Where are we going?

Presentation on decentralised energy trends to IPAG

July 2018

sapere research group

Internationally there are two broad approaches to where we are going?

Australian Energy Market Commission
Distribution Market Model
Final Report - 22 August 2017

This evolution is not intended to articulate a particular regulatory path or outcome, or predict the types or level of technology uptake in the future. We cannot know for certain what the future will look like. It is therefore unlikely that Australia's distribution networks will follow the evolutionary path as set out below - we could skip steps, stop at any point, or end up somewhere else entirely.

Intangible?

Consultation Report
FutureSmart - A smart grid for all: Our transition to Distribution System Operator
UK Power Networks

What might future market design look like?
New arrangements in market design to support a more distributed energy system, including new market platforms and more sophisticated price signals, will set the framework in which DSOs can facilitate and drive benefits of smarter, flexible networks.

Concrete?

Intangible future?
Long term safe bets

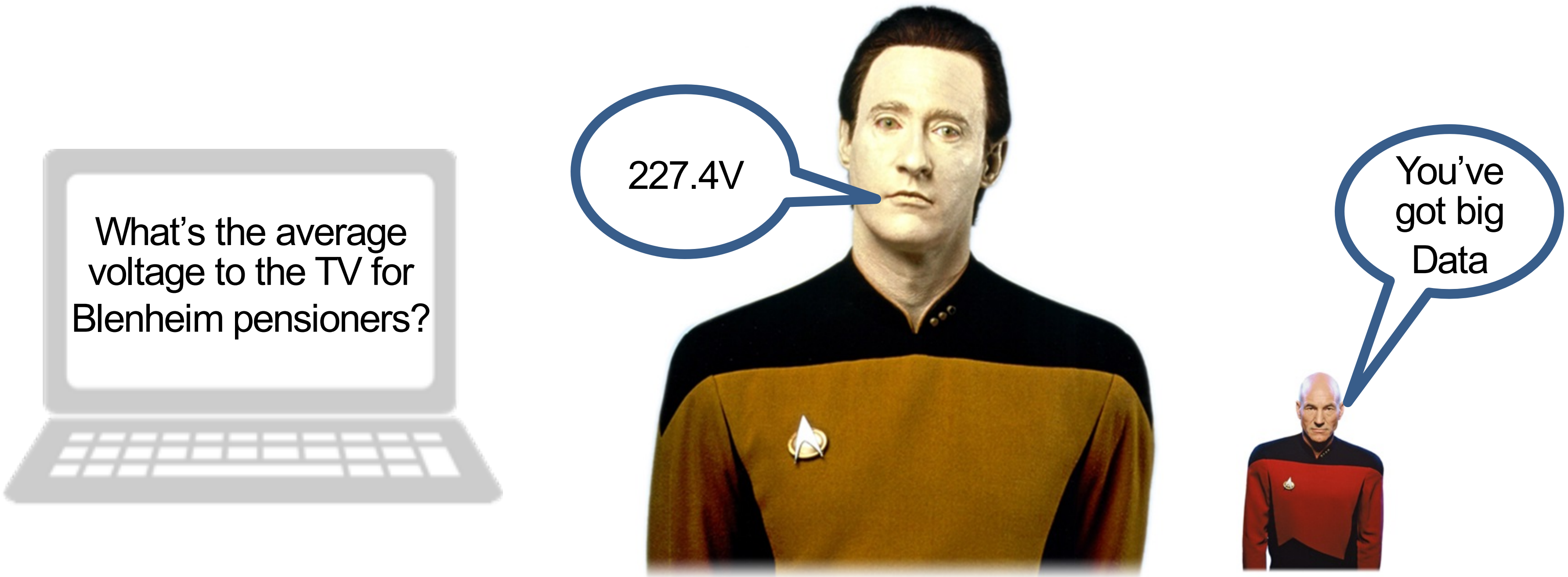
Technology, computer power and models will continue to advance dramatically, getting smaller and measuring more

