Future Power Markets Forum

A PROJECT OF

Johns Hopkins
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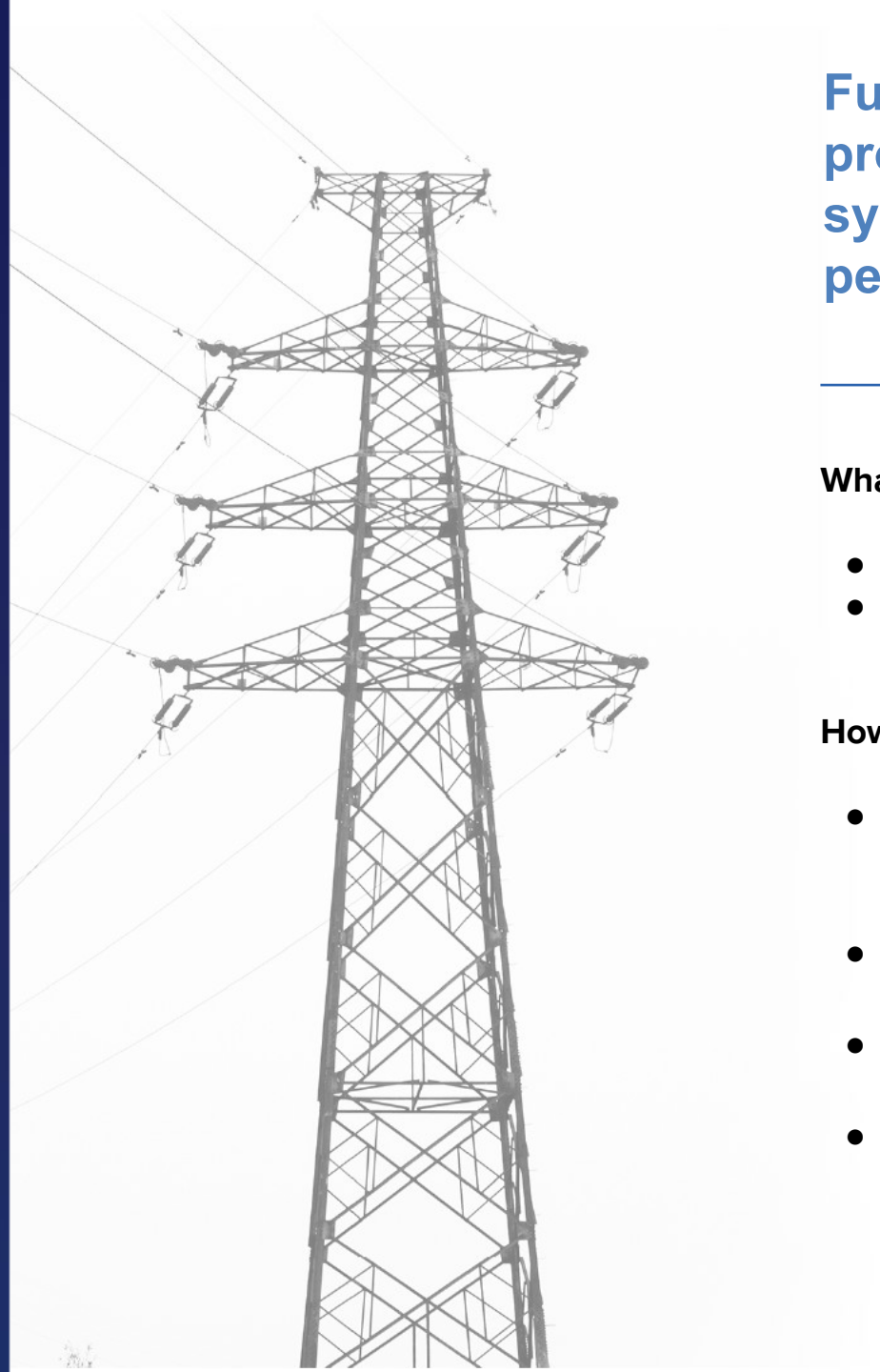
Center on Global Energy Policy

When Small Risks are Big Risks: tail risk and strategic reserves

About Future Power Markets Forum



Future Power Markets Forum investigates proposals for market designs that maintain system efficiency and reliability with a high penetration of variable generation.

What

- Meetings of practitioners, experts and regulators
- Website and digital resource library to share the the research under discussion and the participant perspectives

How

- To encourage participation, there is no explicit or implied value judgment about whether we SHOULD have a high renewable penetration scenario
- To encourage candid discussions, Chatham House Rule will be followed (no attribution to individual speakers outside the meeting)
- To provide a high-quality resource to stakeholders and policy makers, presentations will be posted publicly if authorized by the speaker
- To ensure balance and quality, a diverse advisory committee will provide input on content and speakers

