

Market Design for High Shares of Renewables: Is Radical Change Required?

Presentation based on study for IEA RETD

CEEM Chair - Workshop on Market Designs for Low-Carbon Electricity Generation

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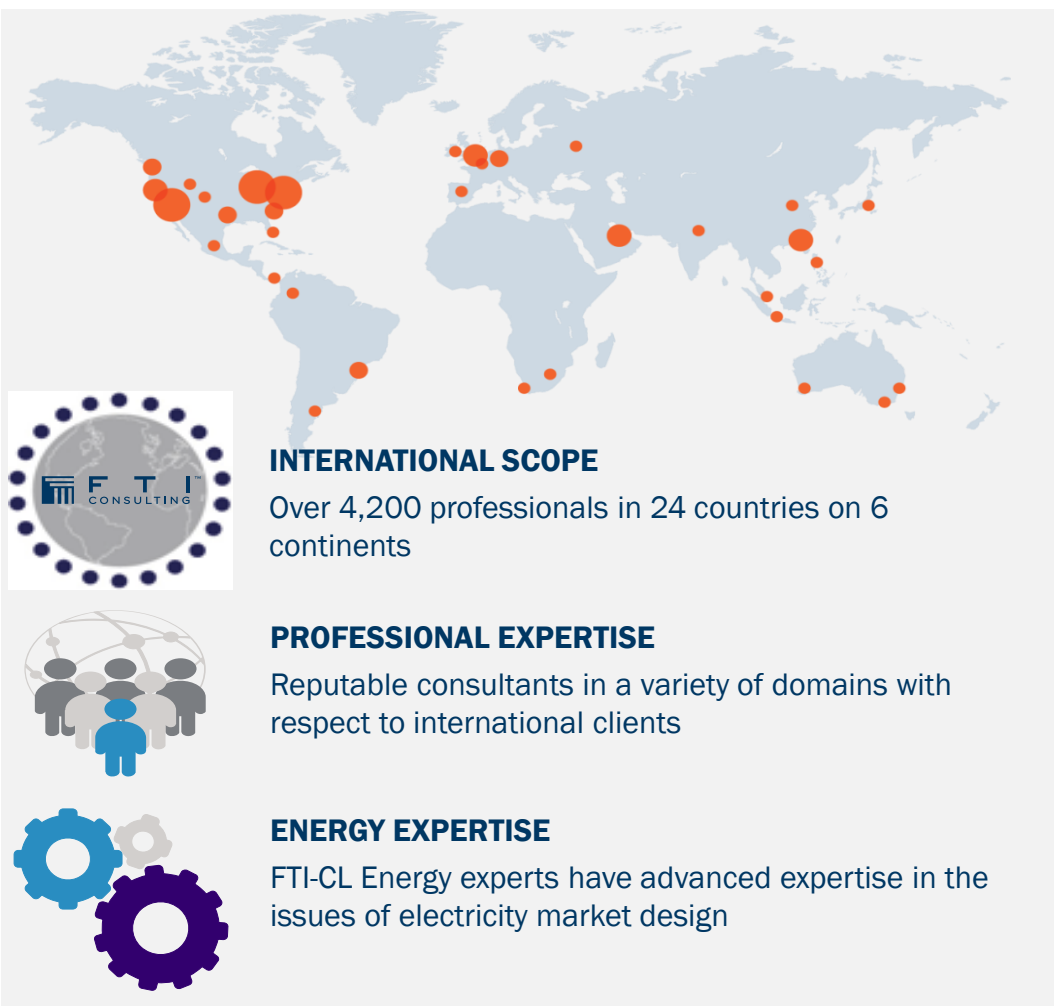


Content

- Study context and objectives
- Key challenges for power system with high shares of VRE
- Criteria for an ideal power market design with high shares of VRE
- Diversity of power market design – Case studies of market prototypes
 - Energy only market
 - Hybrid market
 - Vertically integrated system
 - Prosumer market
- Conclusions and policy recommendations
 - Wholesale market
 - Retail/Wholesale market interface
 - Overarching recommendations

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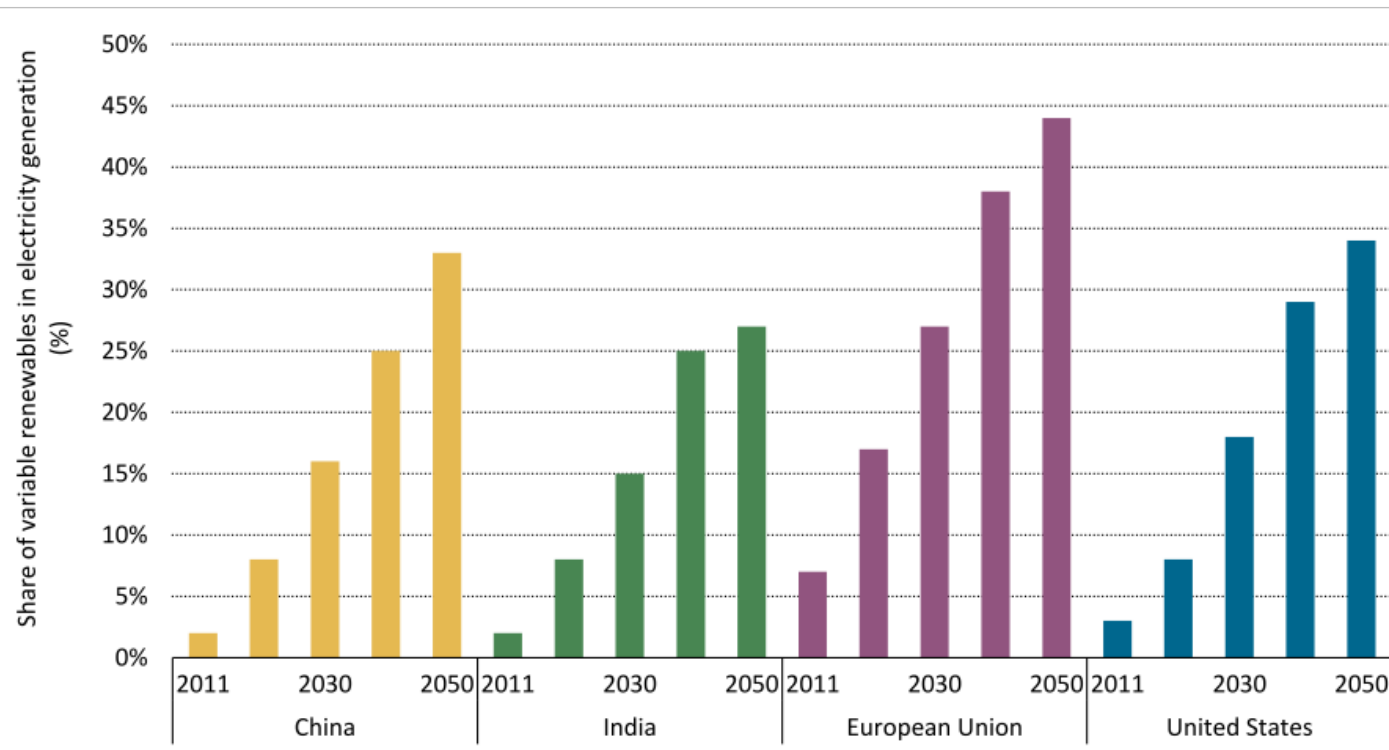
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1. The economics of wind and solar power
2. Design of spot and balancing power markets
3. System costs / integration costs
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Study context: Toward high shares of renewables in the generation mix

