

Role of Demand Flexibility Trading in Australia's Clean Energy Transition: A Systems Thinking Approach

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Key messages

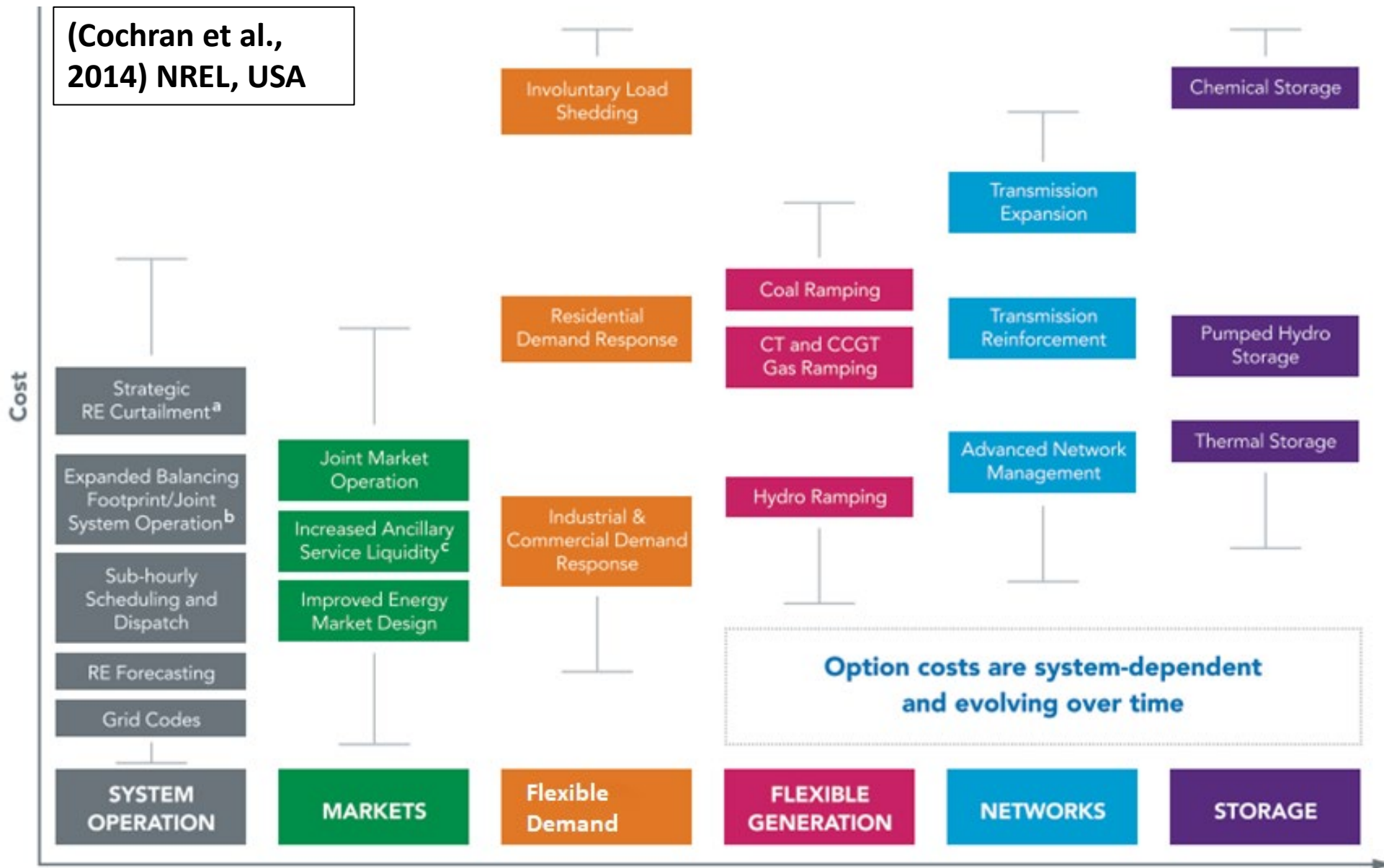
- Coal fired power stations cannot exit until we replace the services they provide.
- Post 2025 energy market reforms focus on “Integration of large-scale variable renewable energy”
- National CER Roadmap process focus on the DER scale

DER integration challenge

- Uncontrolled and uncoordinated DERs are the problem
- Controlled and coordinated DERs (as demand flexibility) are the economic solution.
- The NEM defines what is valued and what is not.
- Solution is to value the services that coordinated and controlled DERs provide (DER services).

Integration of Variable RE: Relative costs options

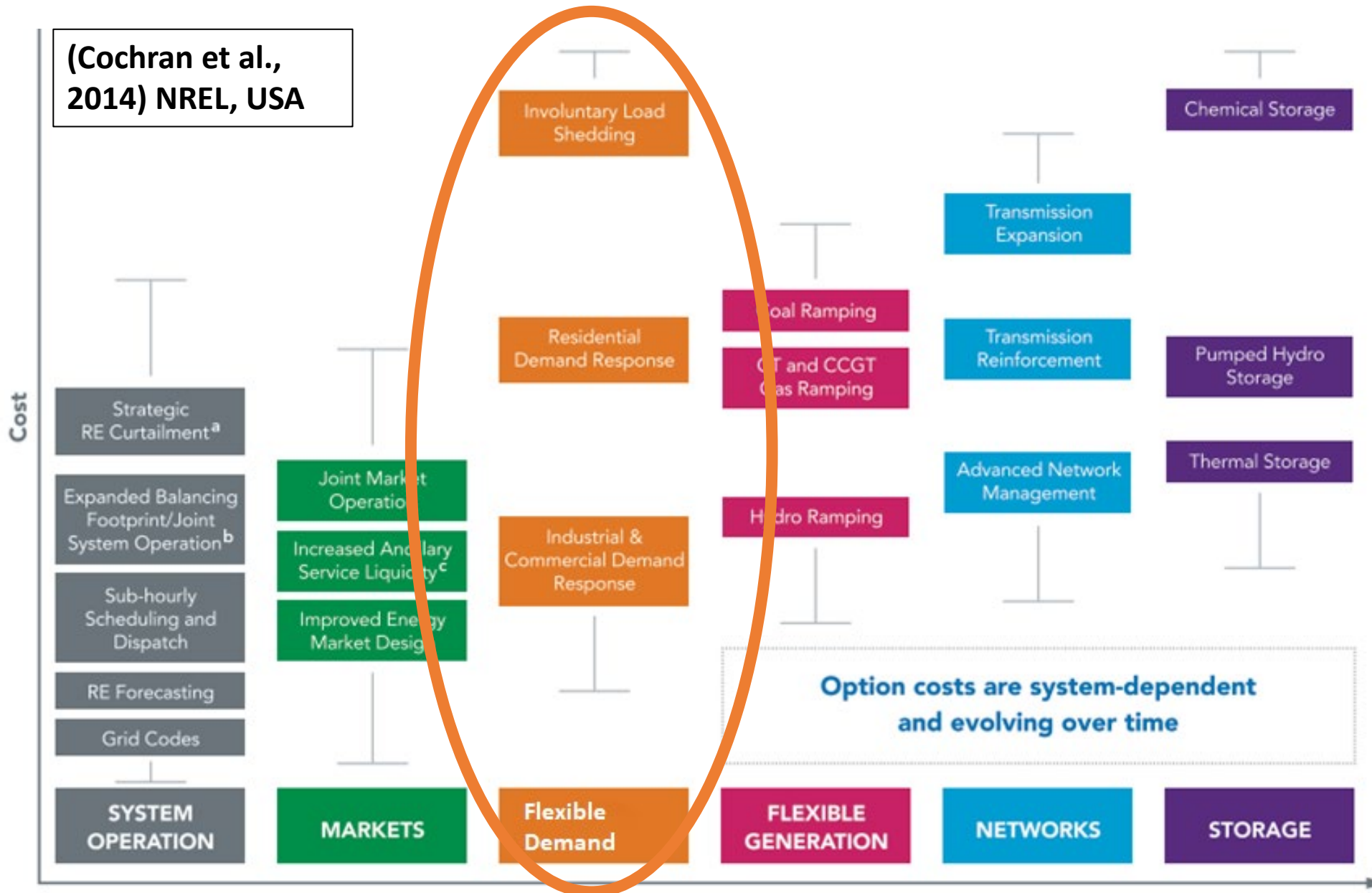
(Cochran et al., 2014) NREL, USA



- Historically supply followed demand.
- To 'firm' variable renewable need additional sources of power system flexibility at every level
- Demand needs to follow supply

DER Integration and Demand Flexibility

(Cochran et al., 2014) NREL, USA



- Relative costs of power system flexibility options
- US\$, US Case studies and 2014

Trade in Demand Flexibility?

What is it?