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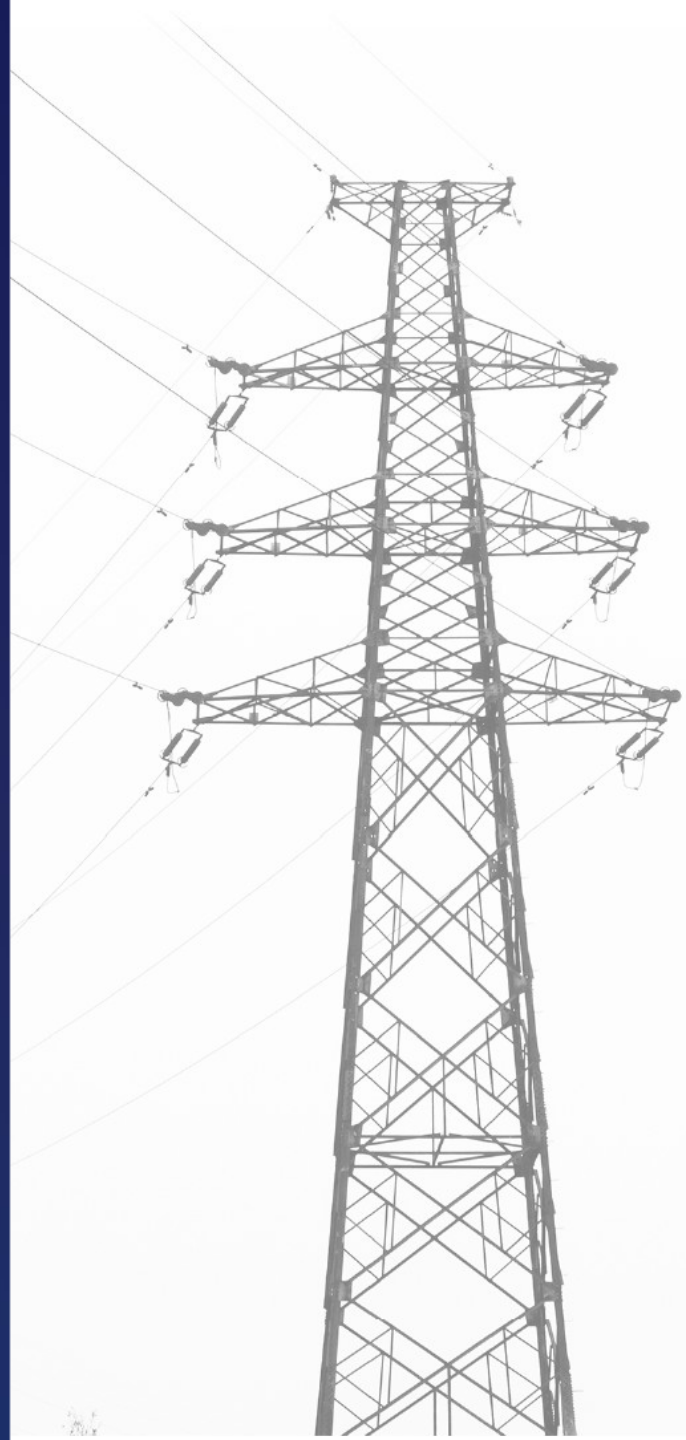

Thank You

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Insuring Electricity System Tail Risks

Farhad Billimoria, Department of Engineering Science, University of Oxford

Future Power Markets Forum, 23rd September 2022, United States

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- Thomas Morstyn
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Agenda

I. Tail risk in electricity markets
II. Strategic reserves
III. Insurance frameworks
IV. Challenges and complexities
V. Implementation

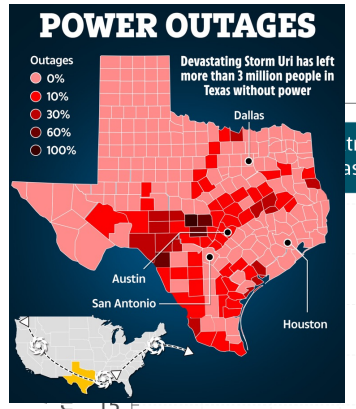
* medieval practice of putting illustrations of dragons on uncharted areas of maps where potential dangers were thought to exist.

