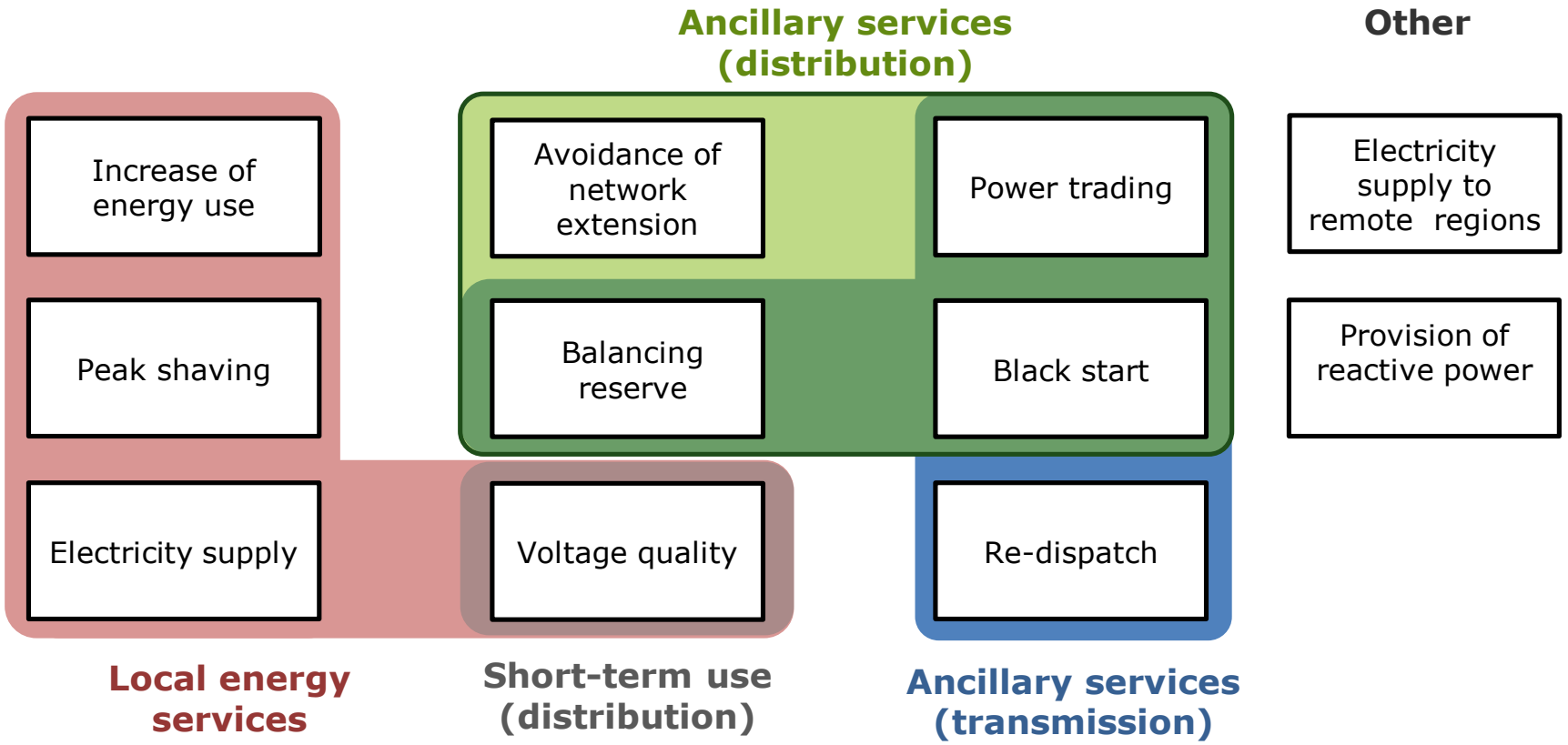
- Lithium-ion batteries are able to deliver significantly higher capacities compared to other forms of storage.
- The modular nature of batteries allow to move them quickly to different locations and at limited cost.
- The overall efficiency of battery storage (lithium-ion) is higher than other types of storages.
- The discharge time of battery storages in the range of minutes.
- In the last years, large cost reductions for battery storage, in particular lithium-ion batteries, due to demand increase for electric vehicles (EVs) and consumer electronics



- The cost is also expected to continue decreasing pushed by economies of scale and reductions in production costs.

