The Rise of the Machines
What could it look like?

Presentation to IPAG

David Reeve, Stephen Batstone
September 2018

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Recap - DER problem and benefit

Factual
DER is coming and philosophically should be embraced

Problems
DER creates two-way flows on distribution networks predominantly designed for one-way flows
DER offsets traditional generation but does not necessarily replace all their attributes
Potential for the degradation of lines and/or energy services causing either expensive options to fix and/or requiring limits on DER integration

Benefits
DER can be controlled and can be programmed and/or automated
DER is a part of the decarbonisation of the electric power system
Potential for DER to provide alternative, complementary and even competing lines and/or energy services
BUT this needs some coordination

The challenge

To encourage

Innovation
The act of making changes in something established, especially by introducing new methods, ideas, or products

and

Participation
The act of being involved and taking part

Encouraging participation

To combine

Potential
DER to provide alternative, complementary and even competing lines and/or energy services
BUT with coordination

and

More participation
More, and different, parties being involved and taking part

necessarily requires facilitating physical and commercial transactions between willing buyers and willing sellers

We are talking about markets

To quote Wiremu Shakespeare (old Bill's kiwi descendant)

"A market by any other name still facilitates the transactions between willing buyers and willing sellers, sweet as!"

BUT

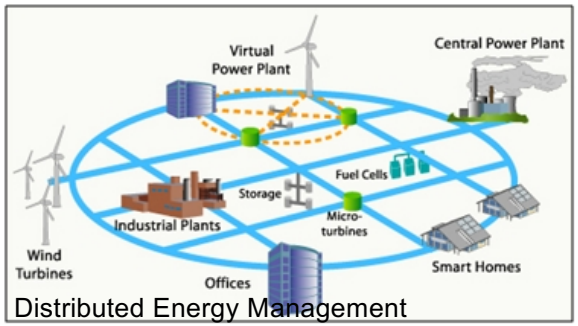
This/these market(s) may not look like the New Zealand Electricity Market
Or any other current electricity market
It/They could be entirely new form(s) of transactional framework
And are probably more computerised, interconnected and interrelated than current markets

What are the desirable attributes of a framework? IPAG meets EA

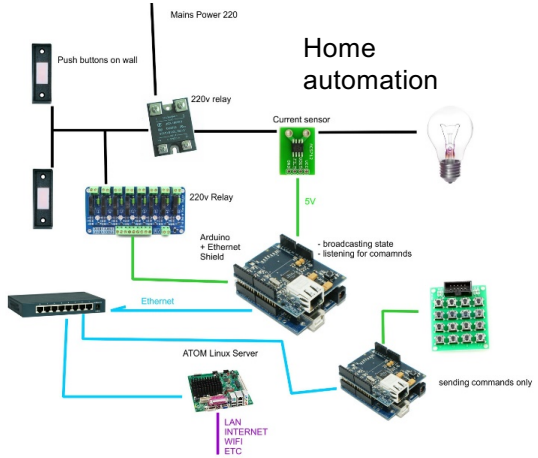
	Competition	Reliability	Efficiency
Innovation	Required attributes? (e.g. opportunity?)	Required attributes? (e.g. standards?)	Required attributes? (e.g. long run price?)
Participation	Required attributes? (e.g. choice?)	Required attributes? (e.g. coordination?)	Required attributes? (e.g. short run price?)

Other relevant policy settings?

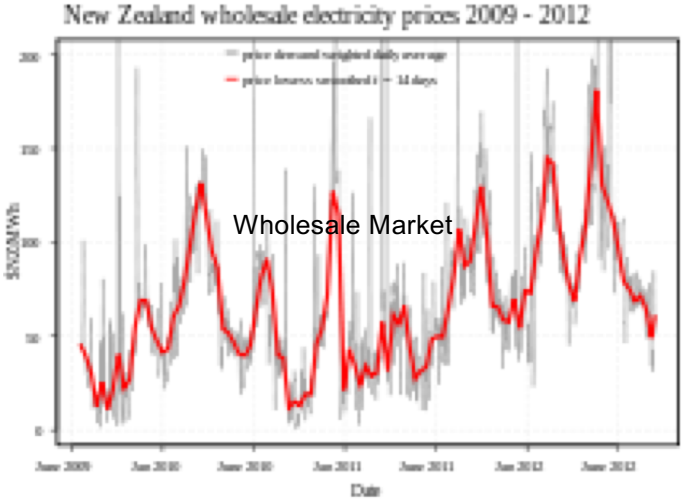
All of these systems are, or are capable of being, a market system