The nature of tail risk in the electricity system is changing…

Generation intermittency and availability uncertainty

More extreme events and fatter tails driven by CC

Demand heterogeneity versus
“All-or-nothing’ impacts of power system outages



Essentiality versus Flexibility

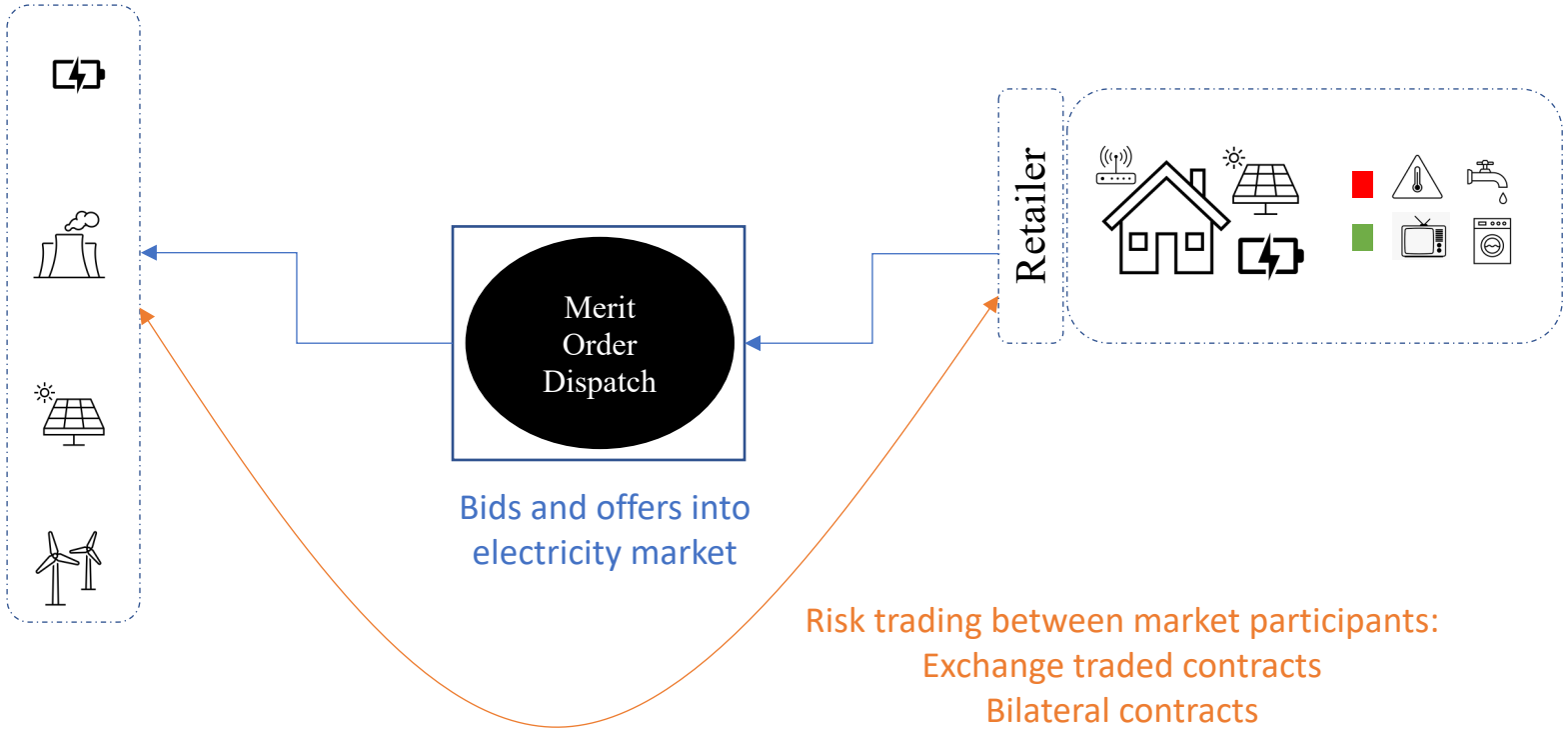
… underscoring the criticality of tail risk identification, assessment and management.

Incentives for resilience muted by market incompleteness…

- Strategic incentives
- Reliability externality
- Retail contracts – outage hedge
- Caps and operator interventions
- Fuel market linkages

For a detailed analysis see …

Mays, J., Craig, M.T., Kiesling, L., Macey, J.C., Shaffer, B. and Shu, H., 2022. Private risk and social resilience in liberalized electricity markets. Joule, 6(2), pp.369-380.



… necessitating an additional mechanism.

Resource adequacy mechanisms

- Reliability Obligations
- **Strategic Reserves**
- Capacity Auctions
- Mandatory Contracting
- Ad-hoc Investment

- Excess investment or contracting of resources
- Resources do not participate in spot market
- Used when market response is inadequate
- Allows full-strength market prices
- Intervention pricing requirements

Strategic reserves as a resource adequacy mechanism

	Australia	Belgium	Germany
Product	Reserve contracts (0-12m)	Reserve capacity (Winter only)	Reserve capacity (Winter only)
Metric	USE	MW requirement based on LOLE	MW requirement based on LOLE
Responsibility	ISO + Reliability Panel	TSO	TSO

Challenges:

- Indirect incentives for reliability
- Incorporating extremes into decision-making
- Economic efficiency

Strategic reserves:

“Getting the incentives right”

Complex extreme event risks…

Common mode events

Explicit and implicit storage

HILP event likelihood and impact

Common mode events

Systems interconnectedness

Customer damage functions

Weather linkages

The main problem is that those articles—often relied upon for policy making—consistently use the wrong thin-tailed distributions, underestimating tail risk, so that every conservative or preventative reaction is bound to be considered an overreaction.

Cirillo, P. and Taleb, N.N., 2020. Tail risk of contagious diseases. Nature Physics, 16(6), pp.606-613.

…require granular risk assessment and mitigation.

Application of insurance to electricity markets

Why insurance?