Batteries / Nature of Services

Batterie can provide services in the competitive and regulated industry segments, and regulators have been challenged in designing suitable rules.



Infrastructure for Renewable Gases

Hydrogen

- Hydrogen can be transported via trucks/rail cars or pipelines. The transport by trucks or rail cars is relatively new across European markets, mostly involving a large industry partner participating in pilot projects.
- While small hydrogen pipeline networks already existing (e.g. Germany, the Netherlands), the technical feasibility of hydrogen transport through natural gas networks is still under research.
- The transport of hydrogen via pipelines of natural gas network should be a regulated activity. It is likely that new hydrogen pipelines will have similar economic characteristics to the existing natural gas networks and therefore should be regulated.
- Regulators should:
  - Accompany and steer the transition towards higher hydrogen quantities blended in the gas networks (adjust the technical specifications for the blended natural gas and regularly amend the relevant regulation)
  - Steer the technology roll-out in terms of time and targeted penetration zones where the hydrogen quantities will gradually grow
  - Develop the design of the commercial and access arrangements of such a system.

Infrastructure for Renewable Gases

Biogas / Biomethane

- Biogas can effectively be a substitute for natural gas once it is further refined and converted to biomethane.
- The transport of biomethane via pipelines of natural gas network should be a regulated activity.
- In the transportation process, the network operator must follow gas quality standards and only allow biomethane that satisfies these standards into their network.
- Energy regulators should set clear connection rules including connection charges, technical connection requirements, responsibilities for setting and maintaining the relevant product quality norms, metering and compression.
- They may consider providing explicit incentives in national regulation to the parties injecting biomethane into the natural gas networks via favourable network tariffs and connection charges.

Regulatory Incentives for Innovation and Decarbonisation

Regulation can apply specific arrangements to promote and encourage innovation investments.

- Investment in innovation is happening in Europe, irrespective whether the funding is part of the regulatory framework and/or on a national policy level.
- However, regulators can provide explicit incentives for innovation as part of the regulatory framework. This would facilitate development and drive improvement in processes and technology application.
- In practical terms national regulators should set clear objectives and qualification criteria for what projects would be subject to innovation incentives.
- For example the innovation project should relate to the development, and research in a field, or technology that could help achieve certain targets, for example decarbonisation.
- Innovation can be incorporated into the regulatory framework by explicit adjustment of the allowed revenues
- There are multiple practical experiences from European regulators (UK, France, Ireland)

EU Policy versus Member States Interest

While individual states may have eligible motives for their policy, a lack of coordination can lead to inefficient network infrastructure and distorted market conduct.

EU policy is not always congruent with the interests of the member states.

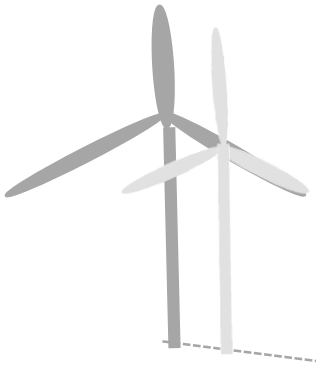
EU Motivation	Motives of Member States	Conflicting Areas (examples)
• Integrated market • Harmonised cross-border access regime • Coordinated evaluation and development of efficient infrastructure • Coordinated RES policy	• Act in the national politic, economic and social context • Respect public view in own countries • Sensitive to increase of national energy prices • Sensitive to competitiveness of national industry • Sometimes reluctant to change existing routines and practices	• Market integration efforts • Harmonisation initiatives • Regional investment projects (allocation of cost and benefits) • Design of RES support schemes (choice of optimal location and technology)