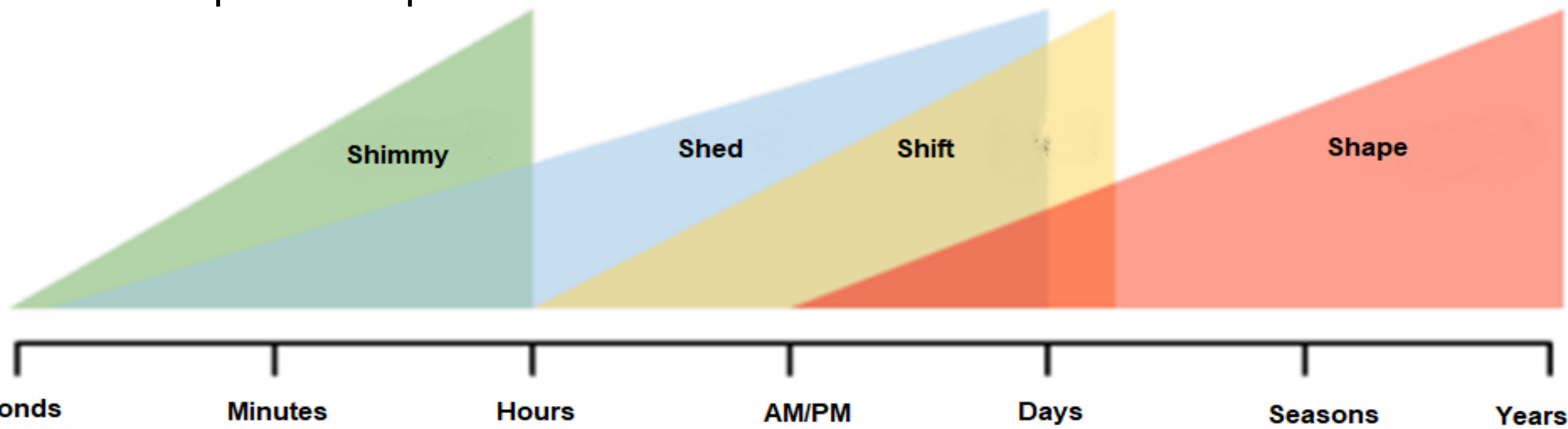
- A form of power system flexibility.

Who has it?

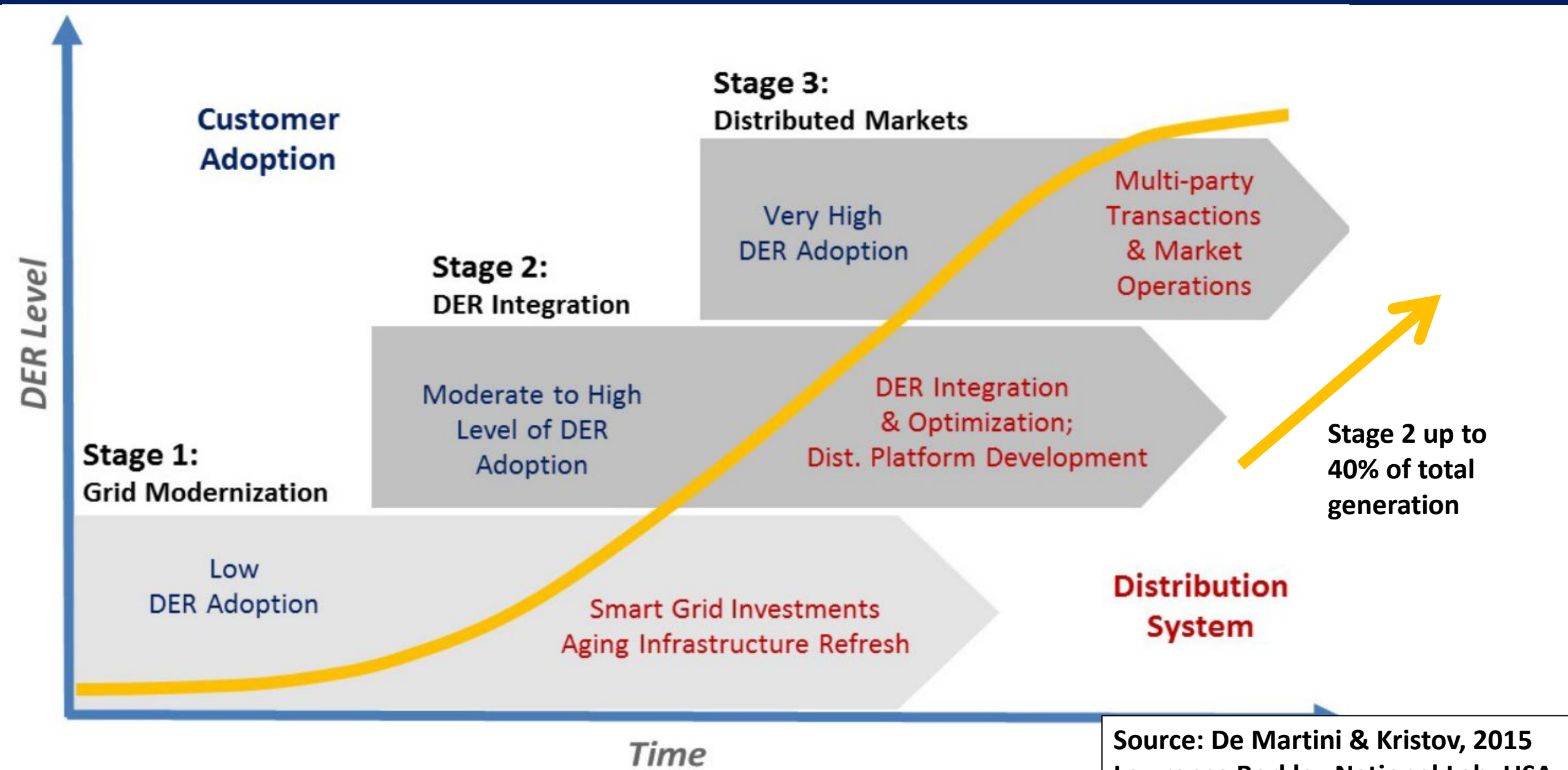
- End Consumers.

How to get it off them?

- Switching on and off End Consumers' privately owned DER assets
- For adequate compensation



DER Integration Pathway to Multiparty trade

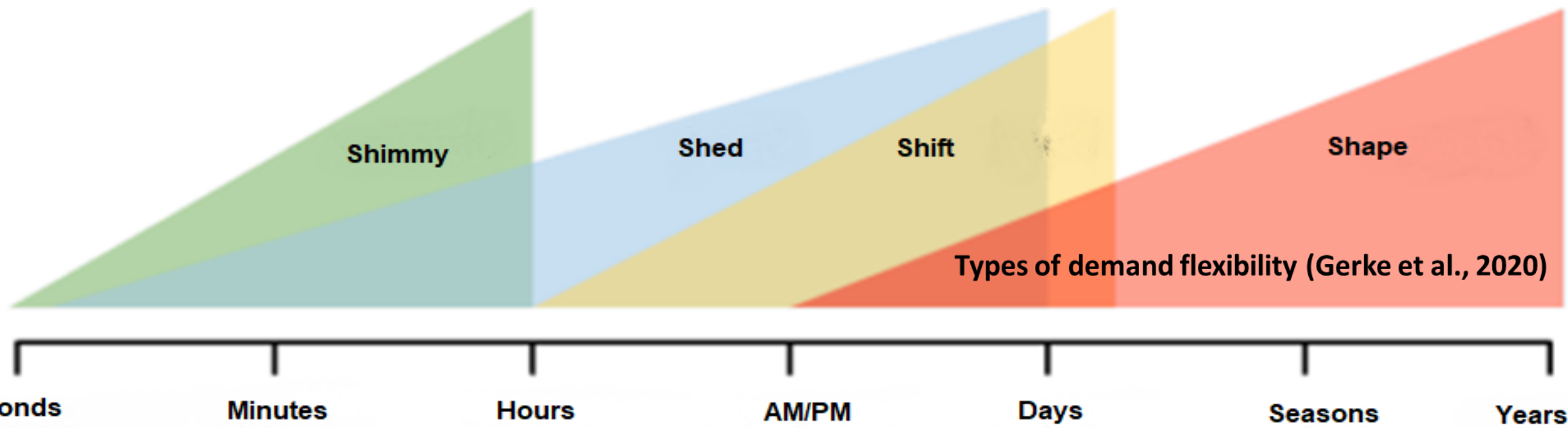


Source: De Martini & Kristov, 2015
Lawrence Berkley National Lab, USA

Multiparty transactions?

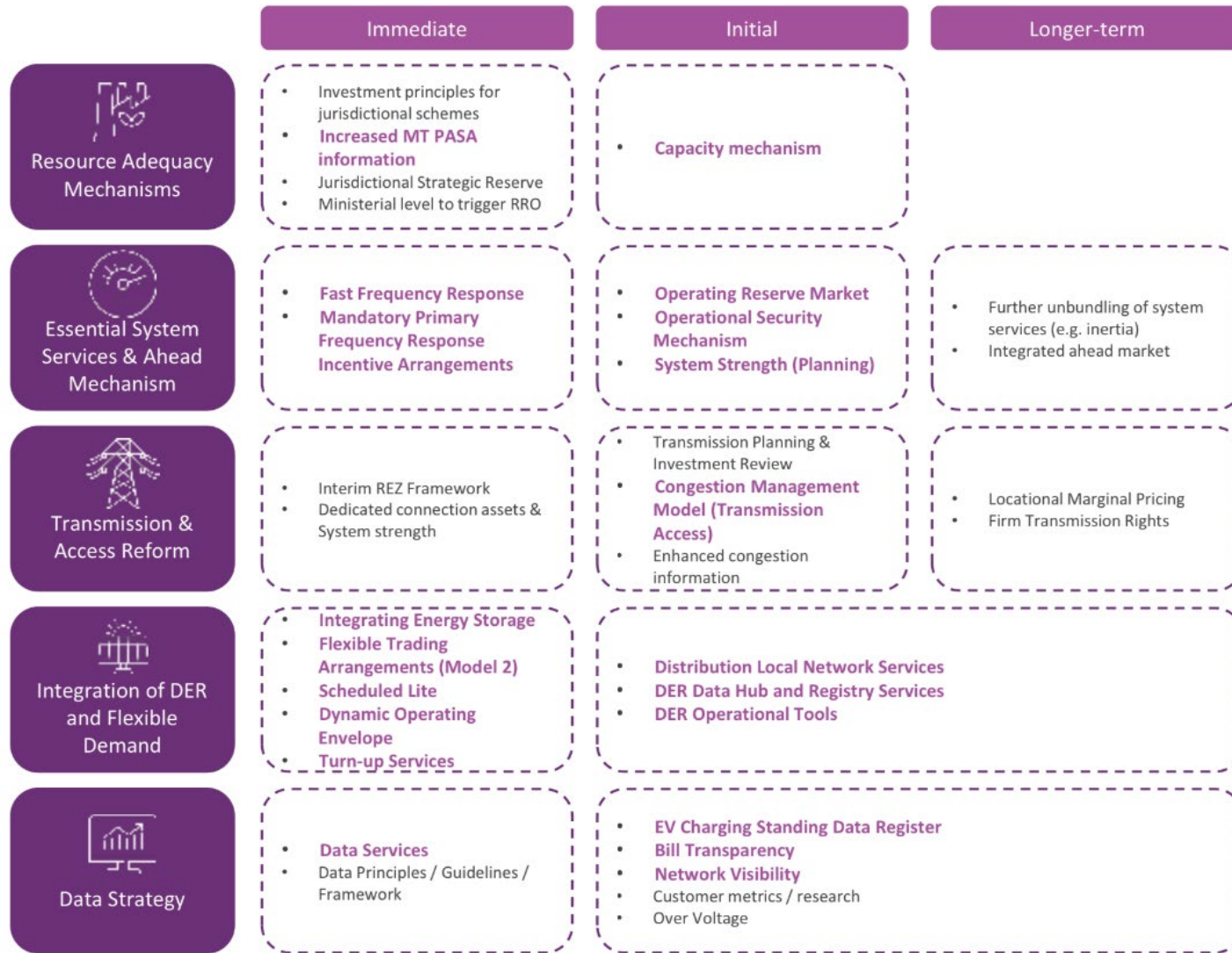
How to trade Demand Flexibility?