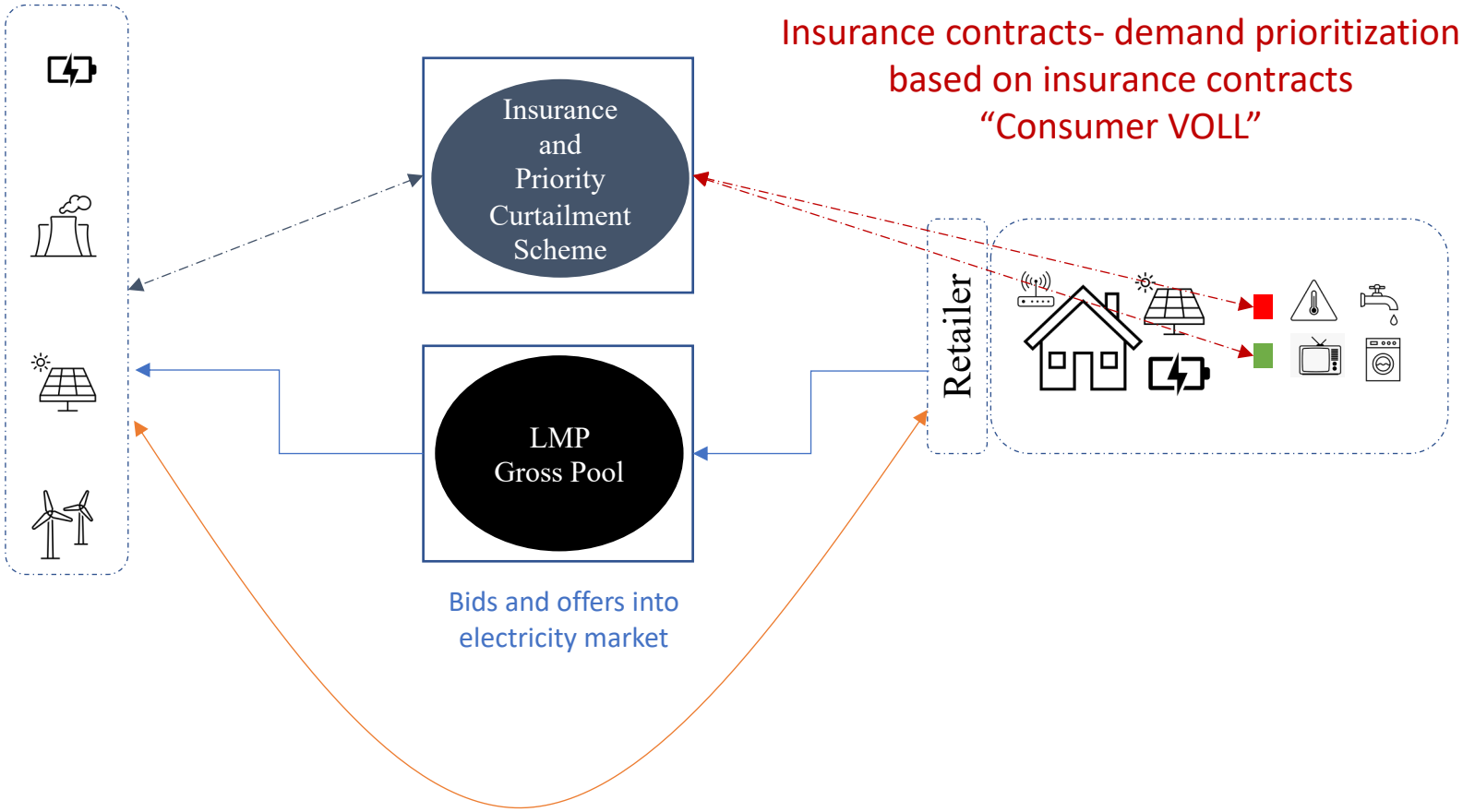
- Business model specifically catered towards managing portfolios of tail risk
- Premium setting enables “actuarial fair” pricing of extreme risk
- Risk provisioning framework suited to assessing correlated, common-mode and extreme outcomes

“we did not see the problem as one of "insurance", though, in the sense in which your paper makes clear of course it is.”