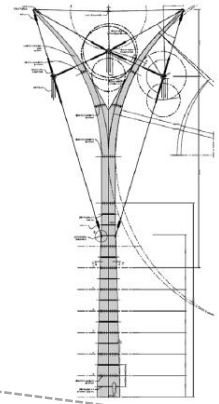
Conclusions

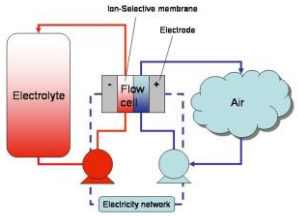
- Regulators and policy makers should recognize the on-going changes in energy industry and provide adequate response
- Regulatory framework should encourage the coordinated development of adequate energy infrastructure and provide consistent set of investment incentives
- Market arrangements should enable the efficient integration of RES and avoid market fragmentation
- Besides natural gas, other gas forms (LNG / CNG and renewable gases) will be used in the future.
- The existing gas infrastructure may also be facilitating the penetration of other gas forms, and particularly of renewable gases.
- Innovation should be explicitly addressed in the regulatory frameworks
- The complex transition process involves substantial changes along the entire value chain and requires:
  - Adequate policy and regulatory attention, and
  - Effective coordination between policy makers, regulators and industry as well.

Appendix: New Technologies / Innovation

New Technologies / Overview (Selected Examples)







Generation
- Gearless wind power
- Unconventional gas

Electricity networks
- Cabling
- Offshore grid
- Flow control
- High temp. conductors
- Tower design

Electricity storage
- Batteries
- Compressed air storage
- P2G

Energy conversion
- Methanation
- Electrolysis
- Fuel cells

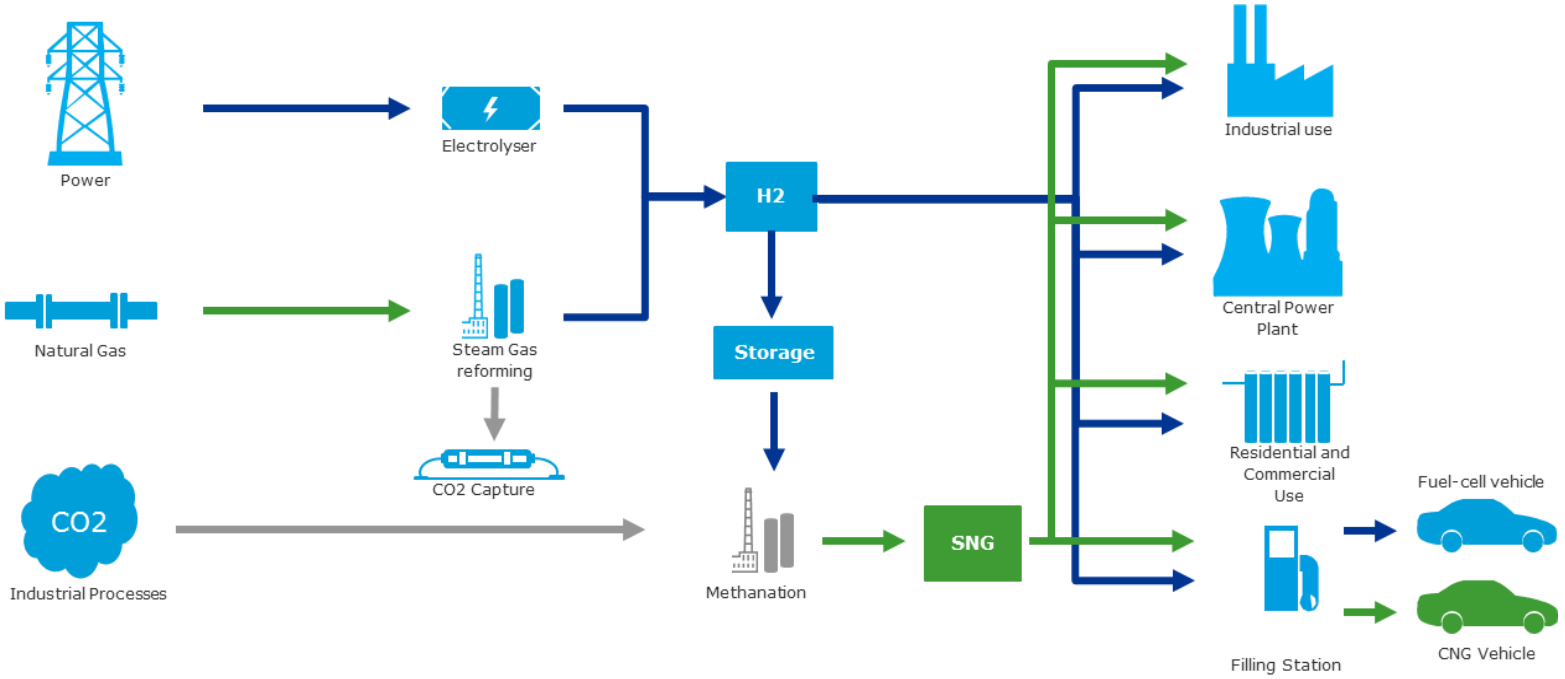
Use of gas
- LNG/ CNG/ LPG/
- Biogas
- H2