2 million node AC optimal power flow solving in seconds – easy!

sapere research group

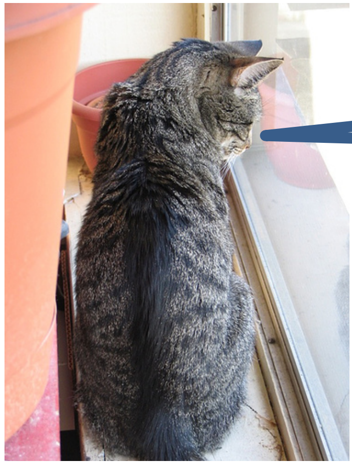
Intangible future?
Long term safe bets

Data will get much larger but more accessible



Intangible future?
Long term safe bets

Technology will work for people



The outside lights are on.
My personal servant must
be home soon

sapere research group

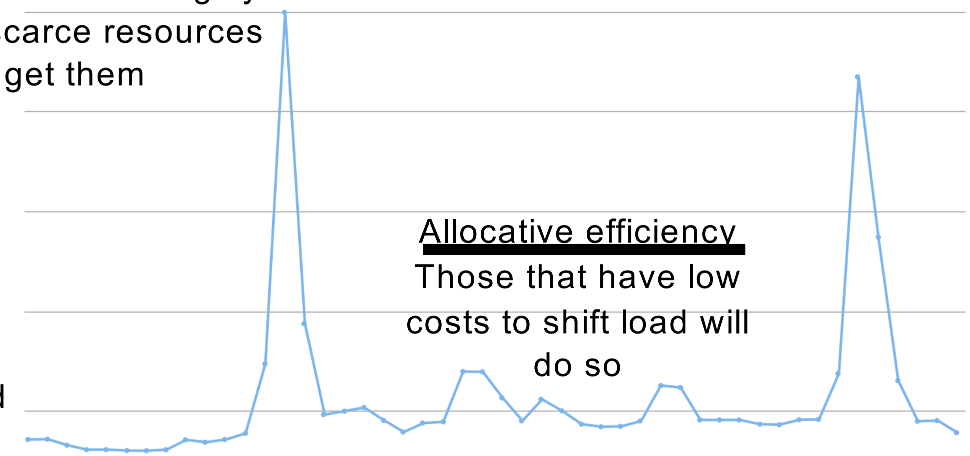
Intangible future?
Long term safe bets

Things will get more measured and more connected

Intangible future?
Long term safe bets

Economic incentives will work

Allocative efficiency
Those that most highly value scarce resources get them



Productive efficiency
Transparent prices and competition will lead producers to reduce costs

Dynamic efficiency
If there's enough *accessible* revenue on the table people will work out smarter and better ways

sapere research group

Intangible future?
Long term safe bets

Individual customer autonomy will continue to increase

LIVING SERVICES
ARE THE RESULT OF TWO FORCES

DIGITIZATION OF EVERYTHING AND LIQUID EXPECTATIONS

Over the next five years, sensors, the cloud, connected smart devices and realtime analytics will combine to deliver a new layer of connected intelligence that will revolutionize the ability of brands and organizations to offer interesting and increasingly indispensable digital services to consumers.

Living Services respond by wrapping around us, constantly learning more about our needs, intents and preferences, so that they can flex and adapt to make themselves more relevant, engaging and useful. Consumers demand this now as the standards are being set by the best of breed across the entirety of their experiences, not restricted by sector—hence liquid expectations.

"*The Era of Living Services*", Accenture, 2015

What are the implications for electricity (energy)?

The technological and business model advances (disruptions?) we see today across many industries (health, transport, communications, entertainment, finance/equity markets and professional services) have a consistent theme of a decentralisation of decision making toward the customer.