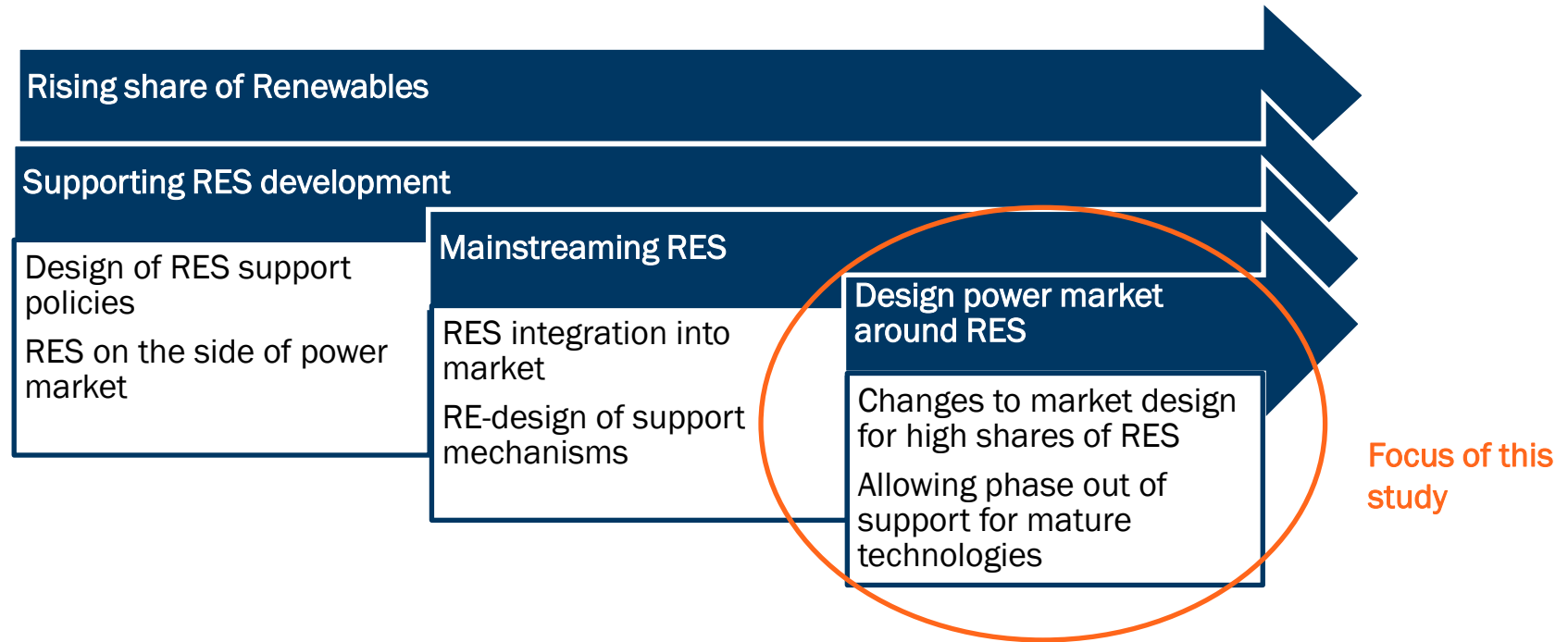
The share of variable renewables (VRE) in electricity generation in selected regions



- In a carbon-constrained world, variable renewables will supply a large share of electricity
- IEA ETP 2014 2 degrees scenario: VRE represent 30-45% in most world regions by 2050 (other studies provide similar estimates)

IEA (2014): Energy technology perspectives, 2DS scenario.

The 3 stages of RES development



■ These challenges will play out differently depending on the power system organisation:

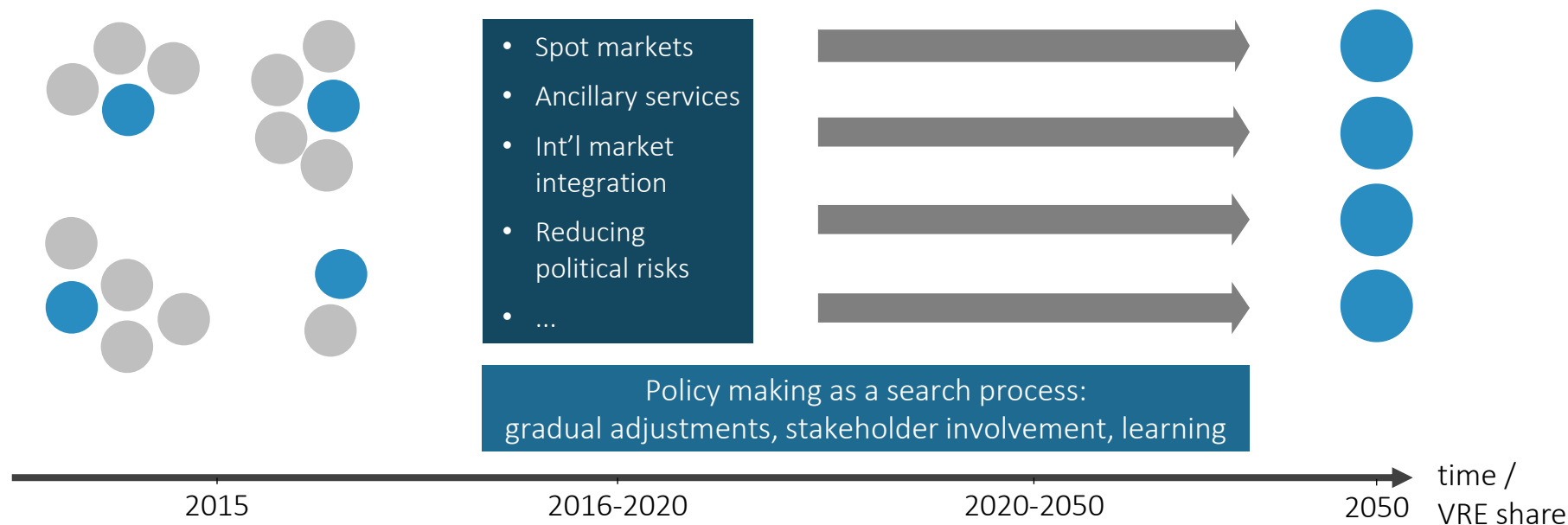
- **In jurisdictions with liberalised power sector:** growing concern that competitive wholesale markets co-existing with policy support for VRE deployment may not provide a level playing field and may turn out unsustainable in the long-term
- **In jurisdictions with vertically integrated utilities or hybrid systems:** increasing RES capacity run by independent power producers may require revisions of the regulations defining the rules for grid access and system operation, ensuring the level playing field between the IPPs and the incumbent
- **In jurisdictions with active prosumer participation:** new questions emerge around the interface between retail and wholesale markets as well as on the regulation of distribution system operators

Our approach: from the ideal market design toward transition pathways

Project phases



Markets time scale



Methods

Literature reviews

Bilateral interviews

Case study analysis

Workshop

Key challenges for power system with high shares of VRE

Three main challenges of VRE to power systems

Capital intensity

■ Cost recovery

- VRE are capital intensive
- Flexibility resources are capital intensive

■ Cost of capital

- Capital costs (expected rate of return / WACC) becomes major driver of power system costs

Limited predictability and variability

■ Optimal generation mix shifts

- Shift towards mid- and peak-load thermal plants
- Transition towards new mix needs to be managed

■ Time horizon of power system operations shortens

- Operational planning horizon shortens
- Rates of change become larger (e.g. residual load ramp rates)

■ Assurance of system stability

- Higher demand for AS
- New constraints of AS provision (e.g. few thermal plants left)

Decentralized and scattered generation

■ Transmission grid

- Good sites for wind and solar power are often far from load centres

■ Distribution grid

- Larger share of generation is connected to distribution grid

Wholesale market challenges: Future production mix and the system marginal cost

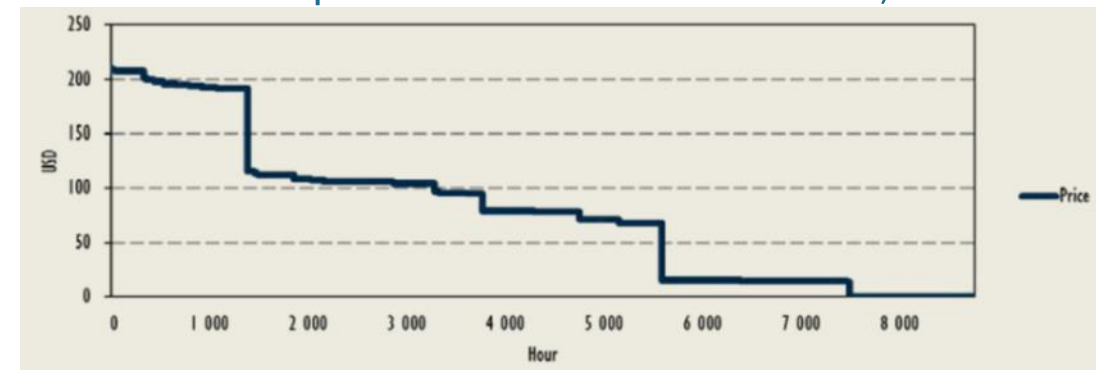
■ Possible future structure of system marginal cost:

1. **Dominant low variable cost RES with low system flexibility**
 - Large number of hours with low prices
 - Rare but large spikes in system MC during scarcity
 - Questions over ability of SRMC to guide system dispatch / investment
2. **Significant share of non-zero variable technologies (incl. nuclear/ CCS/ biomass) and/or significant system flexibility**
 - SRMC prices still a good basis of system dispatch / expansion

■ Merit order example for Europe in 2050:

- Two thirds of electricity generated with low marginal cost
- IAE forecast high variability with zero to low levels one third of the time

Modelled price duration curve in ETP scenario, 2050



Source: IEA 2015 RE-POWERING MARKETS

The retail / wholesale market interface – challenges associated with the rise of prosumers

