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

Presentation based on study for IEA RETD

EPRG Spring Seminar in partnership with FTI Consulting and Compass Lexecon
"Energy markets, policy and regulation: evolution and revolution"

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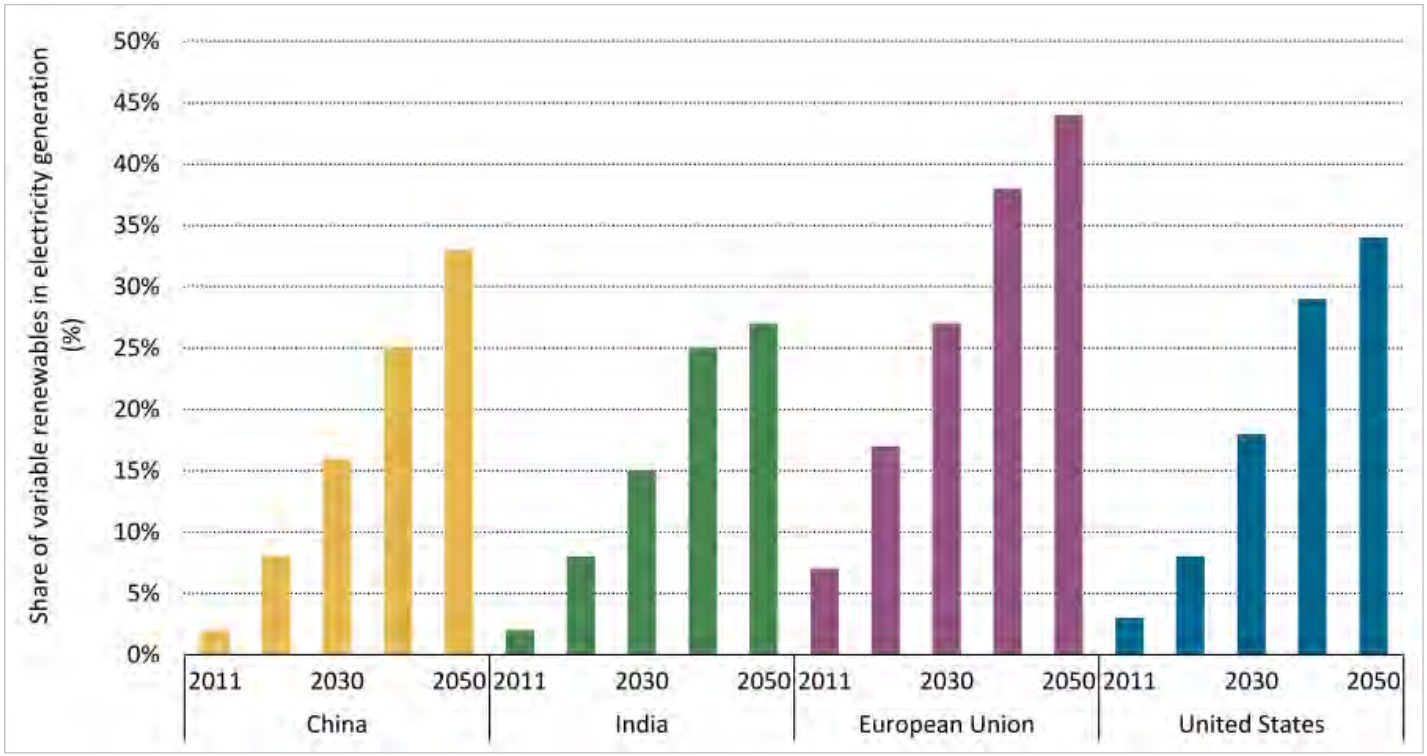
Study context:
Toward high shares of renewables in the generation mix