- Commoditise as **DER Services**.
- Buyers and sellers. Respond reliably to a market signal. Delivered when and where required.
- Quality and delivery criteria: Technical (up / Down), Response time, Reliability, Availability



Energy Market Reforms Initiated

of 8



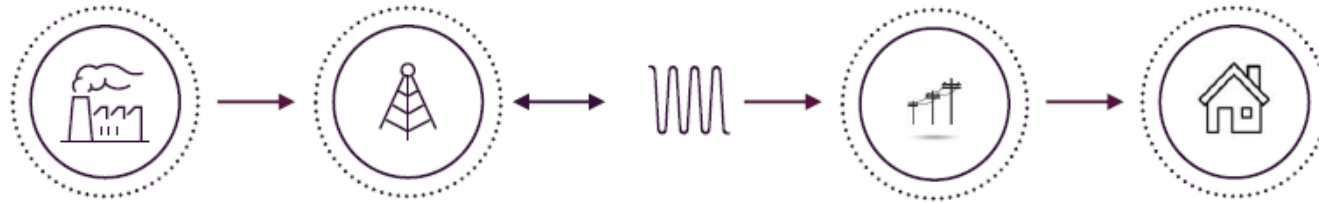
Note: Items in purple reflected in NEM2025 Program Scope as further detailed below.

- Post Energy Market Process lead by Energy Security Board (2019 to 2023)
Incomplete tasks handed over to:
 - Energy Ministers acting as Energy and Climate Change Ministerial Council.
 - Au Energy Market Commission

² Energy Security Board website. Last accessed 13 May 2022. Available at <https://esb-post2025-market-design.aemc.gov.au/>.

Energy Market Reform Process

Traditional power system

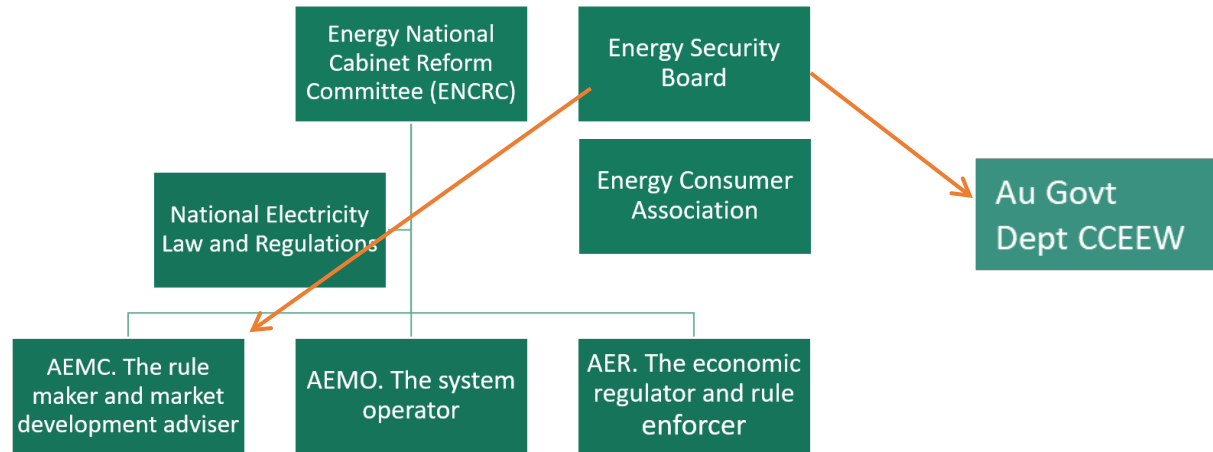


Power Plant

Transmission

Distribution

Consumers



Market Participants



Version: 20.5.2021

South Australia

National Electricity (South Australia) Act 1996

An Act to make provision for the operation of a national electricity market and for other purposes.

Contents

Part 1—Preliminary

- 1 Short title
- 3 Interpretation
- 4 Crown to be bound
- 5 Extra-territorial operation

Part 2—National Electricity (South Australia) Law and National Electricity (South Australia) Regulations

- 6 Application in South Australia of National Electricity Law
- 7 Application of regulations under National Electricity Law
- 8 Interpretation of some expressions in National Electricity (South Australia) Law and National Electricity (South Australia) Regulations

Part 4—Making of regulations and rules under National Electricity Law

- 10 Definitions
- 11 General regulation-making power for National Electricity Law
- 12 Specific regulation-making power
- 13 Making of rules

Part 5—General

- 14 Freedom of information
- 15 Conferral of functions and powers on Commonwealth bodies
- 15A Regulation-making power for the purposes of the National Electricity (South Australia) Law

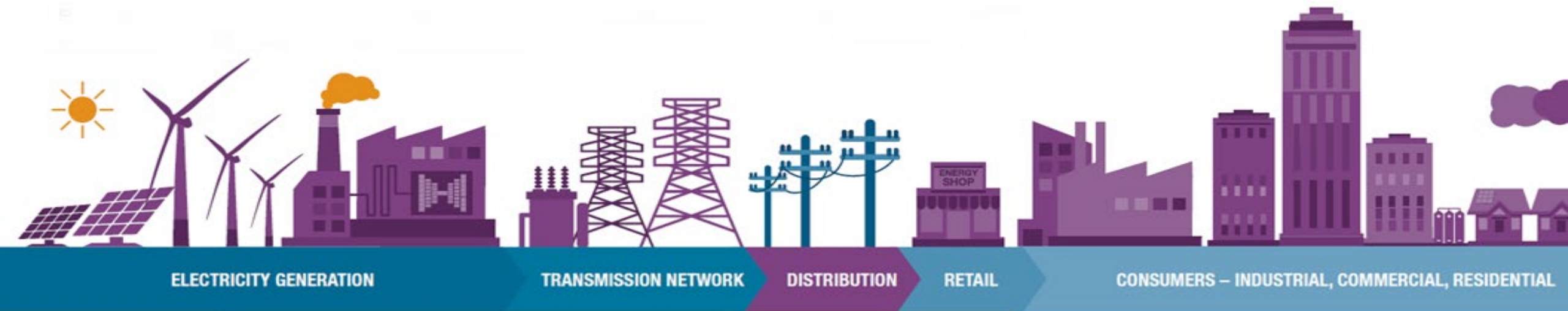
Part 6—Transfer of economic regulation of electricity distribution to AER—local provisions

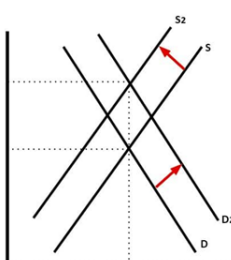

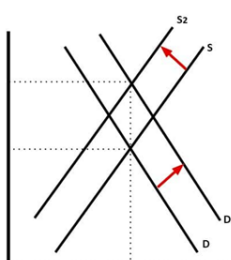





- 16 Interpretation
- 17 Provision of information and assistance by ESCoSA
- 18 Price determinations

Part 7—AEMO's additional advisory functions

- 19 AEMO's additional advisory functions

Energy Reforms Initiated



ELECTRICITY GENERATION	TRANSMISSION NETWORK	DISTRIBUTION	RETAIL	CONSUMERS – INDUSTRIAL, COMMERCIAL, RESIDENTIAL
<p><u>Wholesale Electricity Market</u> Generator sells to Retailers Market Operator: AEMO Batteries allow Arbitrage, Merit Order</p>  <p>[elec-] [FCAS]</p>	<p><u>Wholesale Demand Response Mechanism (WDRM)</u></p> <p>Aggregators bidding >30MW of 'nega-watts' sourced from large Commercial and Industrial Customers</p> 	<p><u>New Market at Distribution Level (Local Energy Market)</u></p>  <p>[elec-] [FCAS]</p> 	<p><u>End Consumer</u></p> <p>20% of h'h w Solar pV Aggregators / Virtual Power Plants</p> <p>Bidding 5-30 MW (?)</p> 	
 				

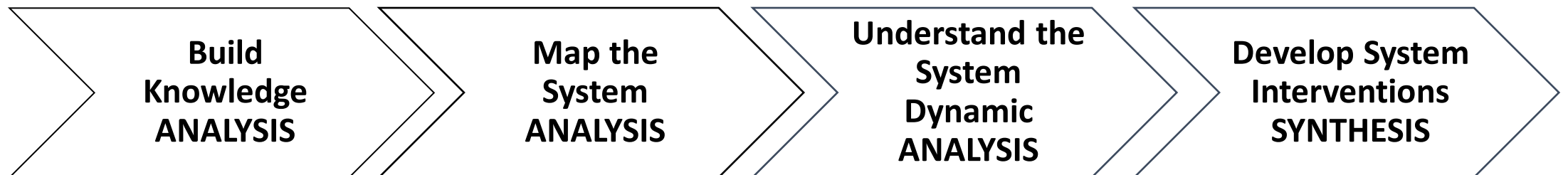
Energy Transition: Meet the criteria of complex??