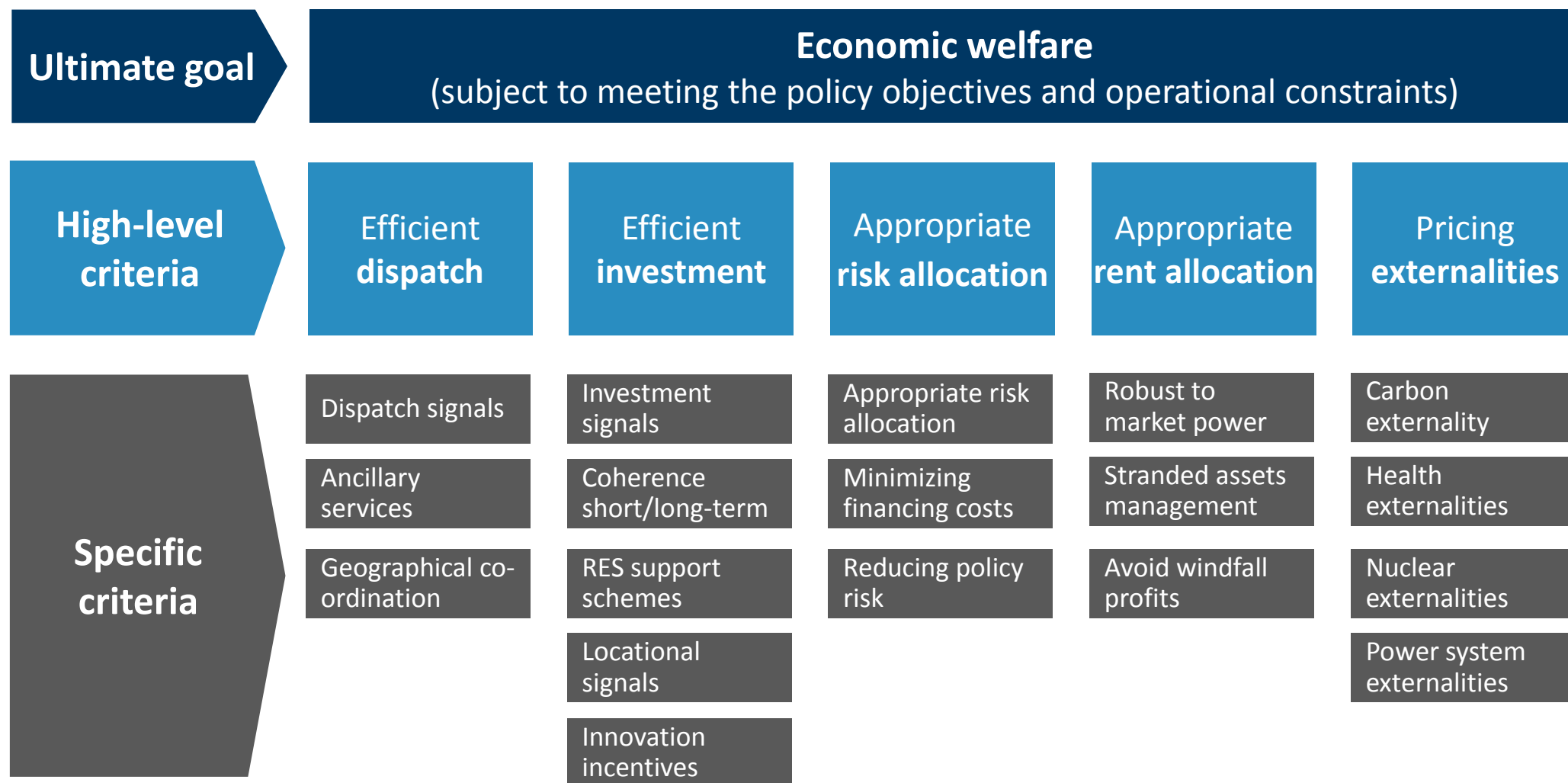
Governance and institutional framework (roles of policy, independent regulator, etc.)



- Market design shapes the incentives under which all these decisions are taken
- Market design consists of a set of rules specified by policy and regulation at multiple layers, implemented in a large number of different laws, administrative orders, and market provisions
- VRE have an impact on wholesale markets interface with RES support policies and balancing and ancillary services
- VRE and distributed generation/storage also raise the issue of the interface between the retail and wholesale markets in new ways

Criteria for an ideal power market design with high shares of VRE

Criteria for ideal market design with high level of VRE



Three main challenges of VRE to market design

Capital intensity

- **Cost recovery: Credible investment incentives**
 - Credible investment signals
 - Implications for the design of energy markets, capacity markets, support schemes
- **Cost of capital: limiting risk exposure**
 - Exposure to risk, including policy risk, is a fundamental factor determining total system costs if the system is capital-intensive
 - Trade-off between policy flexibility and regulatory risk

Limited predictability and variability

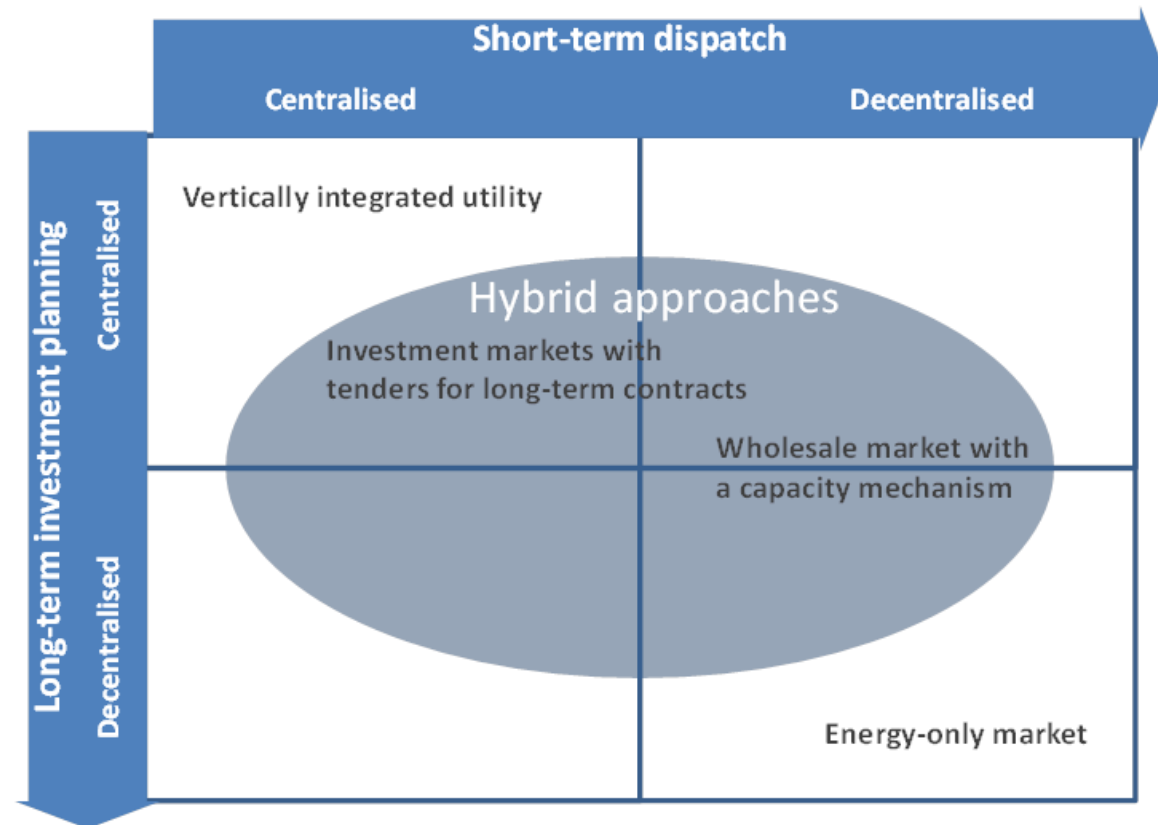
- **Price volatility**
 - More volatile prices
 - Product definition (e.g., peak/off-peak) loses relevance
- **Spot market design**
 - Reduced gate closure
 - Higher frequency
 - Both day-ahead and intra-day
- **Assurance of system stability**
 - Need for new AS products, e.g. providing system inertia
 - Redesign AS to allow VRE participation