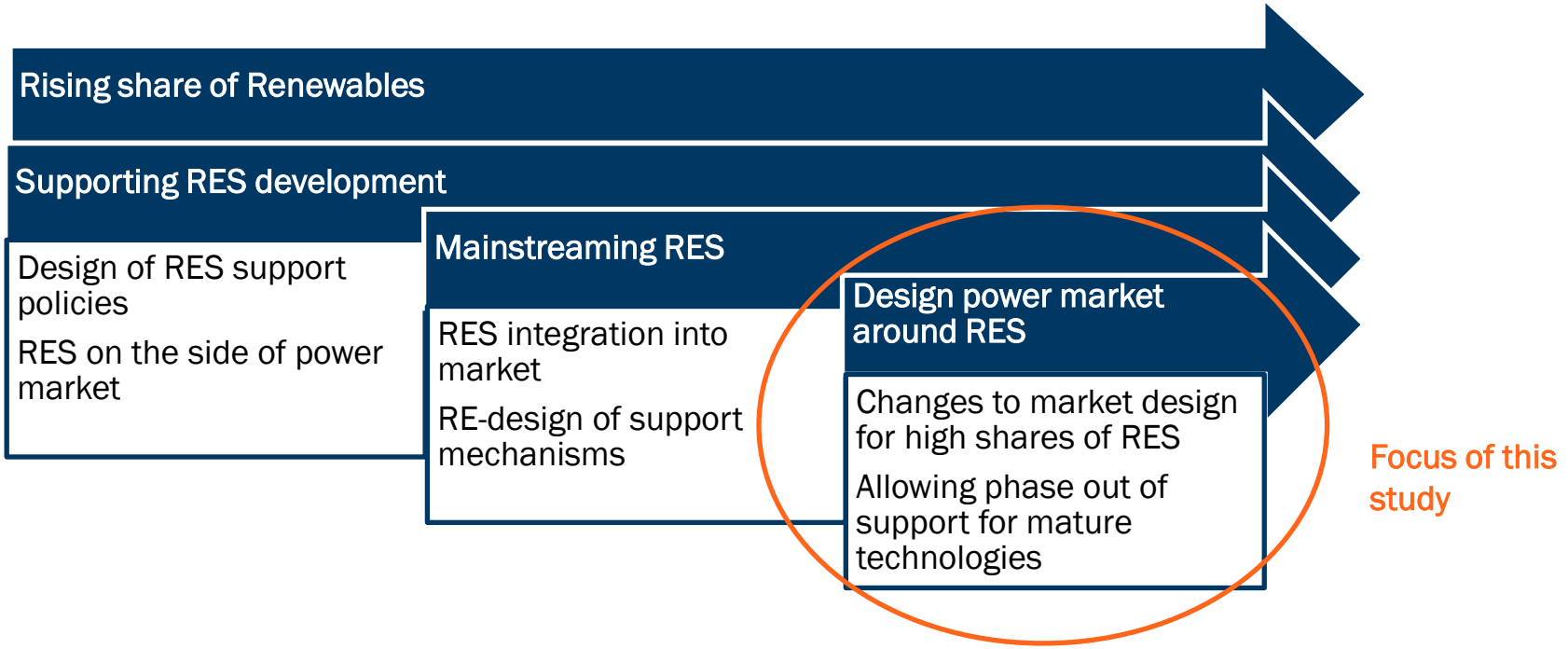
The share of variable renewables (VRE) in electricity generation in selected regions



- 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

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

Criteria for ideal market design with high level of VRE

Ultimate goal

Maximise economic welfare
(subject to meeting the policy objectives and operational constraints)

High-level criteria	Efficient **dispatch**	Efficient **investment**	Appropriate **risk allocation**	Appropriate **rent allocation**	Pricing **externalities**
Specific criteria	Dispatch signals	Investment signals	Appropriate risk allocation	Robust to market power	Carbon externality
	Ancillary services	Coherence short/long-term	Minimizing financing costs	Stranded assets management	Health externalities
	Geographical co-ordination	RES support schemes	Reducing policy risk	Avoid windfall profits	Nuclear externalities
		Locational signals			Power system externalities
		Innovation incentives			