NEM energy market reforms are occurring within

- A complex adaptive system that is in transition
- Involving multiple state government jurisdictions transitioning at different rates, differing resources, infrastructure and policies.

In a policy environment such as this

- a systems thinking approach based on complexity theory is recommended.



Systems Thinking Practice and Tools

- Define the dynamic problem, its boundary and the goal.
- Use of ST tools to capture, understand and analyse complex system dynamics into a succinct and explicit system structure able to be communicated.
- Visualise the subject actors, objects, interconnections, power relationships, potential intervention and leverage points.
- Create a dynamic hypothesis based on the structure of the system
- Test the interventions and impact on problematic behaviour of the system

System Dynamic Modelling Software

The image shows the Vensim software interface with a license dialog box open. The dialog box contains the following text:

VENSIM[®]

Vensim[®] PLE Version 9.3.4 x64 (x64), Build : TK-220926.00179

Registered to: Vikki McLeod
Company : Academic Use Only

VENTANA

Copyright Ventana Systems, Inc.
This software is subject to the terms of the licence agreement at vensim.com/license/
Causal tracing, Reality Check, Vensim, Ventana and the Ventana Logo are registered trademarks of Ventana Systems, Inc.
Vensim is covered by United States patents 5,428,740 and 5,446,652.

Buttons: Check Now, Attempting to retrieve version information, Close

Check for updates on startup

The background shows a system dynamics model with a stock-and-flow diagram. A stock is labeled 'Consumer (\$Budget/unit)' and has a value of 100. A flow is labeled 'Att (\$Budget/unit)' and has a value of 0.1. Other flows are labeled 'bsitutes (situte/unit)' and 'bility (ery/unit)'. The interface includes a menu bar (File, Edit, View, Layout, Model, Simulation, Tools, Output, Window, Help), a toolbar, and a status bar at the bottom showing 'Workbench Variable : Consumer (\$Budget/unit)' and 'Zoom Level : 100 %'.

Working Hypothesis : Trade in DER Services

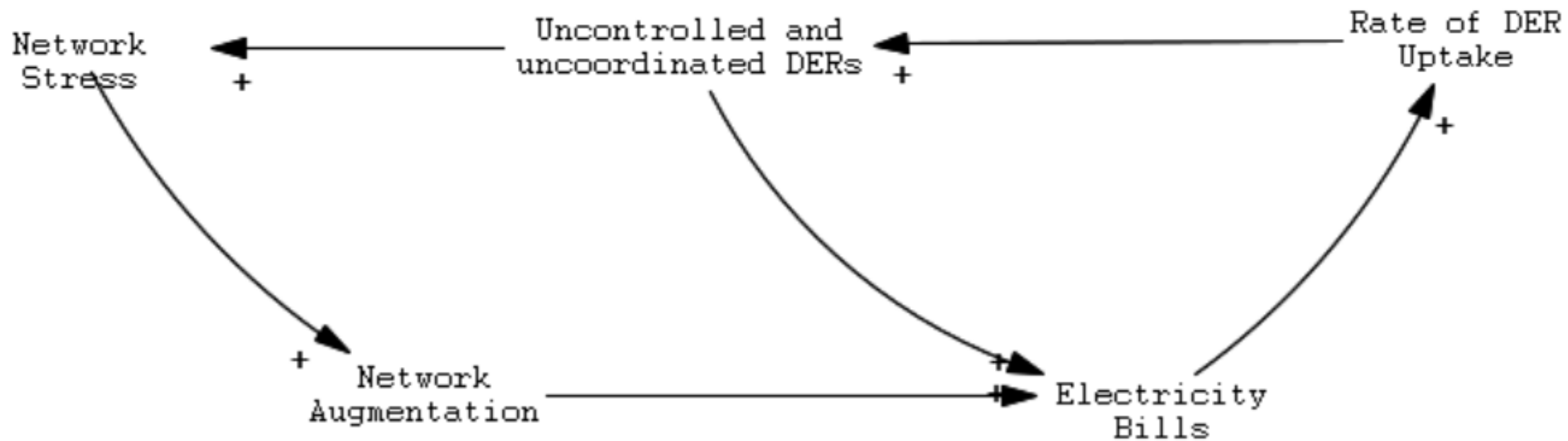
Issue:

- If uncontrolled and uncoordinated DERs are the problem
- Controlled and coordinated (orchestrated) DERs are the economic solution

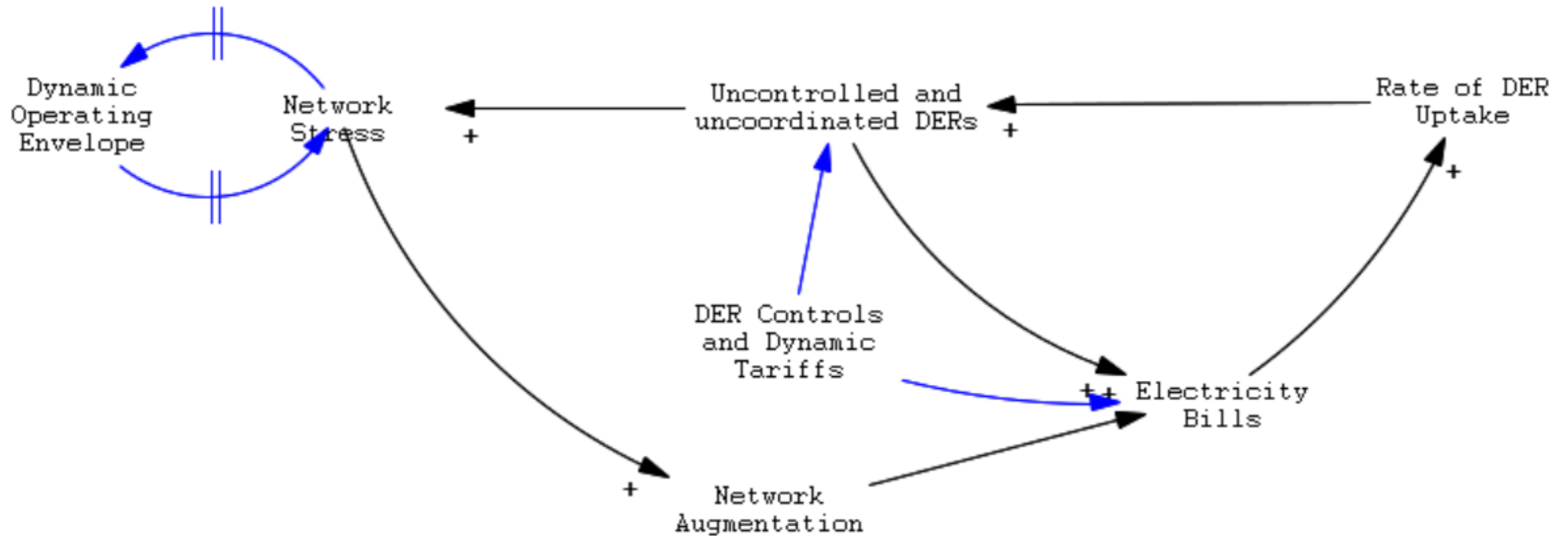
Hypothesis:

- Commoditise Demand Flexibility
- Value the services that orchestrated DERs can provide
- Create a trade in DER Services (demand flexibility)