Priority curtailment scheme …

“Differentiated Reliability” Market Design

- Priority curtailment scheme
- Rationing based on essentiality

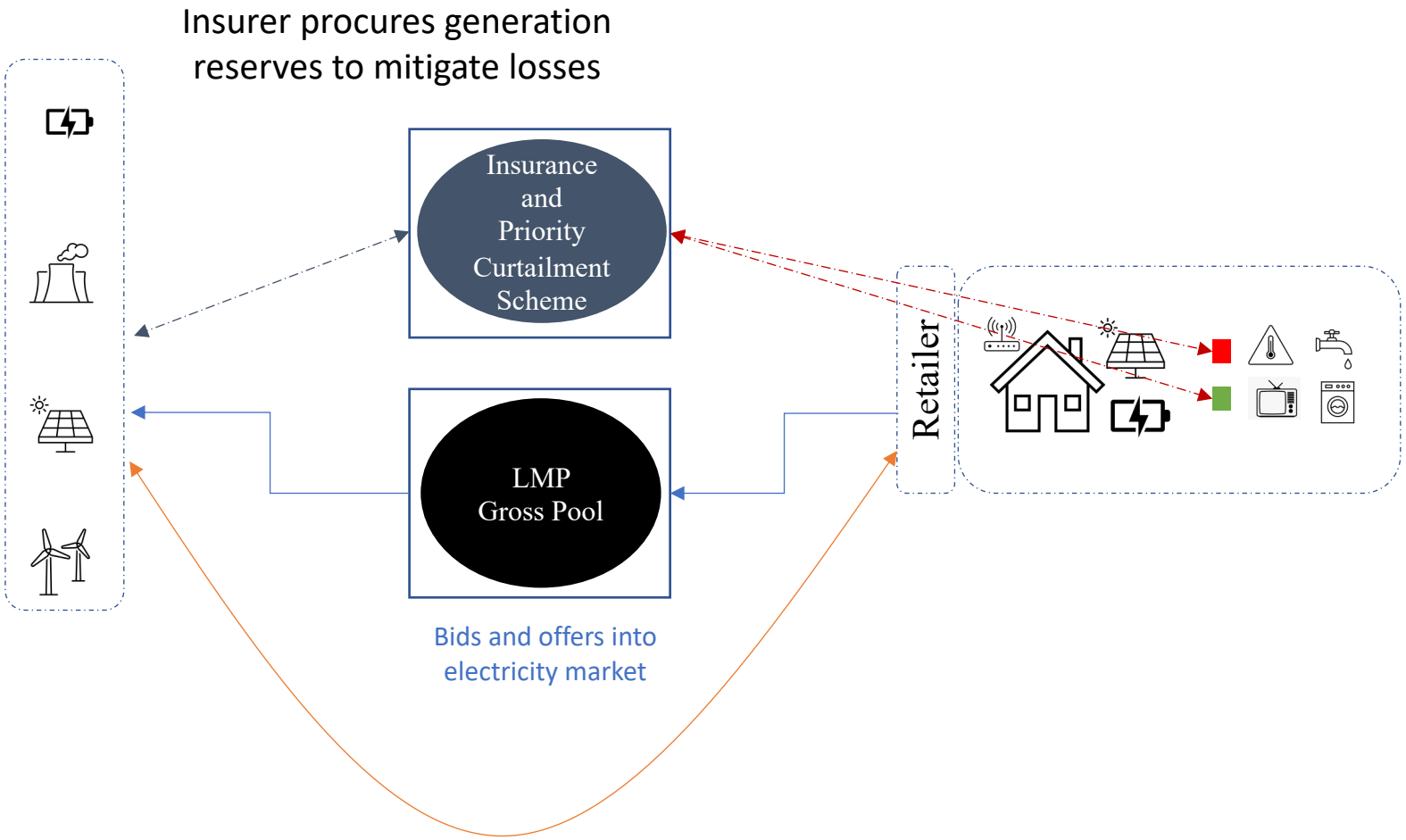


… facilitates differentiation based on essentiality and impact.

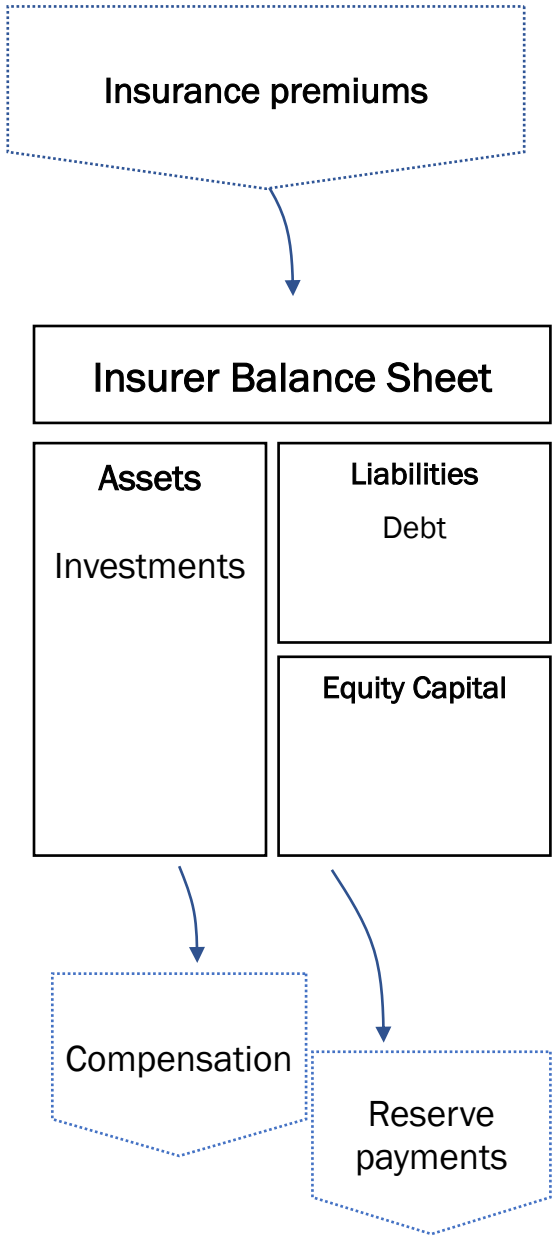
Insurance framework aligns incentives for reliability…

"Differentiated Reliability" Market Design

- Priority curtailment scheme
- Rationing based on essentiality



… with consumer preferences guiding decision-making.



Fair premium principles: Actuarial value of contingent compensation (Wilson 1989).

Risk provisioning:

- Hold reserves ϕ to cover 'worst case losses'
- Industry best-practice and regulatory frameworks

Loss mitigation:

- Natural incentives for investments in reserves/resilience…
- … only where those investments improve service interruption outcomes.

An insurer's cashflows φ are defined as:

Premium Income + Investment Income – Operating Expenses – Debt Service – Compensation