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

Three main challenges of VRE to market design

Capital intensity

- **Cost recovery: investment incentives**
  - Adequate investment signals
  - Implications for the design of energy markets, capacity markets, support schemes
- **Cost of capital: optimal risk allocation**
  - 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

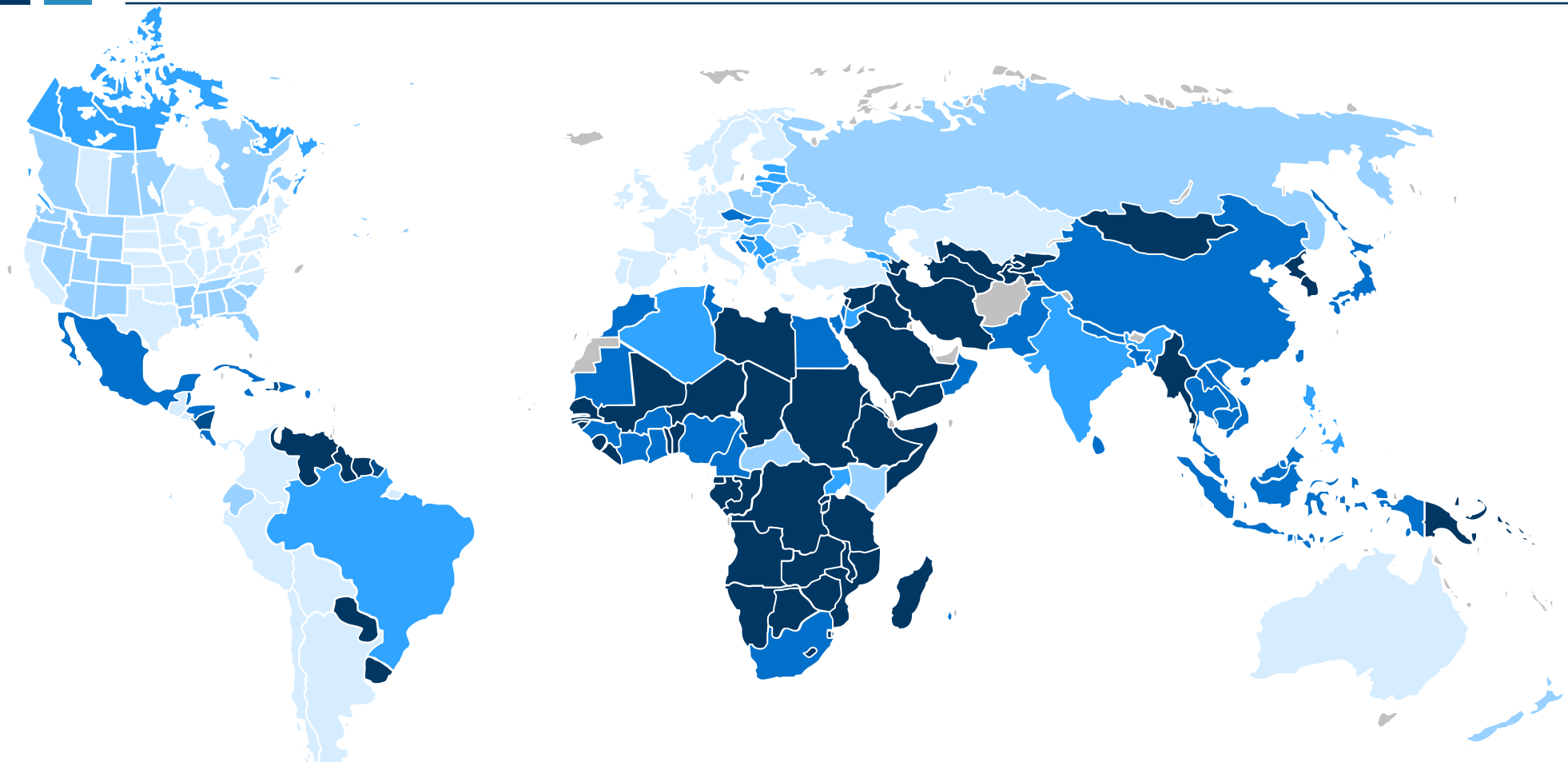
- **Price volatility**
  - More volatile prices
  - Product definition (e.g., peak/off-peak) looses relevance
- **Spot market design**
  - Reduced gate closure
  - Higher frequency
  - Both day-ahead and intra-day
- **Assurance of system stability**
  - Need for new ancillary services products, e.g. providing system inertia
  - Redesign ancillary services 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 centralised & decentralised generators needed
- **Prosumers**
  - Retail prices becomes investment signal
  - Base for taxes and grid fee erodes
  - Many small producers need access to wholesale markets