Figure 3: global rate of electricity market decentralisation

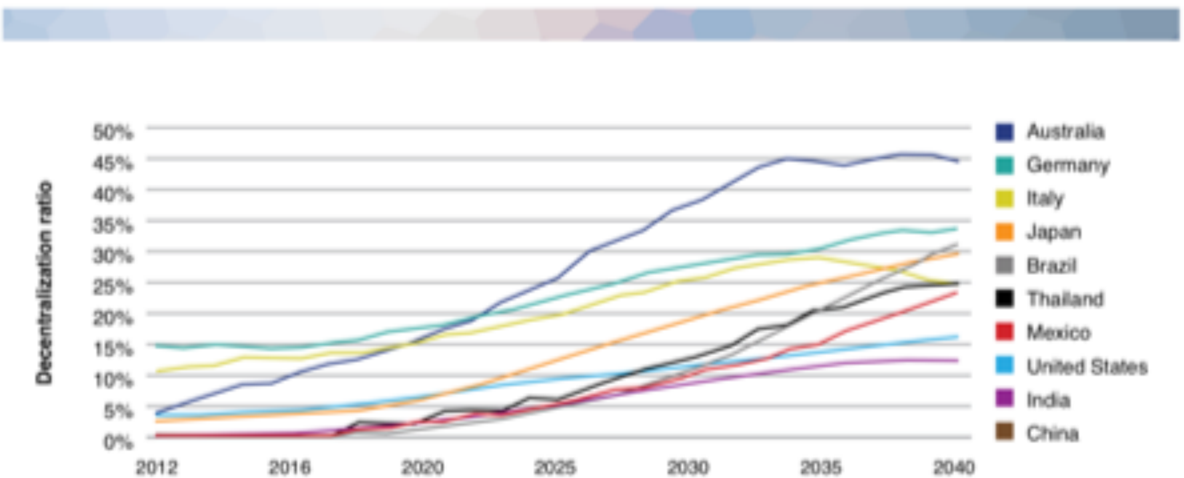


Chart source: Australian Energy Market Operator, “Open Energy Networks”

While it may be a question of degree, energy is no exception:

- A desire for more customer autonomy over the way they interact with electricity/energy
- Local generation economics catching up with/exceeding grid scale
- Leading to an increased in decentralised energy “procurement” and control

Some terminology for the transformation

Well, mostly electricity, but can include e.g., solar thermal

Distributed **E**nergy **R**esources

By this we typically mean it is connected at distribution, not grid level, and often behind-the-meter

Often-used examples:

- **Rooftop solar PV**
- **Storage (e.g., batteries)**
- **Demand Response**

EVs are a combination of these

sapere research group

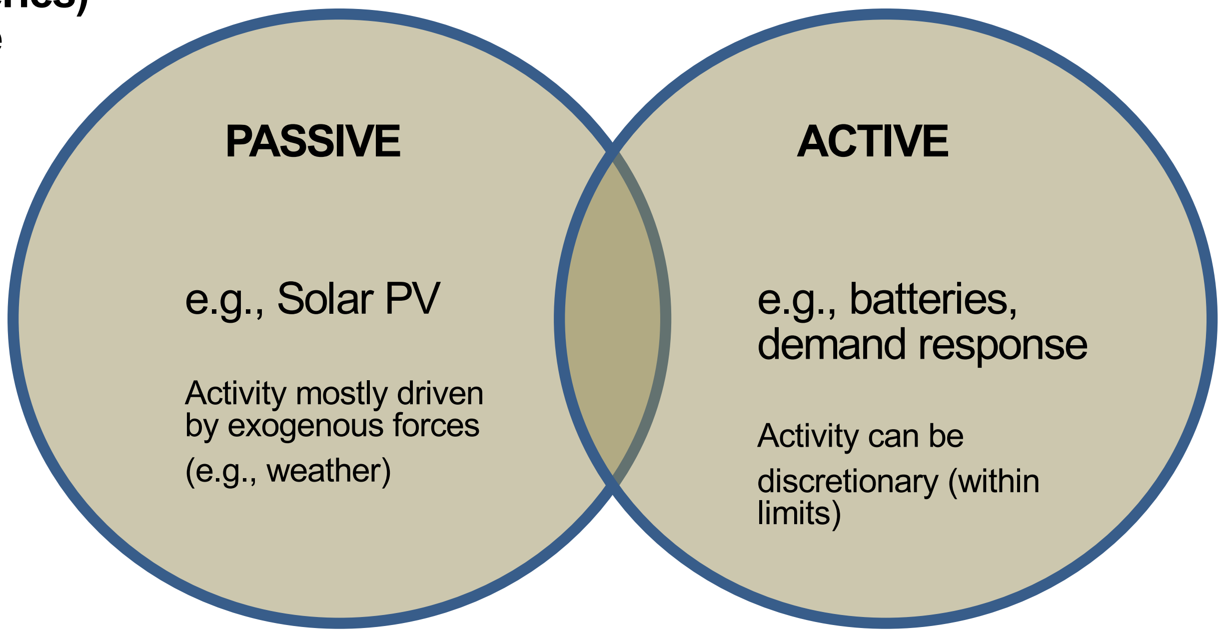
Some terminology for the transformation

Often-used examples:

- **Rooftop solar PV**
- **Storage (e.g., batteries)**
- **Demand Response**

Distributed Energy Resources

Most DER today is in this camp



The implications of the behaviour of DER on networks and the wider system is a function of its aggregate behaviour…which – since they are distributed - forces us to consider how "coincident" the underlying drivers are

sapere research group

So what's the issue with DER?

Box 2.1 Technical impacts of distributed energy resources

- Some distributed energy resources do not provide voltage or reactive power support, which can lead to **voltage stability issues**.
- Distributed energy resources can, by displacing synchronous plant, **reduce grid inertia and frequency response**, which can result in high rates of change of frequency and potential loss of synchronism.
- Inverter-connected distributed energy resources can **increase harmonic distortion**, the impact of which can include excessive heating, nuisance tripping, protection mal-operation and interference with communications
- Distributed energy resources fuelled by intermittent sources of energy can result in **unacceptable levels of flicker**. This is more prevalent on electrically weak networks with large concentrations of distributed energy resources and low fault levels.
- Distributed energy resources with no reactive power support will mean that the rest of the grid will need to supply reactive power, which may result in a **lower grid power factor**.

Source: Australian Energy Market Commission, "*Distribution Market Model*"…quote:

"Stakeholders largely concurred with these technical impacts in their submissions to the approach paper, but had different views about the scale of each impact and how each should be, or is already being, addressed."

sapere research group

So what's the issue with DER – yesterday, today..?

sapere research group

So what's the issue with DER – tomorrow…

Figure 9: VPP impact on network flows

sapere research group

So what's the issue with DER? (2)

- If a feeder has distributed energy resources installed, surplus generation is fed back to the grid during times of low load. This reverse power flow may exceed equipment ratings, resulting in **thermal overloading** of equipment.
- Many existing re-closing devices on distribution networks are not capable of reliably detecting distributed energy resources. If the distributed energy resources are not detected, the network could still be live, which can cause **safety issues and unsynchronised switching**.
- Distributed energy resources could **reduce fault levels** to a point where the delineation between a fault and a load is challenging, which may result in the existing protection systems no longer detecting a fault. If the fault is not cleared, this could cause a danger to anyone in the vicinity and damage to equipment.

We would add that there is potential for significant forecast errors in the wholesale market (and consequential issues for dispatch and security management) if a large quantity of uncoordinated DER changed behaviour as a result of a common driver (price, weather).