Causal Loop Diagram: BAU Case of Uncontrolled DERs



Reference Case of Uncontrolled DERs + Current Options



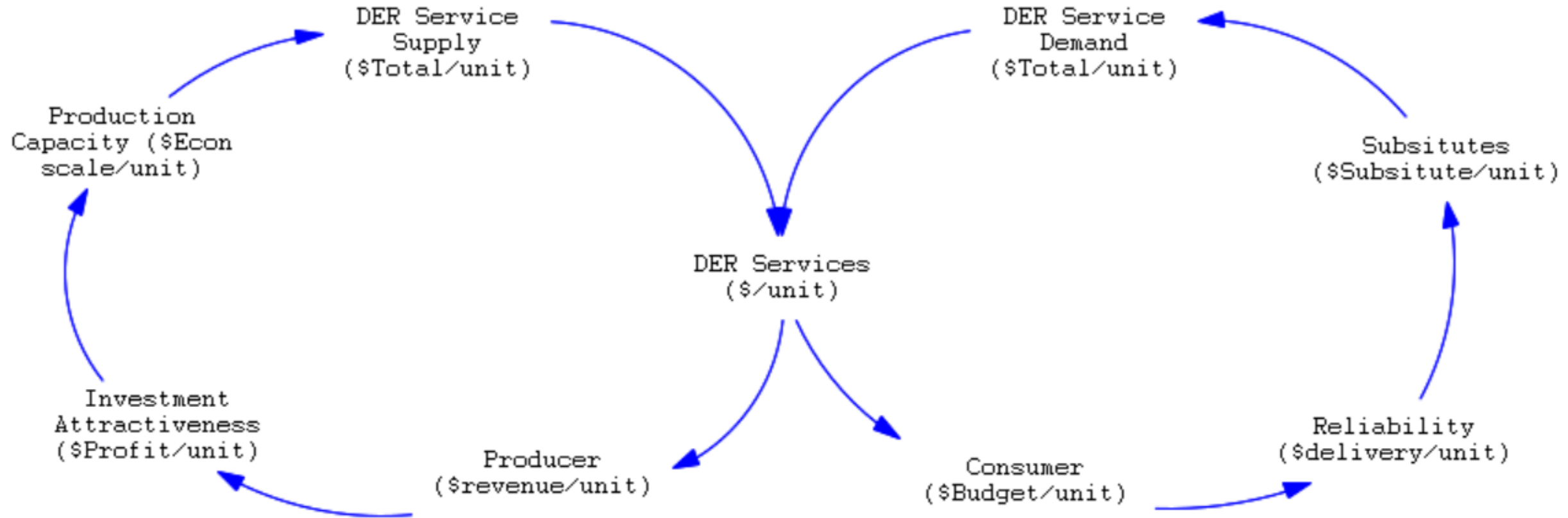
ARENA funded Project Edge \$6B benefits and \$5B attributable to DOE balance to dynamic network tariffs

System Dynamic Archetype

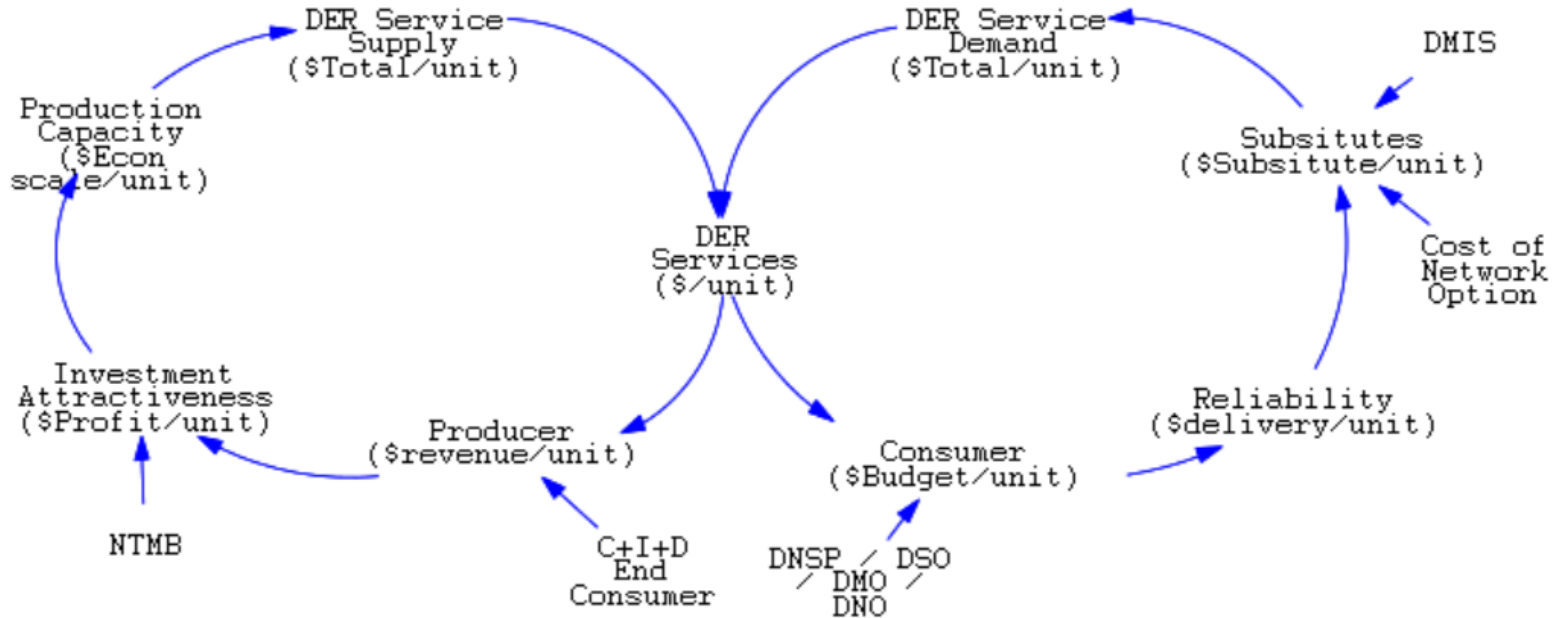
BAU is an “Infrastructure Addiction Archetype”

- Lack of Coordination between Transmission and Distribution generation
- Risk of overbuild at Transmission level
- Without addressing the underlying issue leading to the addiction.
- “the demand side and end consumer” and multi-party trade in DER services.

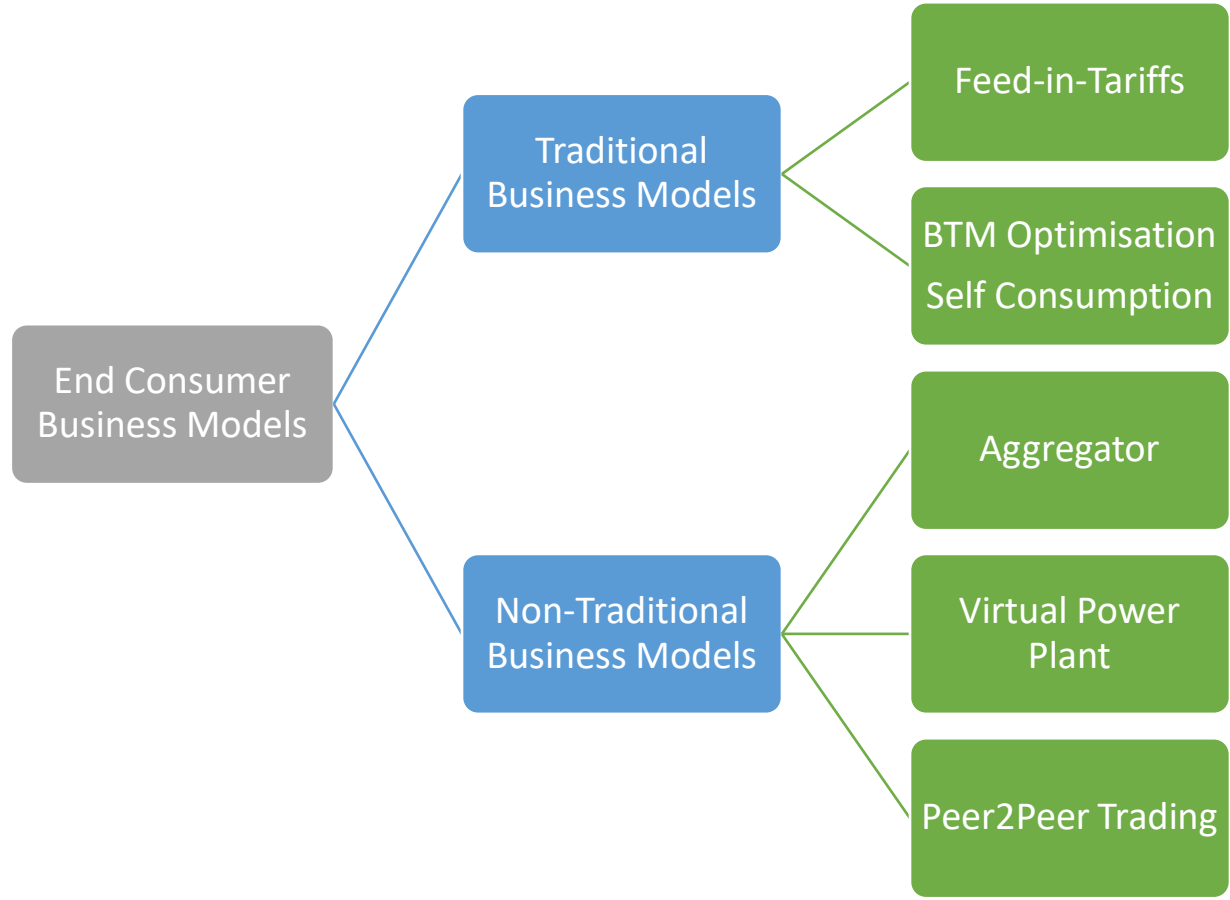
DER Integration Hypothesis: Conditions of Trade



DER Integration Hypothesis: Conditions plus Actors



'Non-Traditional Business Models' (NTBM)



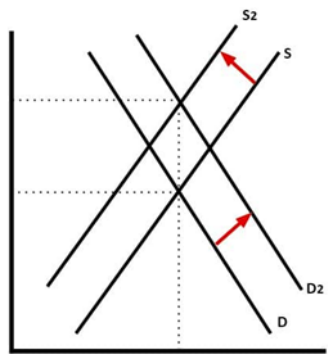
Examples:

- Aggregators, Virtual Power Plants, Flexi-trader

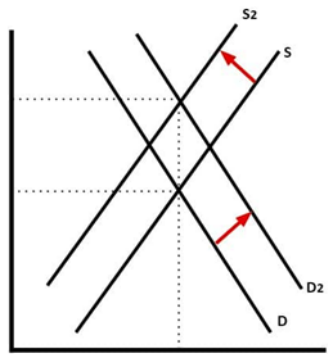
Purpose

- Address barriers to participation by the End Consumer
- Achieve scale
- Achieve broader network benefits
- Access to Full Value Stack