Decentralized and scattered generation

- **Coordination between generation and grids**
 - Increased investment demand requires new approach to TSO and DSO regulation
 - Locational price signals for generators needed
- **Prosumers**
 - Retail prices becomes investment signal
 - Base for taxes and grid fee erodes
 - Many small producers need access to wholesale markets

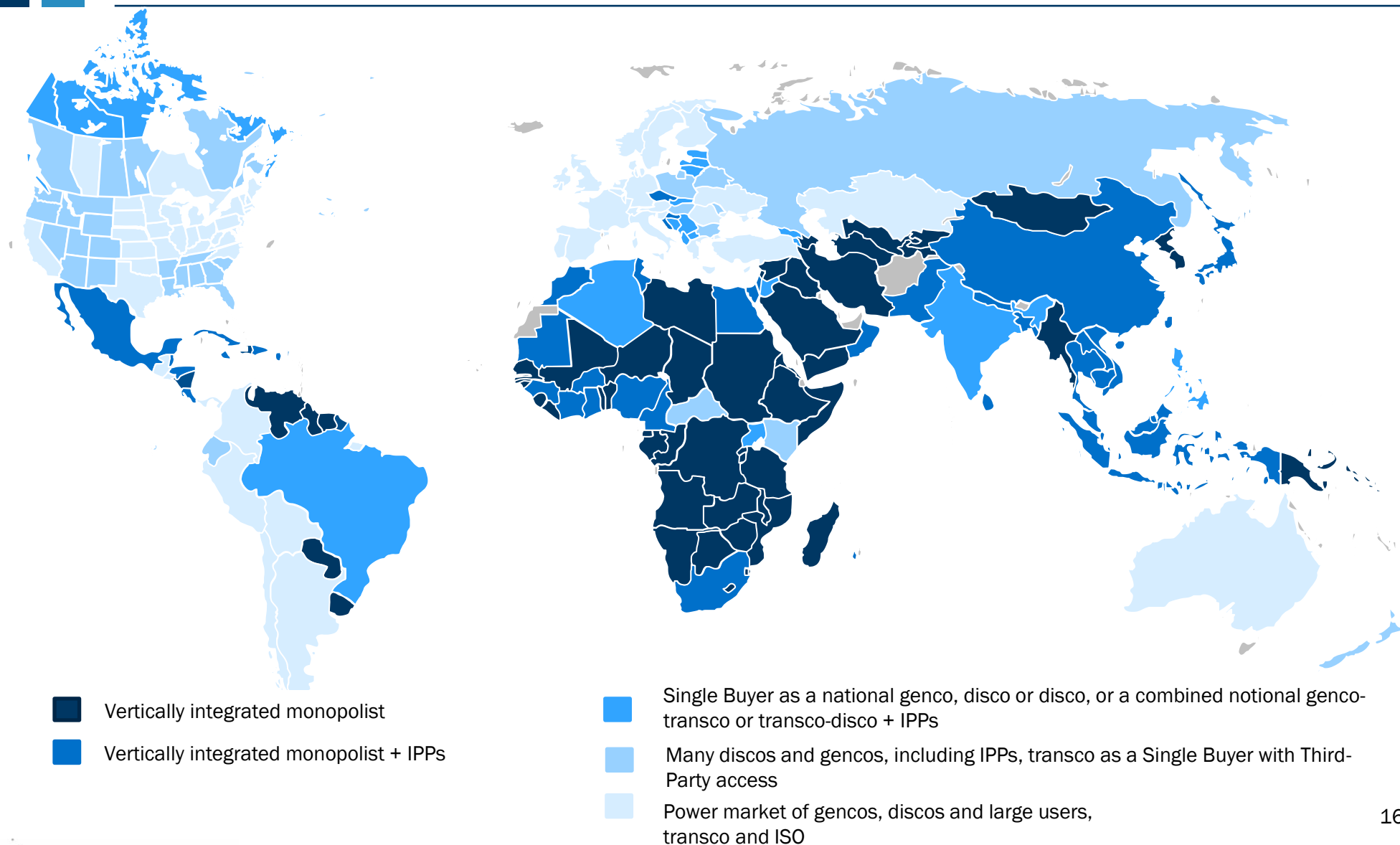
Market design is a coordination and risk allocation mechanism