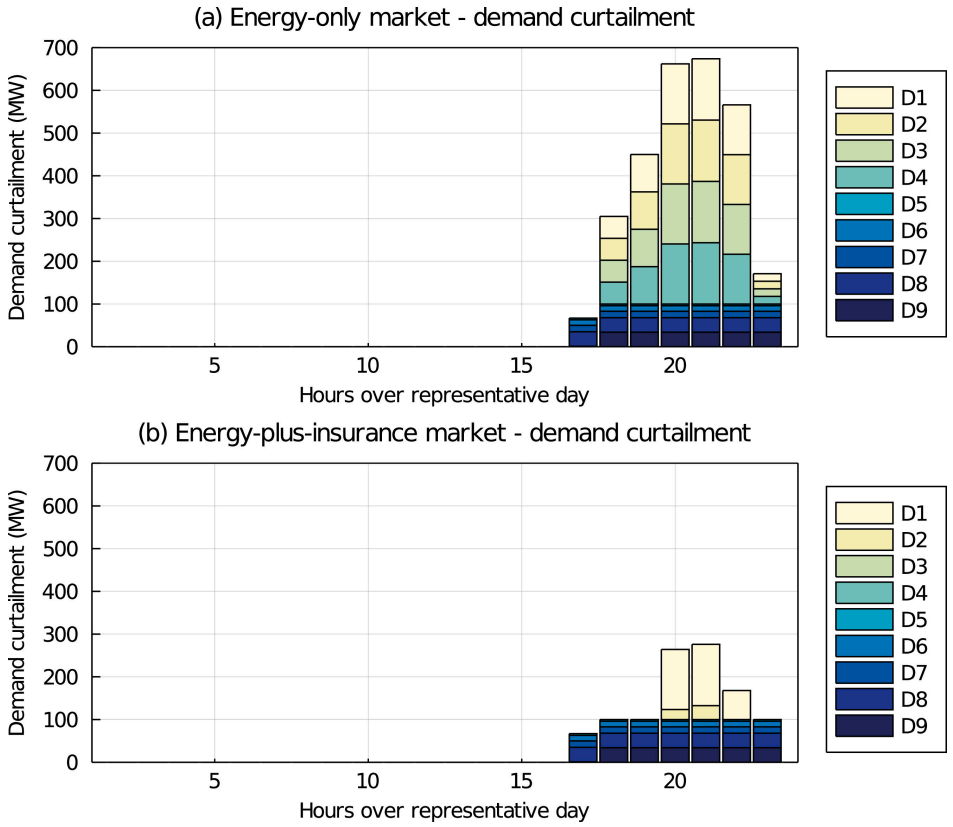
Insurance risk measures and constraints

- Expected returns
- Conditional-value-at-risk CV@R for a ruin probability, α $\quad CV@R\ (\varphi) = \frac{1}{1-\alpha}\int_{\alpha}^{1} V@R(\varphi)$
- Solvency constraint $\quad \phi \geq -CV@R\ (\varphi)$

Source: Billimoria, F., Fele, F., Savelli, I., Morstyn, T. and McCulloch, M., 2022. An insurance mechanism for electricity reliability differentiation under deep decarbonization. Applied Energy, 321, p.119356.

Case Study

- South Australia - 20 scenarios for demand, wind and solar
- 9 candidate dispatchable generators:
- Demand: two categories of demand (1) Essential: VOLL $15000/MWh, (2) Non-essential: VOLL of $7500/MWh



	Risk neutral optimum	Energy only market	Energy plus insurance market
Market design	**RN**	**EOM**	**EIM**
Total capacity (MW)	**3361**	**2730**	**3128**
Market generation	3361	2730	2730
Strategic generation	–	–	398
USE - mean (%)	0.001	0.035	0.015
USE - worst (%)	0.020	0.311	0.116

Social insurance versus electable insurance

Electable insurance scheme

- Fully electable decentralized market
- Competitive premium setting
- Consumer revealed VOLL
- Priority curtailment

- Enhanced metering requirements
- Equity issues – but consider subsidy

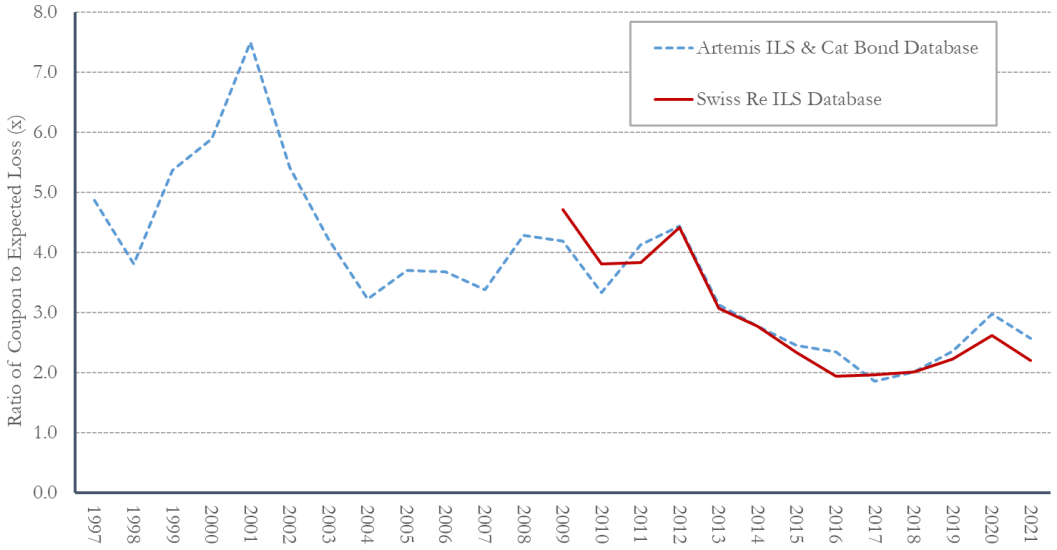
Social insurance scheme

- Centralised with opt-out
- Regulated premium for extreme risk
- Regulatory VOLL