Post 2025 Energy Market + International Trends



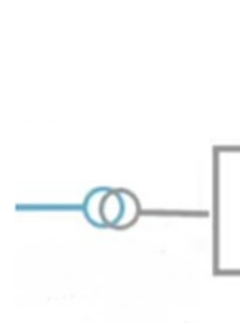
**Wholesale Market Operator
AEMO**



**Distribution Market Operator
(DMO)**

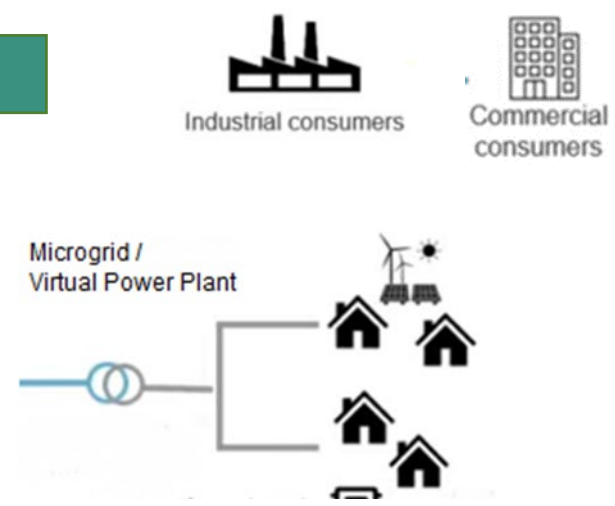
**Distribution System Operator
(DSO) => Distribution Network
Operator**

Demand Side



DER Aggregator

>30 MW

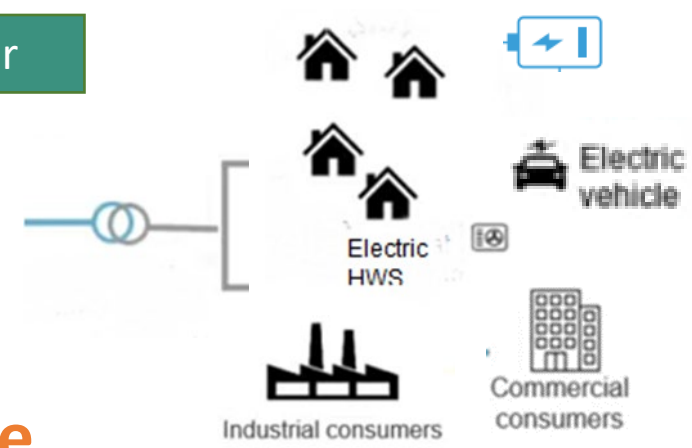


Virtual Power Plant



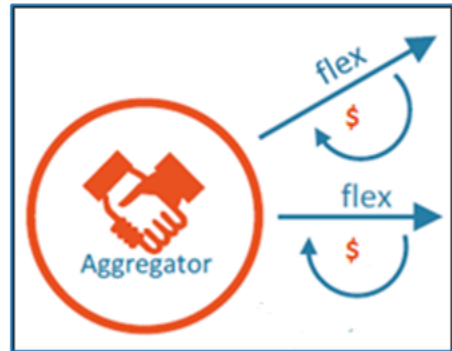
DER Aggregator

5 - 30 MW



Supply Side

Value Stack



NEM Wholesale Market
Wholesale level Market (NEM)



New prices signals
2SM Distribution level market
(d2SM)



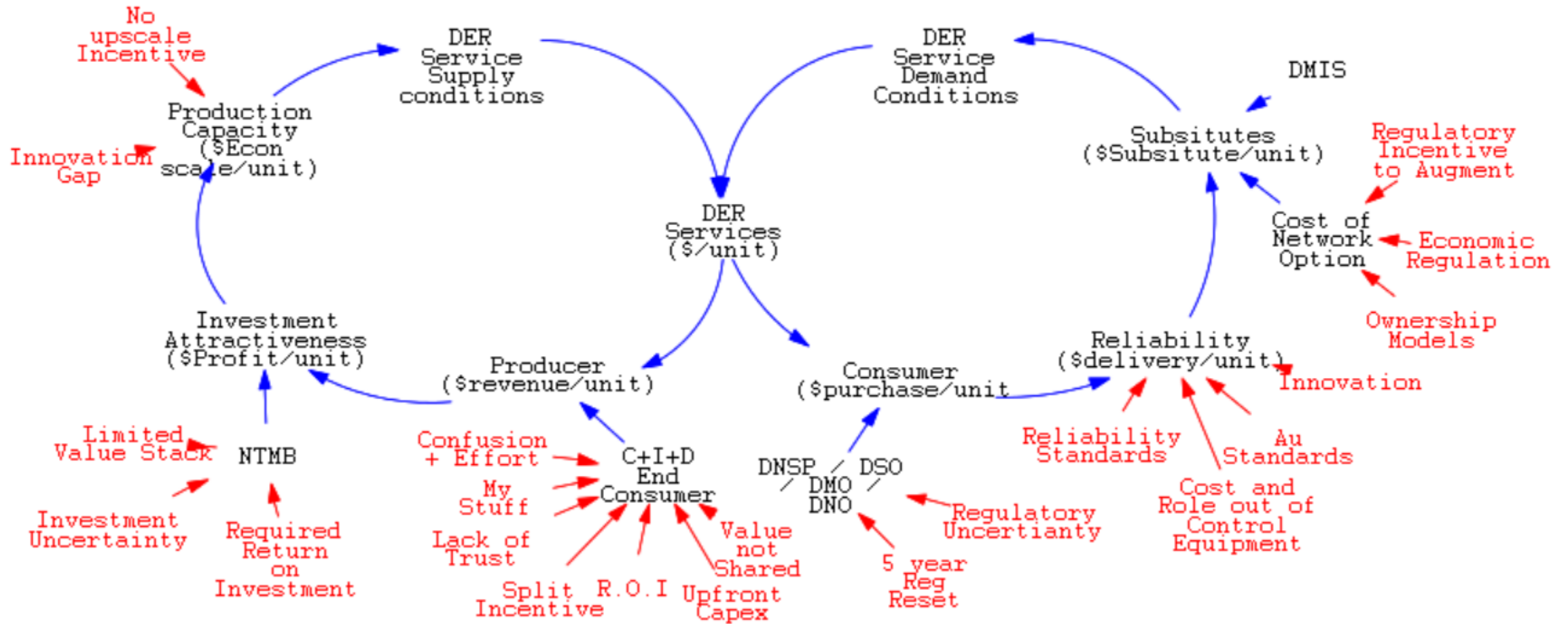
Behind the Meter Optimisation
(BtM)



Carbon Offset Value (SV)

Full Value Stack DER Services
 = \$e w'sale market hedge
 + \$BoS Trans + distribution
 + \$NonNetwork Services
 + \$Btm Savings
 + \$carbon price (Societal Value)

Limitations and Constraints to Trade



Energy Transition versus Energy Transformation

Electricity systems are undergoing both an energy transition and a grid transformation challenge.

The difference between transition and transformation is the degree of management required.

This management role results from:

- Government energy policy direction
- Role of energy markets? Energy market reform?
- Innovation? Technology path dependency? Business Model innovation

Societal Value? Supports Govt intervention

Costs of Energy BAU (aka “Infrastructure Addiction Archetype”)

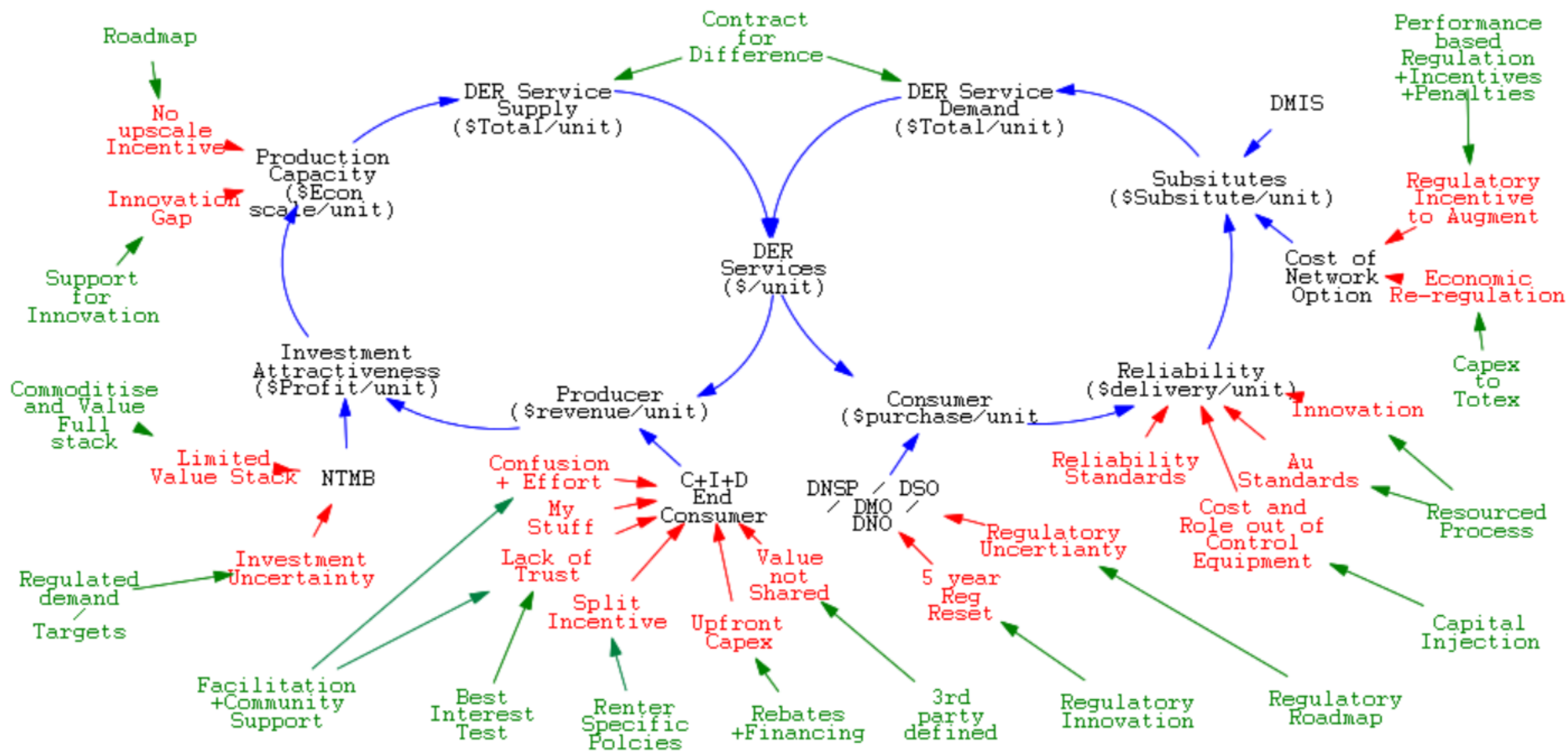
- Lack of Coordination between Transmission and Distribution generation
- Risk of network overbuild (IEEFA, 2023)
- Overspend in networks due to network re-regulation (Capex to Totex) delays (IEEFA, 2023)