- **Power prices are a decentralised coordination mechanism**
 - **Short term** – Efficient dispatch of all generation units based on variable costs
 - **Long term** – Signal retirement or new investment, trigger new entrants
- **Vertical integration**
 - Historical approach – coordination of short term dispatch and long term investment centralised
- **Liberalised markets**
 - Wholesale market prices coordinate market players' actions – short and long term
- **Hybrids**
 - Most markets are hybrids with some form of regulatory intervention
 - Public intervention differs depending on objective, type of intervention and risk allocation



Recognizing the diversity of power market design – Case studies of market prototypes

The diversity of power systems and implications for market design



Stylized models of power system organization: 4 different prototypes

- Real-world market and policy design is diverse, complex, multi-level and path-dependent.
- To address this diversity in a transparent way, we propose to study a small number of **power system prototypes**
- Each real-world market represents a combination of these prototypes
- Each prototype allows to focus on *a specific aspect* of market design

	Energy-only	Hybrid	Vertically integrated	Prosumer
Dispatch decisions	Decentralised through wholesale market prices	Decentralised through wholesale market prices	Centralised based on costs and other drivers	Decentralised through retail market prices
Investment generation	Decentralised through wholesale market prices	Centralised based on planning and/or risk sharing mechanism	Centralised based on planning	Decentralised through retail market prices
Examples	Texas , Australia, Europe	Brazil, UK	South Africa, US	Germany, Australia, California

Energy Only market

Critical elements of ideal market design

Element of market design	Challenge presented by VRE	Ideal market design elements
1 Design of spot and ancillary services markets	<ul style="list-style-type: none"> Shift of the operational timeframe to real-time Increased capital intensity and price variability New requirements for AS products, and new constraints to provide them 	<p>Move the spot price reference to the real-time price, e.g.</p> <ul style="list-style-type: none"> Absence of barriers between real-time and ID/DA markets Single price imbalance prices <p>Credible scarcity pricing</p> <ul style="list-style-type: none"> Scarcity pricing mechanisms based on operating reserve demand curves Non-distortive market power and manipulation legislation <p>Efficient valuation of flexibility services</p> <ul style="list-style-type: none"> Spot ancillary services products (operating reserves) Technology-neutral balancing responsibility
2 Locational price signals	<ul style="list-style-type: none"> Increasing distance between generation and consumption 	<p>Ensure locational differentiation of energy prices perceived by generators to ensure transmission/generation coordination</p> <ul style="list-style-type: none"> Nodal or zonal energy prices Network injection charges
3 Forward markets / hedging products	<ul style="list-style-type: none"> Classical product definitions loose relevance (e.g., peak / off-peak) Increased capital intensity and price variability 	<p>Fostering the liquidity of long-term markets</p> <ul style="list-style-type: none"> Market makers New financial products to hedge against all spot products (e.g. operating reserves) Forward financial transmission rights

Vertically integrated system

Critical elements of ideal market design

Element of market design	Challenge presented by VRE	Ideal market design elements
1 Regulatory framework	<ul style="list-style-type: none"> Achieving the optimal generation mix under the decarbonisation constraints 	<p>Ensure efficient investment, including renewable, with no undue rent transfers through regulatory mechanisms</p> <ul style="list-style-type: none"> Incentive regulation to invest in the renewable generation to meet the applicable environmental targets The regulatory framework should ensure an efficient risk sharing between customers and the utility.
2 Rules for the third-party access	<ul style="list-style-type: none"> Operational timeframe shift towards real-time System stability through ancillary services and demand response 	<p>No discrimination against IPP's for the short-term dispatch</p> <p>Efficient IPP's investment (timing and location)</p>
3 Cross border trading arrangements	<ul style="list-style-type: none"> The shift of operational timeframe to real-time 	<p>Ensure efficient short-term trade with neighbouring utilities</p> <ul style="list-style-type: none"> Introduce bilateral and or organised energy cross-border trading May require reforms in the direction of those in the Energy Only prototype

Hybrid market

Critical elements of ideal market design

Element of market design	Challenge presented by VRE	Benchmark market design elements
1 Integrated resource planning / coordination	<ul style="list-style-type: none"> Increasing distance between generation and consumption Increased capital intensity and price variability Shift of the thermal plants towards mid- and peak-load 	<p>Efficient resource planning and procurement process</p> <ul style="list-style-type: none"> Transparent process for determination of investment needs Transparent and non-discriminatory process for tendering and allocation to third parties
2 Interface between centralised and decentralised processes	<ul style="list-style-type: none"> Shift of the operational timeframe to real-time New requirements for AS products, and new constraints to provide them 	<p>Ensure the state driven processes do not distort the short-term price signals required for flexibility resources</p> <ul style="list-style-type: none"> Avoid rolling the short-term products into the capacity contracts Ensure the capacity contracts do not prevent the incentives for efficient short-term operation
3 Structure of the state-led capacity contracts	<ul style="list-style-type: none"> Shift of the thermal plants towards mid- and peak-load Decentralised and scattered generation 	<p>Induce efficient investment in all types of capacity coordinated with network development</p> <ul style="list-style-type: none"> Induce the optimal volume of capacity including volume of VRE consistent with the social cost of emission to the society Ensure that for each technology the contracts reward the specific value that this technology provides to the system Allow coordinating the investment in generation with the existing and future transmission and distribution networks

Prosumer market

Critical elements of ideal market design

Element of market design	Challenge presented by VRE	Ideal market design elements
1 Retail pricing	<ul style="list-style-type: none"> Prosumers' investment incentives Tax base erosion 	<p>Acknowledge the new role of retail prices: not only cost recovery, also generation and investment incentives</p> <ul style="list-style-type: none"> Opt 1: finance certain retail price components from other sources (capacity-based fees, general budget, ...) Opt 2: tax self-consumed electricity as well
2 DSO regulation	<ul style="list-style-type: none"> Regulation for (smart) grid investments Geographic coordination 	<p>Coordinate distribution grid and generation investments to incentivize investment and innovation</p> <ul style="list-style-type: none"> Opt 1: cost-reflective grid fees (connection and/or usage) Opt 2: "zoning" for distributed generation investments
3 Distribution grid coordination	<ul style="list-style-type: none"> Risk of local "hotspots" that require massive distribution grid investments 	<p>Design distribution network to reflect the existing constraints and the costs of grid expansion</p> <ul style="list-style-type: none"> Prevent excessive costs for distribution grid upgrades in VRE hotspots where VRE development happens in a very concentrated manner Locate VRE generation where benefits for the grid are greatest, rather than cheapest
4 Market access	<ul style="list-style-type: none"> Market access for many small-scale actors 	<p>Provide market access: consider risk and transaction costs</p> <ul style="list-style-type: none"> Opt 1: single-buyer model– should not be the SO Opt 2: competing aggregators, prosumers can choose Opt 3: aggregators + "market access of last resort" Balancing and pricing rules should be size-neutral