- Limited metering requirements
- Equitable – applies to all

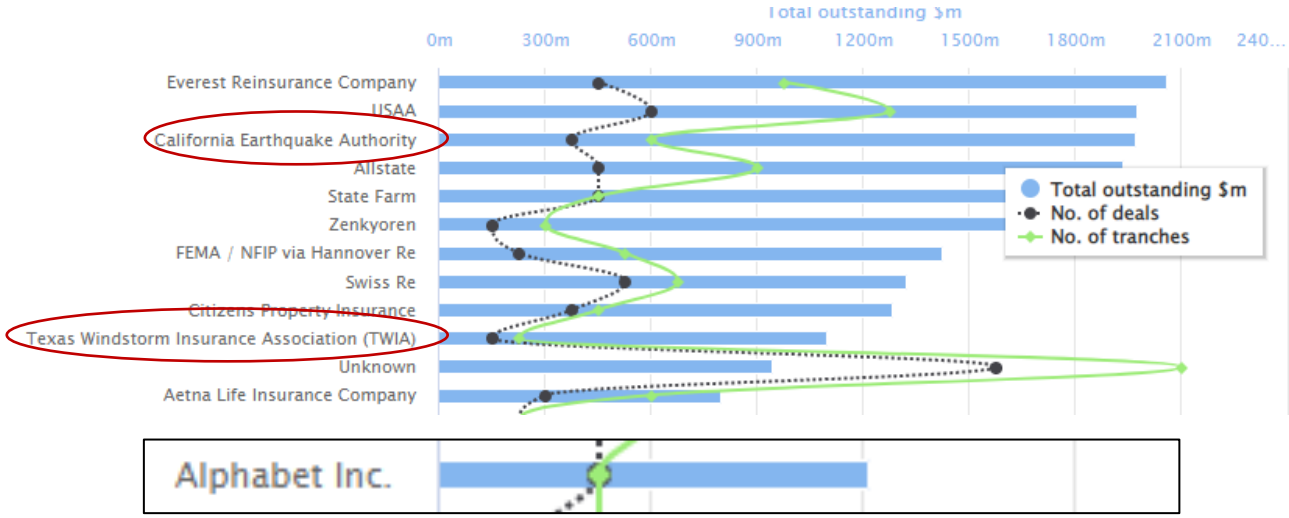
Both retain the benefits of an insurance decision-making framework catered to assessing tail-risks

Are electricity interruption risks insurable?



Coupon is calculated as the average bond issue coupon for catastrophe bonds and insurance linked securities transactions. The expected loss is a measure of the average loss that investors in a catastrophe bond issue can expect over a certain period relative to the capital invested. This metric is typically provided to investors at issuance, and calculated by a third-party risk modelling agency (such as for example RMS, AIR Worldwide, EQECAT, Milliman, and KatRisk).

Data Source: Swiss Re Capital Markets Deal Database - Catastrophe Bonds (2009-2021). Artemis Catastrophe Bond & Insurance Linked Securities Deal Database (1997-2021). Includes public and some private issuances tracked by Artemis.



Markets for ‘extreme risk’ reveal appetite for both location, hazard and company specific risk

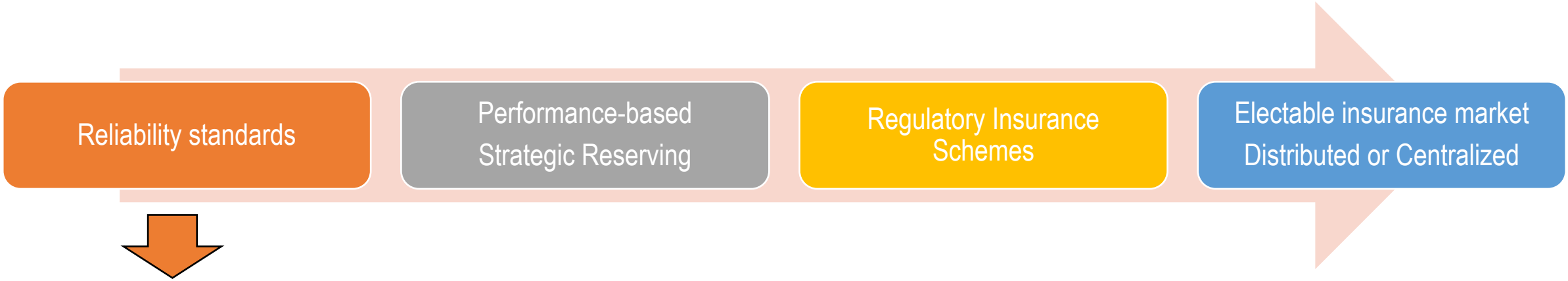
Source: Billimoria et al (2022) On the insurability of tail risks in energy markets, forthcoming.

Complexities of implementation…

Challenge	Implementation options
Lack of metering and comms.	**Opt-out scheme for insurance.** Only those seeking to be treated 'differently' need the infrastructure.
Social equity	**Socialised insurance** – equity factors included in premium allocation framework
Centralised monopoly provider	The status quo for CMs / strategic reserves. Insurance creates vertical competition in the form of demand
Risks unable to be assessed	Currently consumers bear risk. Market participants / insurer better placed than consumers.
Risks unable to be managed/mitigated	Currently consumers bear risk. Insurer could transfer 'unmanageable risks to global reinsurance markets.
Premium setting	Actuarially fair premium principles set in regulations
Markets for reliability	Multi-lateral contracting options

… require practical solutions.