Societal value:

Value of Demand Flexibility Trading

- \$19Billion p.a. (IEEFA, 2024)
- Un-lock energy savings and (anti-inflationary) productivity benefits
- Local economic development benefits
- Meeting Carbon Targets and exceeding 2 deg

Policy Interventions



Complex Systems

In managing complexity in an adaptive system:

- Outcomes can be nonlinear and surprising
- Need for whole of system design approach
- Focus on the *interaction* between elements
- Apply systems thinking tools

Examples from history

- Kennedy era “Moonshot”
- “O-ring responsible for the Challenger disaster”
Richard Feynman

.... need to take a systems approach

☐☐☐Nine



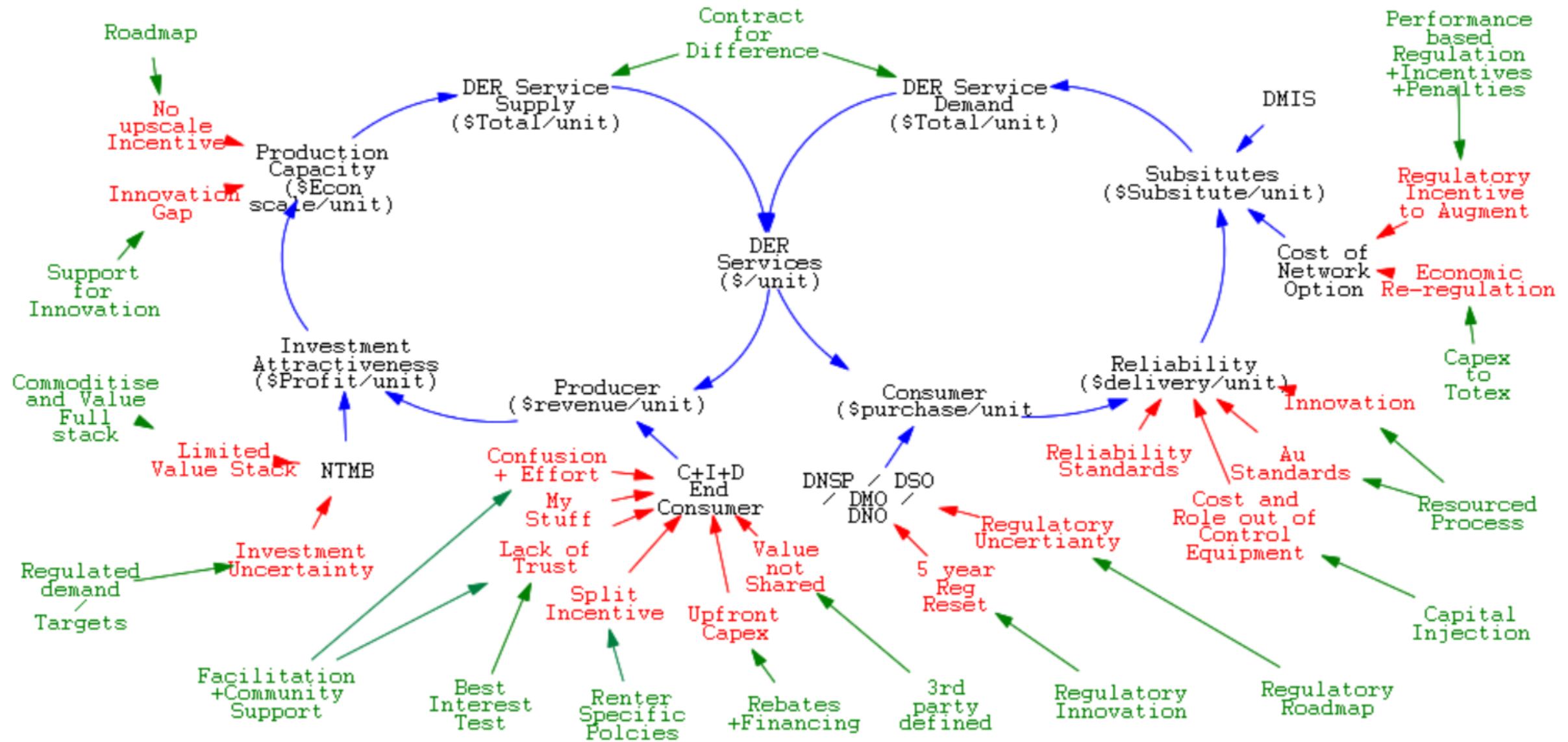
Implementation: Energy Policy and Regulatory Reforms

Like Moonshot the “objective” is defined but “How to get there is not”.

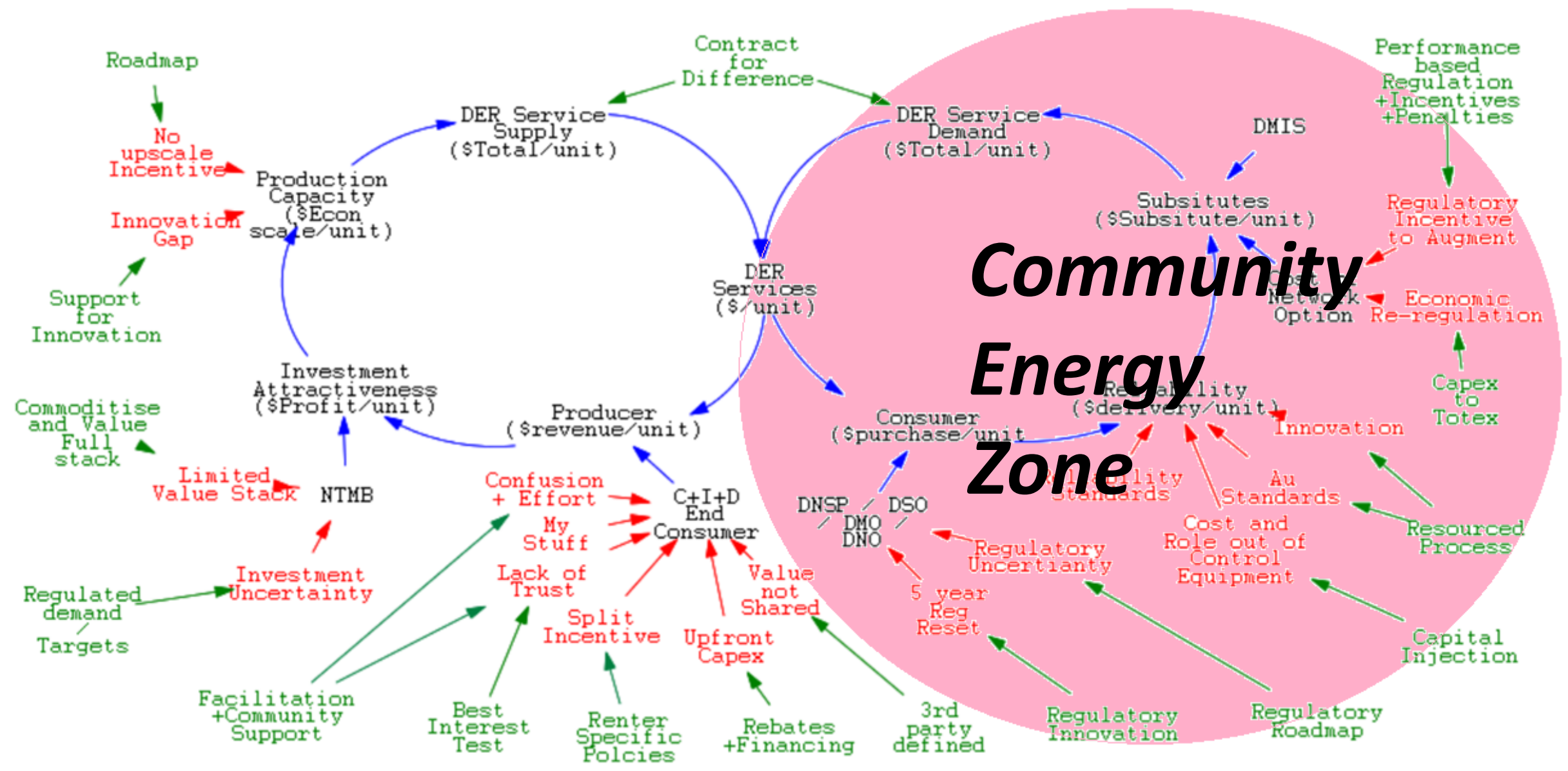
- Innovation: draw on successful ARENA trials but in interaction and then upscale
- Pace and Scale? Existing NEM Rule change process is inconsistent with pace

What does “System Thinking dynamics” suggest?