Recognizing the diversity of power market design

The diversity of power systems and implications for market design



Vertically integrated monopolist

Vertically integrated monopolist + IPPs

Single Buyer as a national genco, disco or disco, or a combined notional genco-transco or transco-disco + IPPs

Many discos and gencos, including IPPs, transco as a Single Buyer with Third-Party access

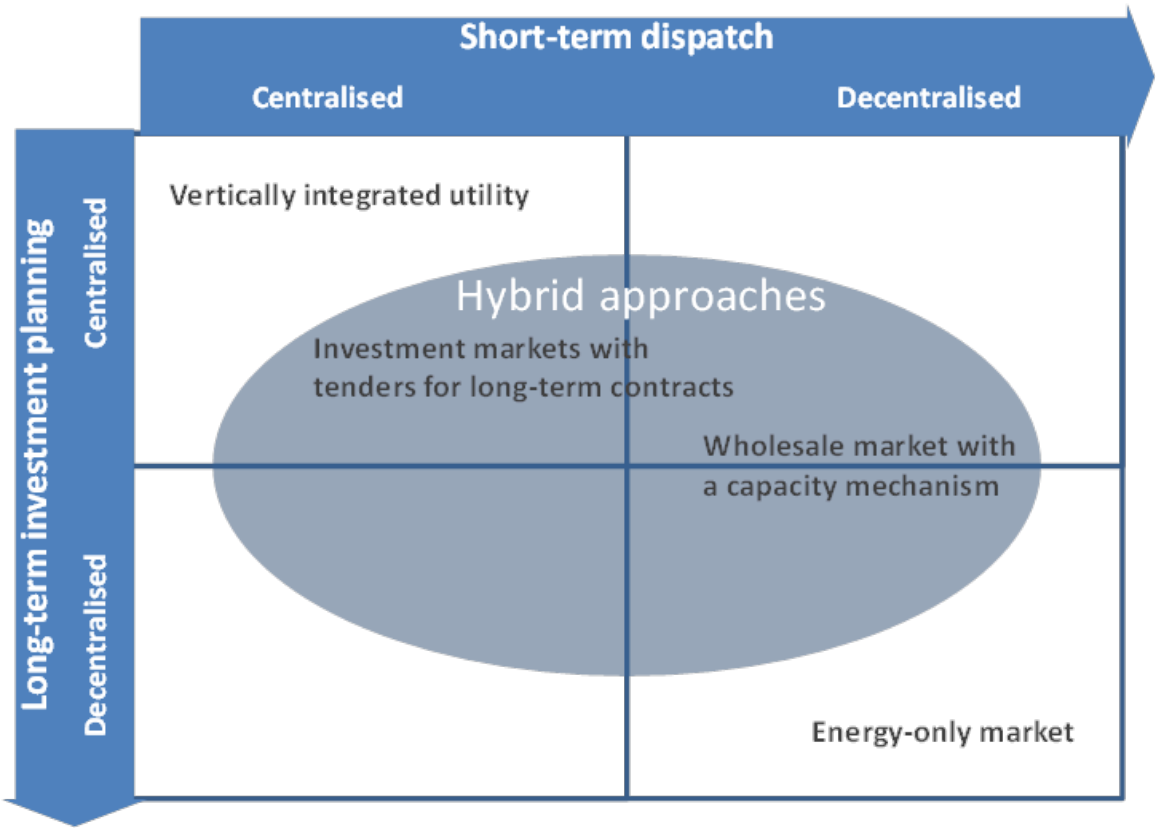
Power market of gencos, discos and large users, transco and ISO