Conclusions and policy recommendations – wholesale market

Energy-only policy recommendations

Design of spot and ancillary services markets

- Harmonise market designs across time frames
- Increase price caps and remove barriers to scarcity pricing
- Market power monitoring
- Improve balancing markets
- Improve the operating reserve markets
- Allow DSR participation in all market segments

Locational price signals

- Introduce geographical price differentiation through
 - Zonal splitting
 - Nodal prices
 - Other location signals, e.g. locational connection charges, locational loss charges, etc.
- Geographical differentiation of balancing prices

Development of hedging products

- Introduce measures to improve opportunities for voluntary forward hedging
- Let the market demand for hedging develop as the intensity of price spikes increases

Vertically integrated system recommendations

Regulatory framework

- Implement incentive regulation to foster deployment of low carbon technologies and support the development of the enabling infrastructure,
- Possibly delegate the planning role to a neutral third party.

Rules for third-party access

- Apply transparent and non-discriminatory rules for third-party access.
- Possibly, delegate third-party connection and dispatch roles to a neutral agency.

Cross-border trading arrangements

- Implement regulation and legal frameworks allowing bilateral cooperation on trading.
- Develop regional cooperation to ensure secure operation through a regional coordination agency

Engineering the transition to hybrid approaches

■ Challenges presented by high-VRE on market designs may require the introduction of hybrid system elements

■ Two key uncertainties will determine the type of hybrid market:

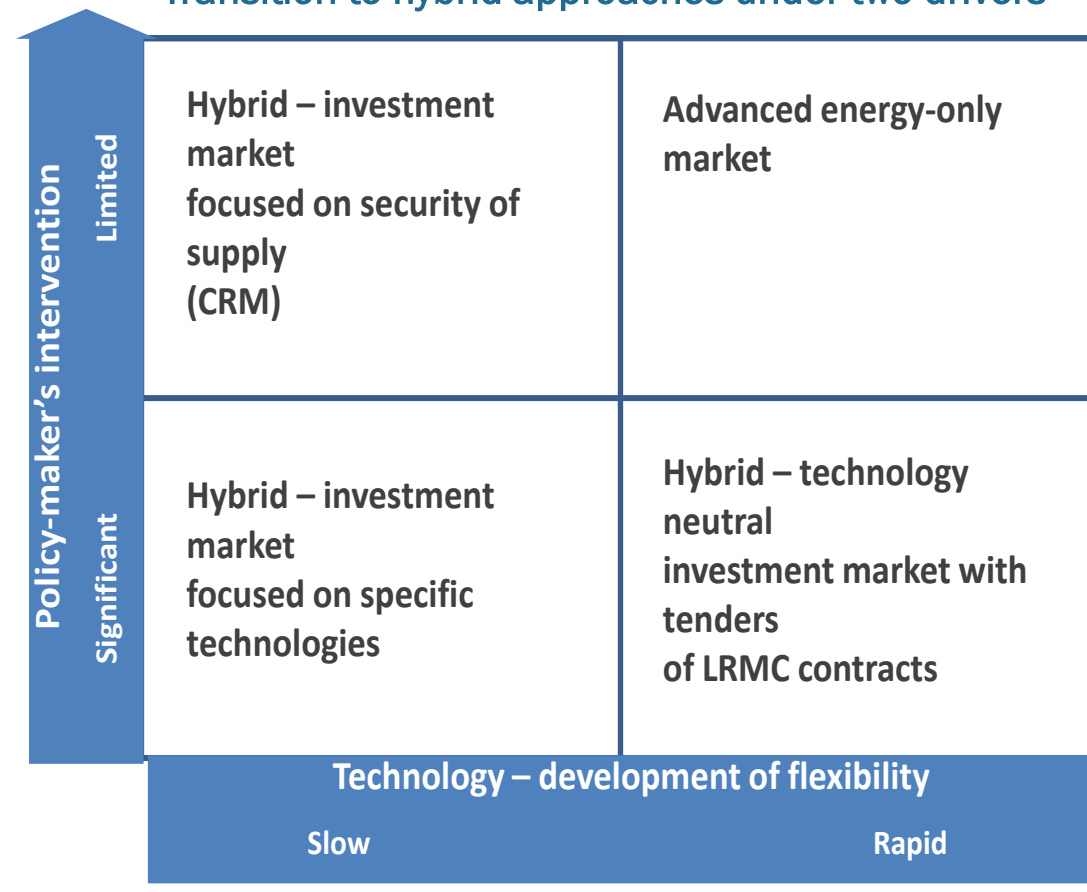
1. Policy maker's degree of intervention

- The degree of a policy-maker's intervention and the resulting tendency for centralised solutions.
- This is determined by policy-maker's attitude to risk and information asymmetry

2. Technology – development of flexibility

- The development of the generation mix along the decarbonisation path leading to high shares of VRE, especially the flexibility of the mix
- A mix with higher flexibility reduces the urgency of market design challenges presented by VRE and smooths the transition of the market design.

Transition to hybrid approaches under two drivers



Hybrid approach policy recommendations

Integrated resource planning

- Efficient resource planning and procurement process.
- Transparent process for determination of investment needs.
- Efficient governance and incentives of the planning agency.