But DER is not just a problem

While the historical uptake of DER has been of the passive type, active DER can be a flexible resource for the system:

- Individual or aggregated storage/demand response; microgrids; virtual power plants all have the ability to be "dispatched" to meet a system need
- Our electricity (and wider energy) system is on a trajectory to higher renewables (decarbonisation)
- If this involves higher penetration of solar/wind (and lower gas peakers), flexibility will become the "coin of the realm"*

Orgis and Aggarwal (2017), "A Roadmap for finding flexibility in Wholesale Markets"

But DER is not just a <u>problem</u> (2)

The power electronics that are typically packed into inverters for solar panels and batteries, as well as the sheer speed of response of batteries, could offer a host of additional services that, hitherto, have only been provided by grid-connected power stations (inertia - simulated, frequency and voltage support).

These could be required by minimum required standards, but this might lead to inefficient costs of investment – economic theory suggests correct financial incentives would be best if an efficient pricing framework could be implemented – at the right time

So…..

There seems to be changes coming (DER)…

This brings challenges and opportunities…

How do we maximise the chance that the challenges are met and the opportunities are harnessed?

sapere
research group

Developing an IPAG framework for DER

Demonstrate the AEMO framework as an example from a similar jurisdiction and regulatory perspective

Test the premise, assumptions and logic for the NZ case

Workshop at September’s meeting

The AEMO logic
An <u>example</u> of a framework for assessment

Propositions

DER uptake will increase	Uncoordinated DER is unpredictable	Consumers will suffer (cost or reliability) from widespread uncoord. DER

To think about:
What is IPAG's view on these assumptions?

Uncoordinated, unconstrained DER – challenges, and what tools does a distributor have now?

Challenges

What does it do to losses and voltage?
How is it going to be protected? How do I isolate it if I'm working on the lines? What will it do to fault current?
How does it affect my voltage profile?
Does it affect power factor? Can it contribute to power factor control or voltage correction? How would we coordinate it?
Can it be coordinated with load control? How?
Do I need to reconductor the line for the DG current?
Will my substations work properly if the power comes from the other direction?
What does it do to voltage regulators?
If this is starting and stopping frequently will it cause voltage sags and swells?
I WILL need to change my protection, how do I achieve discrimination?
This could help backfeed, but how do I safely coordinate it?
Does it use power electronics? Will it meet the standards? How will it react if it suffers distortion outside of the standard?

Current Tools

Limit uptake
Minimum standards
Apply retroactive standards
Temporary/permanent disconnection (where problems occur regardless of meeting standards)
Remote disconnection (adapted load control – e.g, ripple injection/pilot wire)
Pre-event disconnection (require protection to lock out DER during conditions that could lead to problems)
Sensitive, fast post-event disconnection (trip out DER before anything else)
Extra investment in thermal and voltage capacity

Existing distribution tools

How sufficient will the current set of tools/levers be?

- Tools for the short term?
- Medium term?
- Long term?

The AEMO logic
An example of a framework for assessment

Propositions

DER uptake will increase

Uncoordinated DER is unpredictable

Consumers will suffer (cost or reliability) from widespread uncoord. DER

Coordination of DER is in the best interests of consumers

*and system operators!

sapere research group

Questions arising…

But what are the “coordination” levers? Physical limits or economic incentives?