- Energy consumption
- Smart homes
- Mobility (E-cars, H2)

New Technologies / Electricity Transmission

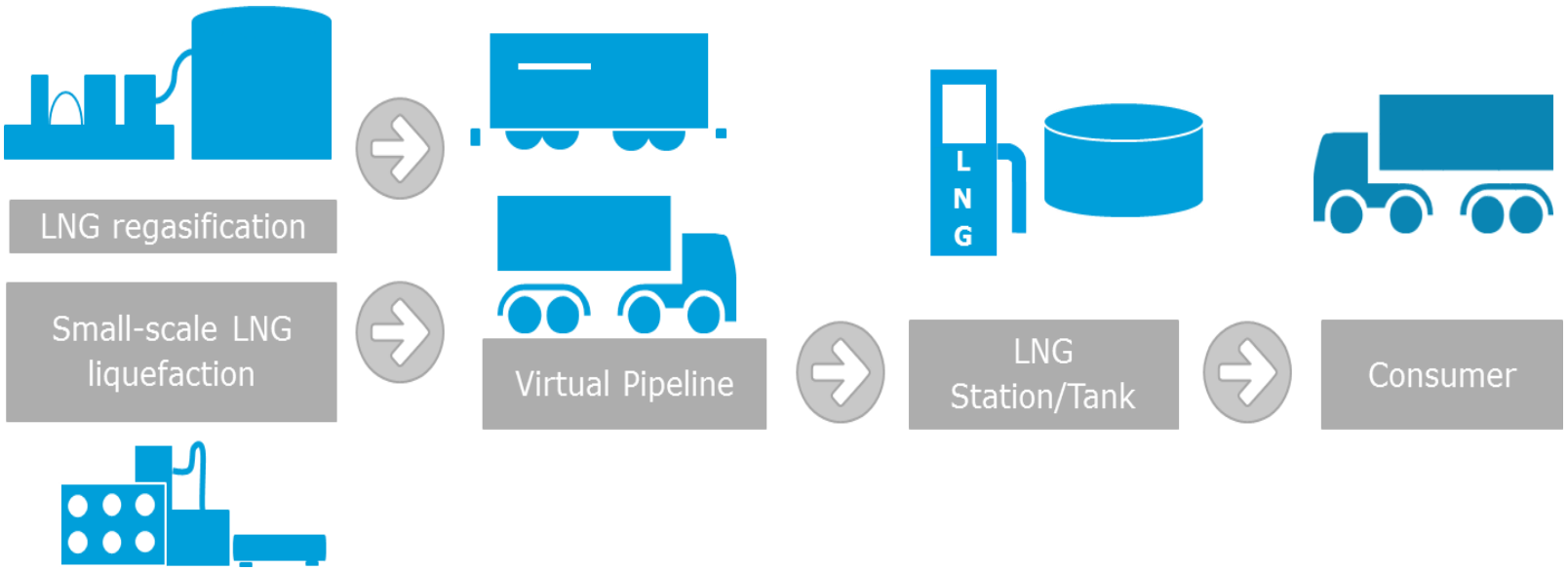
Passive technnologies	Active Technologies	Digital technologies
XLPE underground cables	Power Electronics/ FACTS	Control Center technolgies
Gas Insulated Lines	DC Techn ology	Dynamic rating
High Temperature Conductors	Must- run units	Equipment Condition Monitoring
Superconductors	Fault Current Limiters	Wide Area Monitoring
Innovative OHL towers	DC Breakers	Wide Area Protection and Control