Source: FTI-CL Energy analysis based on various sources including World Bank

Wholesale market design: A range of approaches for short-term dispatch and long term investment coordination

- **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

- **Key categories of power systems:**
  - **Vertical integration**
    - Historical approach – coordination of short term dispatch and long term investment centralised
  - **Liberalised markets**
    - Wholesale marker 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



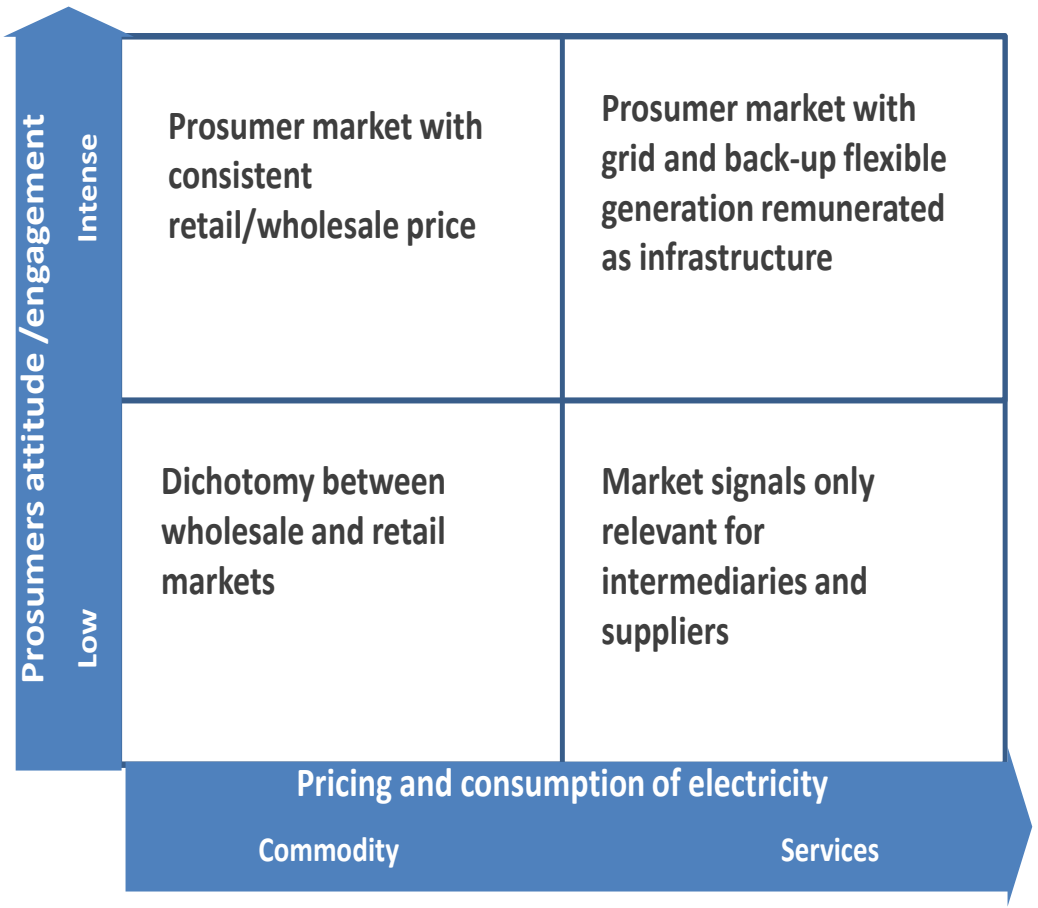
Retail market design: Engineering the transition to the prosumer market

- 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.