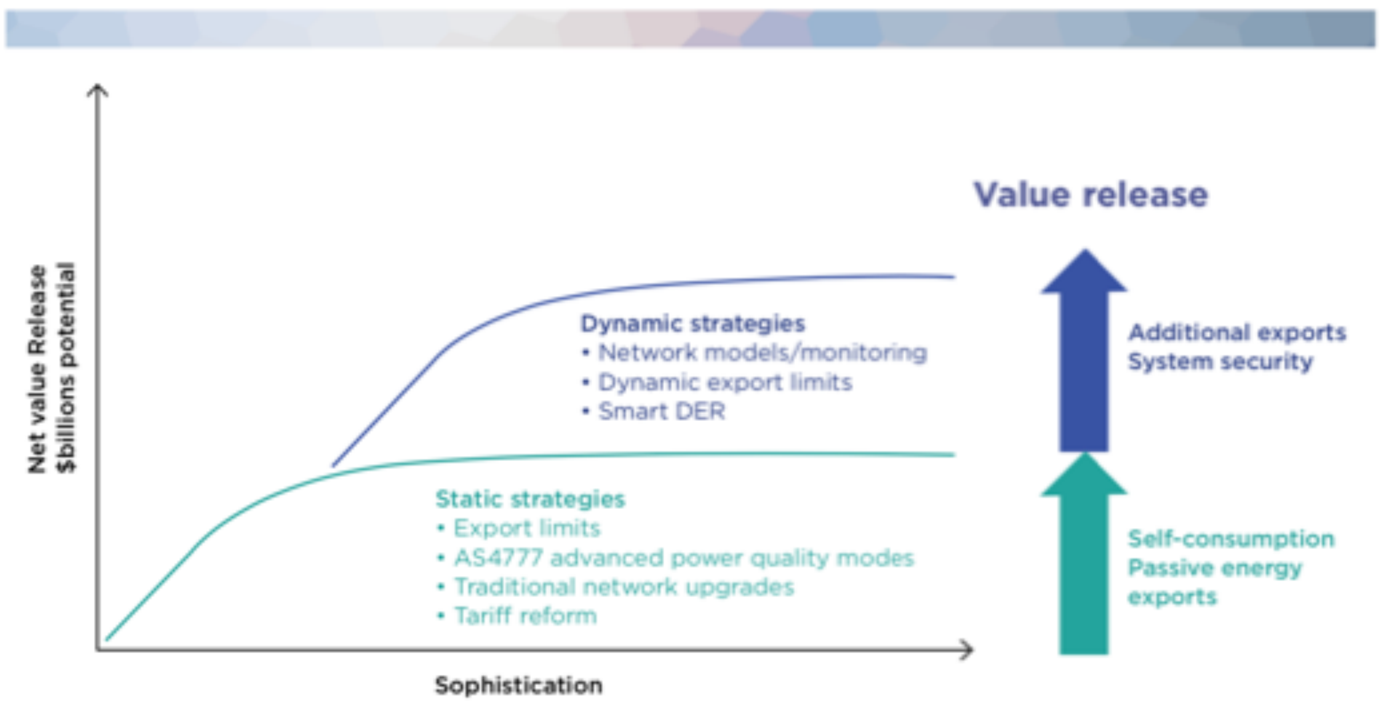
Should the coordination be static or dynamic?

Is the underlying problem static or dynamic?

Who does the coordinating?