Interface between centralised and decentralised processes

- Design products to allow and encourage participation of renewables
- Ensure product definition and procurement process remunerates capacity irrespective of the plant's output and short-term operations.
- Account for specificities of RES cost structure to design mandatory hedging contracts that allow an efficient risk allocation and support capital intensive investments.

Organisation of mandatory risk hedging instruments

- Award the risk-hedging contracts through a transparent auction-based procurement process.
- Design auctions' procurement processes so that they encourage participation of renewables and demand response providers.
- Favour a decentralised procurement to allow contracts to be tailored to meet the specific needs of suppliers and capacity providers.

Conclusions and policy recommendations – Retail/Wholesale market interface

Prosumer market recommendations

Retail pricing and (net) metering

- Make sure the prices that prosumers and non-prosumers face are aligned.
- Apply taxes and charges to self-consumed electricity or clean up the electricity bill from taxes/ charges

Regulation of distribution system operators

- Provide incentives for efficient large-scale investments.
- Stimulate innovative solutions such as demand response, or storage

Geographic coordination between grid and generation investments

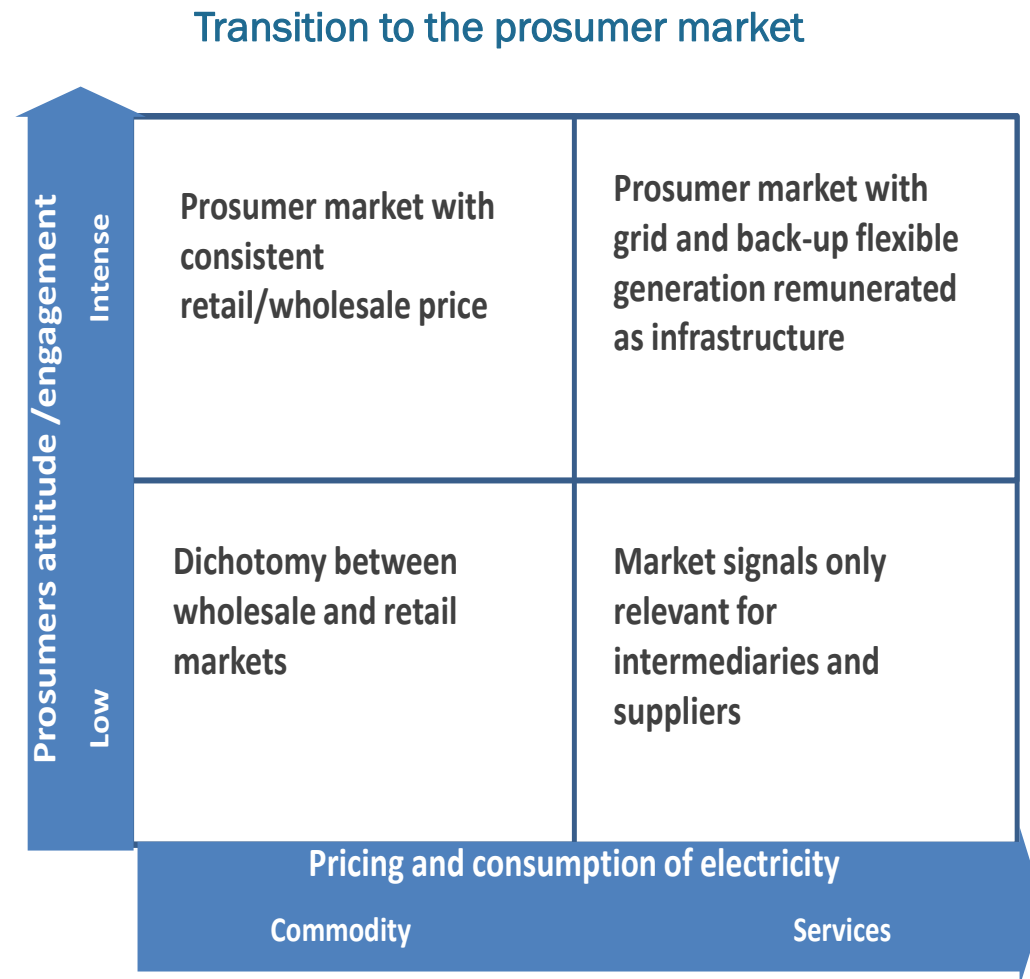
- Introduce retail price geographical differentiation at the level of the distribution grid.
- Differentiated retail price signals should give prosumers investment signals to coordinate with grid constraints and grid upgrade requirements.

Wholesale market access and balancing responsibilities of prosumers

- Ensure low-cost access to wholesale and ancillary service markets for prosumers.
- Foster aggregator competition while keeping a “market access of last resort” to avoid excessive risks.

Engineering the transition to the prosumer market

- The type of prosumer development could be very different depending on the two following drivers:
- **Prosumer attitude /engagement toward electricity**
 - Many factors might increase the intrinsic interest of consumers in electricity generation, such as:
 - status and life-style;
 - the gamification of energy supply;
 - an “early adopter” attitude towards energy technology; and
 - the positive image associated with auto-generation.
- **Commodity vs. service approach**
 - The transition to a power sector with a high share of VRE could reduce the importance of energy commodity prices and transform the retail energy supply into a service-oriented good, rather than a commodity.





Overarching policy recommendations

■ Recommendations for short term system operation with high shares of VRE

- Remove barriers to scarcity pricing
- Foster the development of flexibility in its various forms
- Introduce locational signals to coordinate decentralised players
- Introduce new risk hedging products to manage price volatility

■ Recommendations for optimal system development / investment with high shares of VRE

- Reinvent coordination mechanisms for new plant / lines siting
- Ensure consistent and timely development of the infrastructure necessary to integrate large shares of VRE
- Introduce policies for efficient risk transfer and hedging to ensure financeability of capital intensive technologies and to reduce the cost of capital (e.g. introduce hedging/contracting obligations)

■ Recommendations on governance and regulatory framework

- Support innovation in market design and system management, through e.g. incentive framework for transmission and distribution operators – and possibly power exchanges
- Put in place governance that facilitates evolution and adaptability of market design and regulatory framework.

Thank you for your attention

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