Transition to the prosumer market



Stylized models of power system organization: 4 different prototypes used as case studies

- 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

	1 Energy-only	2 Vertically integrated	3 Hybrid	4 Prosumer
Dispatch decisions	Decentralised through wholesale market prices	Centralised based on costs and other drivers	Decentralised through wholesale market prices	Decentralised through retail market prices
Investment generation	Decentralised through wholesale market prices	Centralised based on planning	Centralised based on planning and/or risk sharing mechanism	Decentralised through retail market prices
Examples	Texas , Australia, Europe	South Africa, US	Brazil, UK	Germany, Australia, California

Case studies of market prototypes and policy recommendations

Energy Only market
Critical elements of target market design

Element of market design	Challenge presented by VRE	Ideal market design elements
1 Design of spot and ancillary services markets	• 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	Move the spot price reference to the real-time price, e.g. • Absence of barriers between real-time and ID/DA markets • Single price imbalance prices Credible scarcity pricing • Scarcity pricing mechanisms based on operating reserve demand curves • Non-distortive market power and manipulation legislation Efficient valuation of flexibility services • Spot ancillary services products (operating reserves) • Technology-neutral balancing responsibility
2 Locational price signals	• Increasing distance between generation and consumption	Ensure locational differentiation of energy prices perceived by generators to ensure transmission/generation coordination • Nodal or zonal energy prices • Network injection charges
3 Forward markets / hedging products	• Classical product definitions loose relevance (e.g., peak / off-peak) • Increased capital intensity and price variability	Fostering the liquidity of long-term markets • Market makers • New financial products to hedge against all spot products (e.g. operating reserves) • Forward financial transmission rights

Energy Only market
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
Critical elements of target market design

Element of market design	Challenge presented by VRE	Ideal market design elements
1 Regulatory framework	• Achieving the optimal generation mix under the decarbonisation constraints	Ensure efficient investment, including renewable, with no undue rent transfers through regulatory mechanisms • 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	• Operational timeframe shift towards real-time • System stability through ancillary services and demand response	No discrimination against IPP's for the short-term dispatch Efficient IPP's investment (timing and location)
3 Cross border trading arrangements	• The shift of operational timeframe to real-time	Ensure efficient short-term trade with neighbouring utilities • Introduce bilateral and or organised energy cross-border trading • May require reforms in the direction of those in the Energy Only prototype

Vertically integrated system
Policy 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

Hybrid market
Critical elements of target market design

Element of market design	Challenge presented by VRE	Benchmark market design elements
1 Integrated resource planning / coordination	• Increasing distance between generation and consumption • Increased capital intensity and price variability • Shift of the thermal plants towards mid- and peak-load	Efficient resource planning and procurement process • 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	• Shift of the operational timeframe to real-time • New requirements for AS products, and new constraints to provide them	Ensure the state driven processes do not distort the short-term price signals required for flexibility resources • 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	• Shift of the thermal plants towards mid- and peak-load • Decentralised and scattered generation	Induce efficient investment in all types of capacity coordinated with network development • 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

Hybrid market
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 irrespectively 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.

Prosumer market
Critical elements of ideal market design

Element of market design	Challenge presented by VRE	Ideal market design elements
1 **Retail pricing**	• Prosumers' investment incentives • Tax base erosion	Acknowledge the new role of retail prices: not only cost recovery, also generation and investment **incentives** • 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**	• Regulation for (smart) grid investments • Geographic coordination	Coordinate distribution **grid and generation** investments to incentivize investment and innovation • Opt 1: cost-reflective grid fees (connection and/or usage) • Opt 2: "zoning" for distributed generation investments
3 **Distribution grid coordination**	• Risk of local "hotspots" that require massive distribution grid investments	**Design** distribution network to reflect the existing constraints and the costs of grid expansion ▪ 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**	• Market access for many small-scale actors	Provide **market access**: consider risk and transaction costs • 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

Prosumer market
Policy 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.