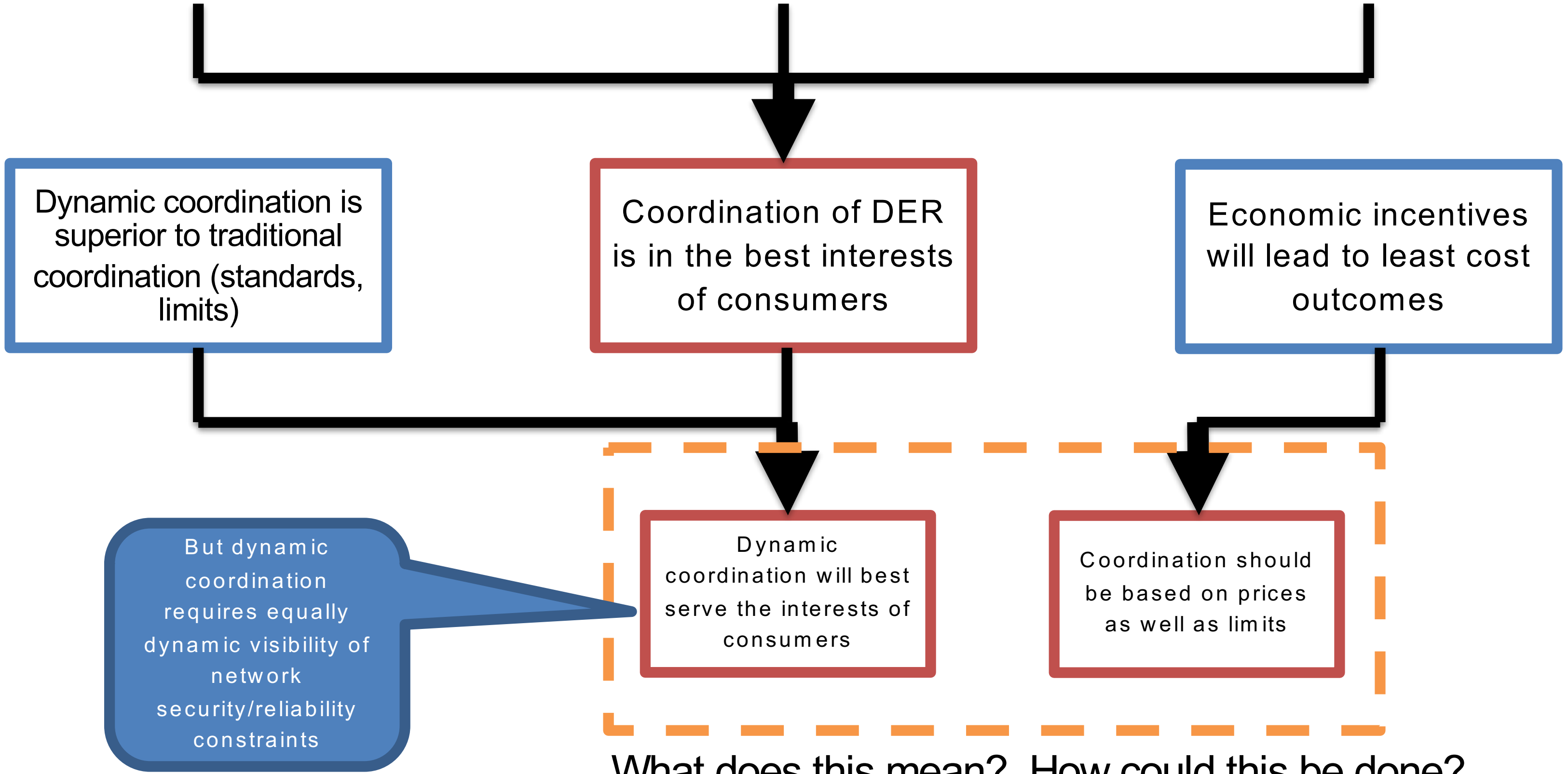
AEMO's view: Static vs Dynamic Coordination

Figure 7: Additional value release enabled by dynamic DER management



sapere research group

Which leads AEMO to conclude….



What does this mean? How could this be done?
Where have we seen this done before?

sapere research group

Case Study
NZEM – managing security in a market

Security constrained economic dispatch?

The wholesale market design was intended to dynamically coordinate, in the least-cost way, resources on the system around a requirement to maintain a secure system.

The objective seems highly relevant…how relevant is the design to the distribution network and DER?

Could this degree of dynamism be achieved on the distribution network?

- Is there a fundamental difference between the "levers" available on the Tx network compared to Dx? Today vs the future?
- Are there additional modelling/data/visibility/communications challenges on the Dx network?
- Is it separate to, or integrated in some way with, the existing wholesale market?
- Who should do the coordinating?

And how would we transition?

Consumers won't engage until benefits are certain and participation means choice?

Technology development will be slow until potential for participation is real?

Distributors will need to impose limits and/or minimum standards until <u>coordinated</u> participation is certain?

Regulators will not ease hard rules until participation is two way and competition normal?

David Reeve
+64 21 597 860
www.srgexpert.com

Our core values are independence, integrity and objectivity

Sapere aude *– dare to be wise*