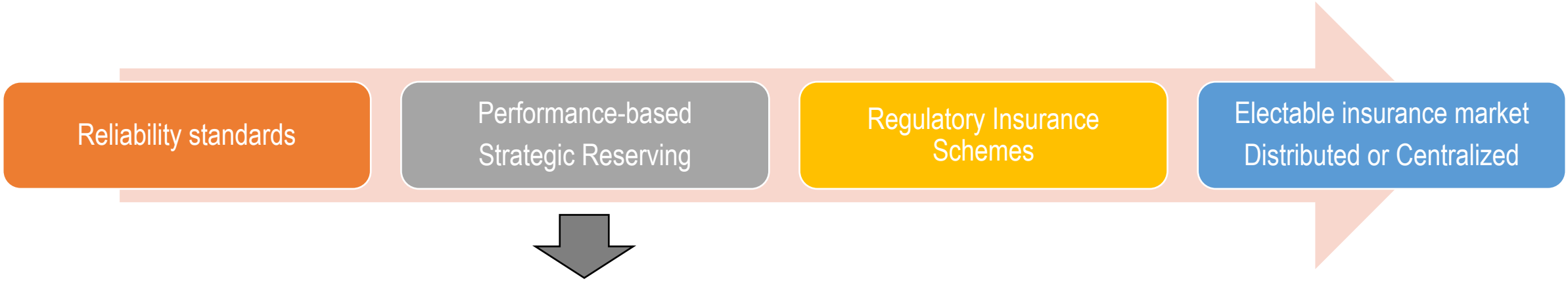
An array of implementation options…



- Incorporate tail risk metrics into reliability standards
- Adapt ‘expected USE or LOLE’ to incorporate extreme scenarios
- Tail risk measures – VAR / CVAR

… to improve tail-risk decision making.

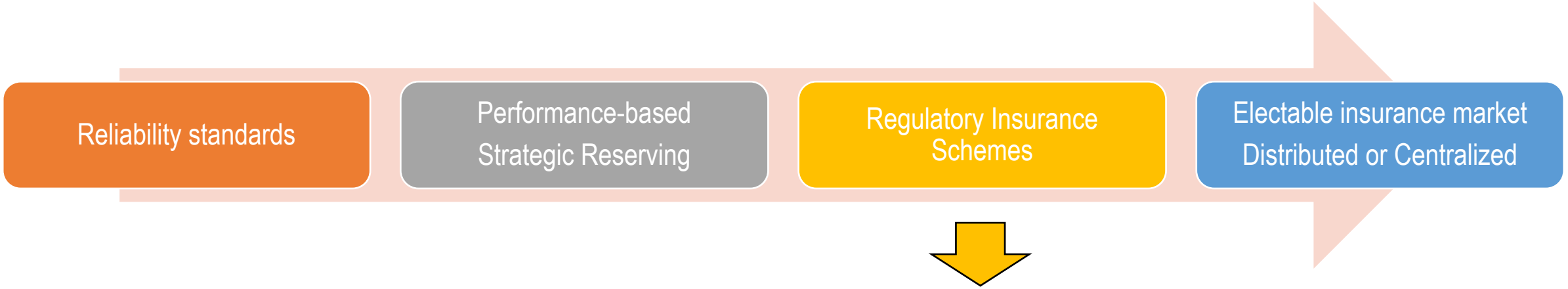
An array of implementation options…



- Performance measures into decision-making
- Balanced scorecard for strategic procurer
- A ‘insurance-based’ proxy
- Performance-based contract

… to improve tail-risk decision making.

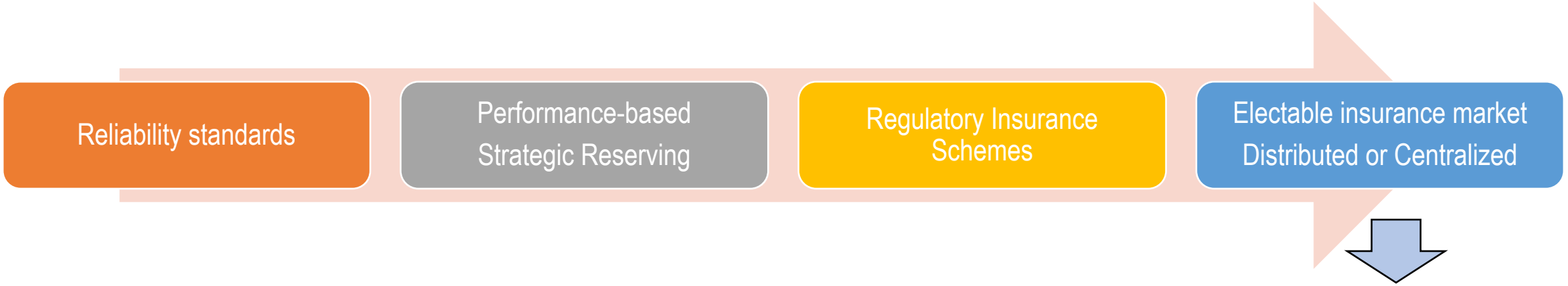
An array of implementation options…



- Regulatory framework for insurance
- Social insurance – with regulated VOLL
- Opt-out under certain conditions

… to improve tail-risk decision making.

An array of implementation options…



- Open market for insurance
- Multiple providers / competition
- Digital technology enabled

… to improve tail-risk decision making.

Conclusion

I. Who should bear the residual risks for system outages?
II. The need for actuarially fair pricing of risk
III. Alignment of investment decisions and outcomes

Thank you for your attention!

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