Conclusions

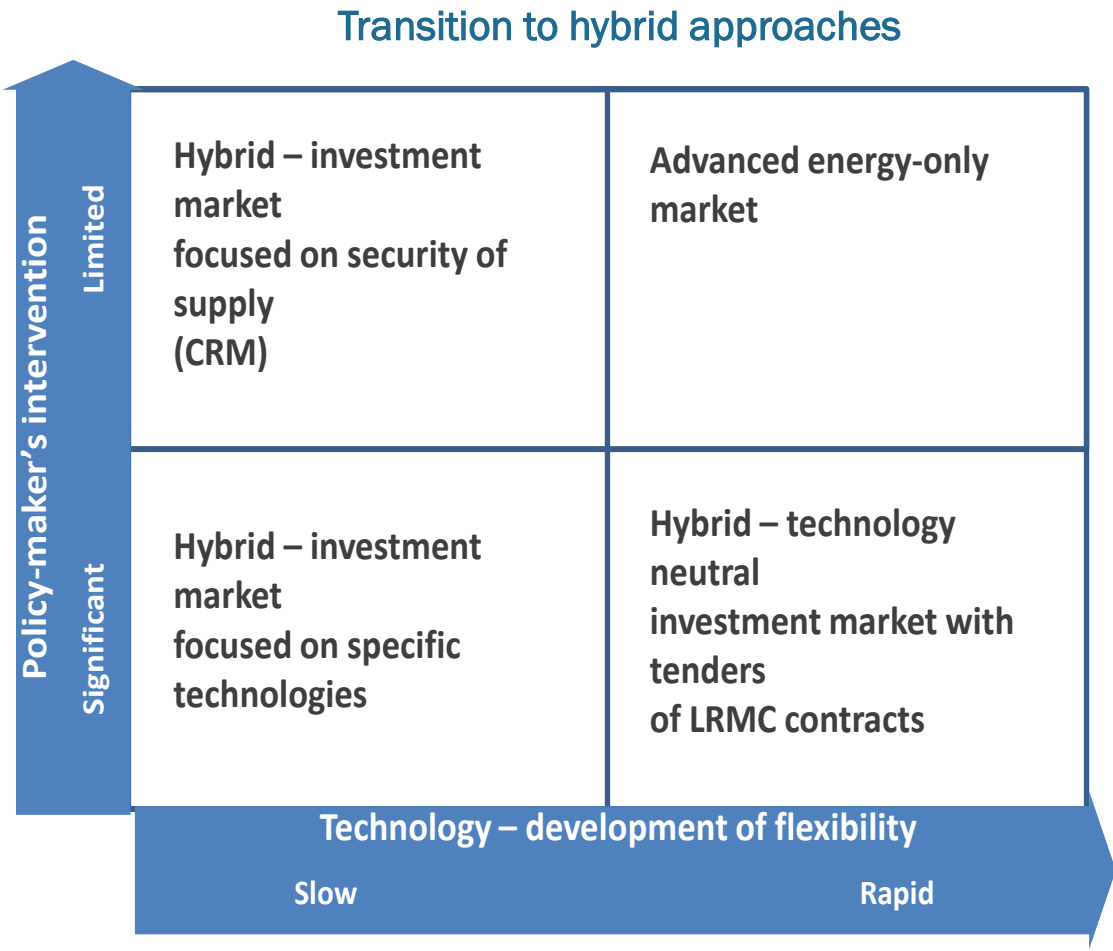
Conclusion: Engineering the transition

- Challenges presented by high-VRE on market designs will likely require the **introduction or redesign of hybrid system elements** (i.e. combination of price signals and other coordination/ risk sharing mechanisms)

- **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 / regulation impact on 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.



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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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