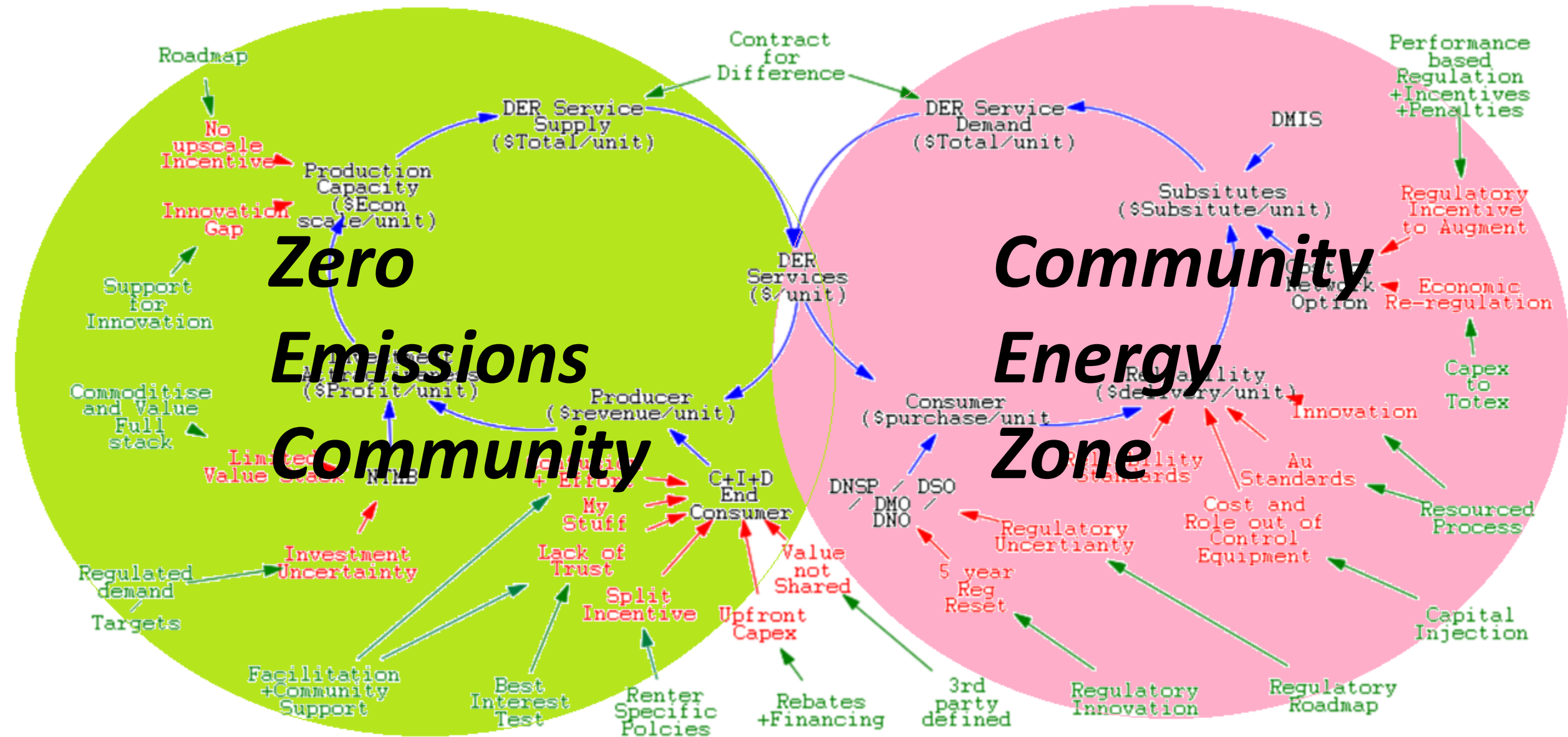
Whole of System: Design approach



Innovation Zone: Focus on System Demand Side



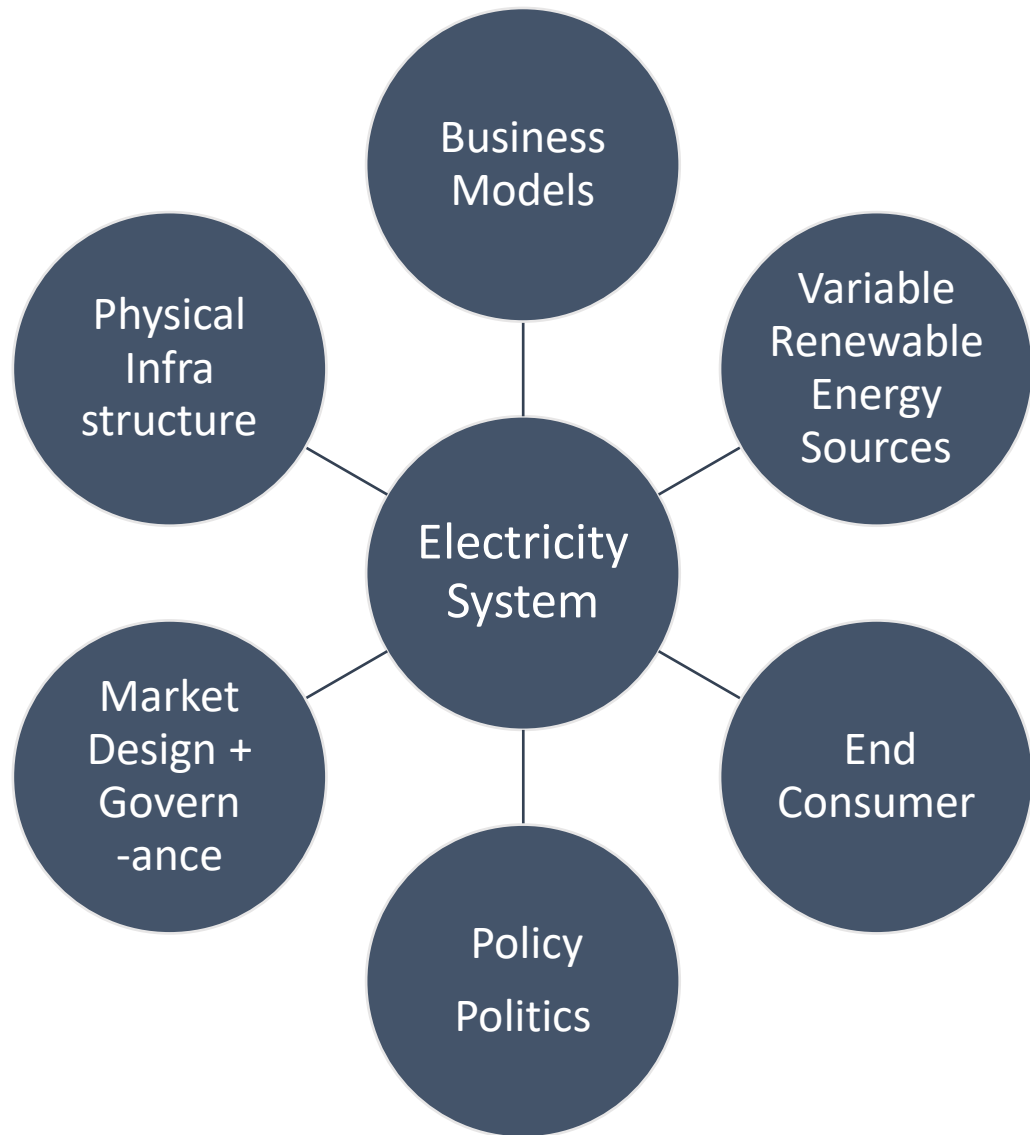
Zero Emission Community: Focus on System Supply Side



Implementation: Energy Policy and Regulatory Reforms

- Place based electrical infrastructure catchment
- “Community Energy Zones” to promote regulatory innovation and agility. Focus on the DER Service “demand side”.
- “Zero Emission Communities”. Focus on the DER Service “supply side”.
- Need to co-ordinate all levels of government (Au Govt, State and Local Government) and leverage existing policies and rebates.

Conclusion



For demand flexibility trading to succeed, the design will need to result in:

- the creation of an investment environment*
- that attracts and rewards*
- Technology innovation,*
- the trade in demand flexibility, and*
- new market entrants with NTBM*
- that can address the barriers to participation by the End Consumer.*

Conclusion: Benefits of Systems Thinking

Promotes

- Visual problem solving
- Co-design and collaboration
- Systematic approach and whole of problem approach
- “Consumer-centric grid” design

Improves

- likelihood of success
- Reduces unintended consequences

Research Implications: Academic and Public Policy

Contribution to the under-researched areas of:

- Demand flexibility trading / energy and environmental markets
- Business Models as a vehicle for innovation in energy markets.
- Creation of investment environments to leverage private investment and result in new Business Models and innovation
- Regulatory innovation

Implications for Public Policy

- Identification of key barriers, essential components, key stakeholders
- Allows for focus on “Are we asking the right questions” => Alignment of aims and stakeholders
- Allows for fast moving political and policy environments
- Allows for categorisation of policy intervention by effectiveness ie transformative through to program