New Technologies / P2G



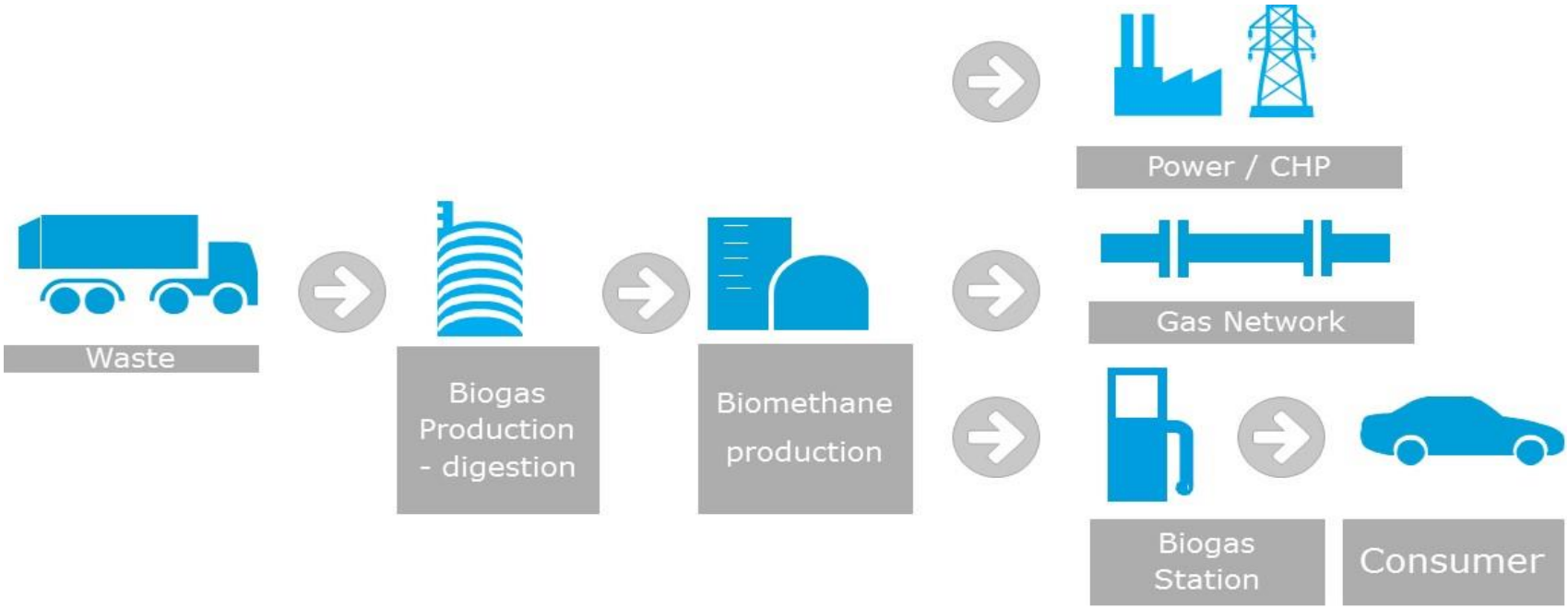
P2G and hydrogen production value chain are closely connected through multiple combinations. The main components in the value chain include the input sources hydrogen production (electricity, natural gas, CO2), the production process and the end-users of hydrogen (industrial, power production, residential or transportation).

New Technologies / LNG in Land Transportation



The LNG value chain includes two possible options. In the first case, LNG is off-loaded from a ship at an LNG regassification terminal and consequently loaded on trucks or train cars (virtual pipelines) for delivery at LNG refuelling stations. In the second case, LNG is produced at a liquefaction plant connected to a natural gas transmission or distribution grid. The LNG produced at the plant is consequently loaded on trucks or train cars for delivery at LNG refuelling stations. .

New Technologies / Biogas



The biogas/biomethane value chain exhibits multiple options. They always include the source of waste, and the biogas and biomethane production plants. The final use of biomethane can be different in the different value chain options. Biomethane can in fact be used either as a fuel for power and heat production, it can be injected in natural gas networks, or it can be used at refuelling stations delivering biomethane as a fuel for transportation (land). In practice biogas, not upgraded to biomethane, is used to produce electricity and heat.

Thank you!

Dr. Konstantin Petrov
Managing Consultant

Konstantin.Petrov@dnvgl.com

Telefon: 0049 228 44 690 58
Mobil: 0049 173 5151946

KEMA Consulting GmbH
Zanderstr. 7
53177 Bonn
Germany

www.dnvgl.com

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