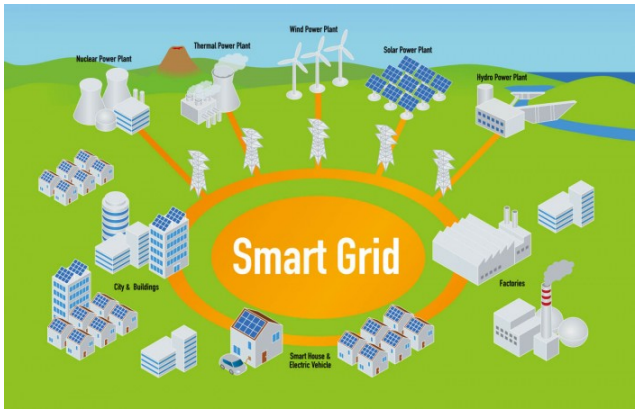
Distributed Energy Management
Or Distributed Energy Resource Management System (DERMS)

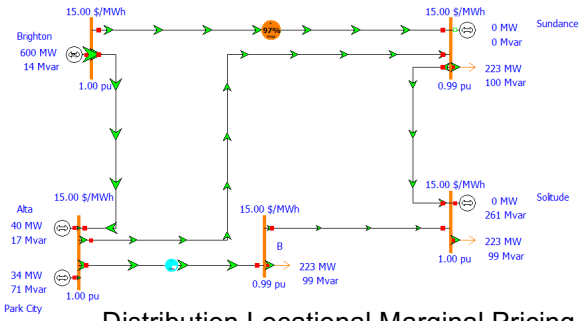


Home automation



Whiz Bang (new idea)





Distribution Locational Marginal Pricing

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AND, all of these systems have the same objective!

To give people what they want (up to their willingness to pay)

Supplied by a number of sources (down to suppliers willingness to sell)

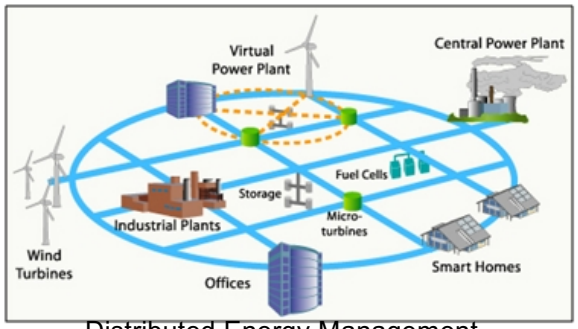
At lowest cost

Where things people want includes security and reliability

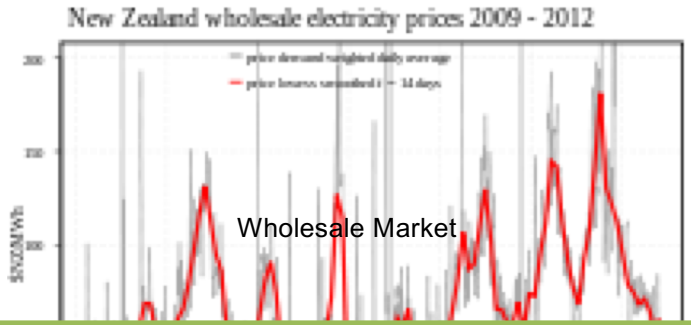
Which requires interconnected coordination

This is also what the NZEM does, in the NZEM it is called security constrained economic dispatch; but if security and reliability were also priced it would just be economic dispatch

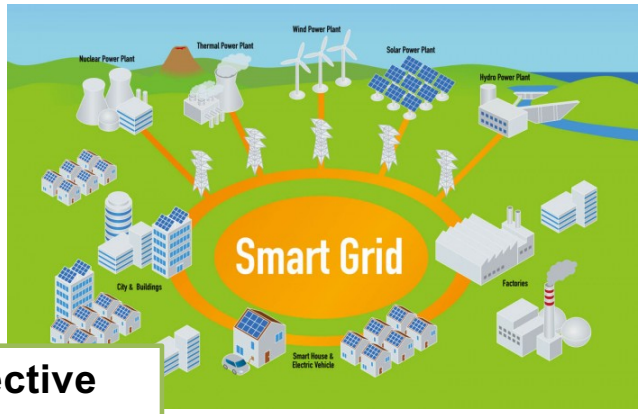
Great News!

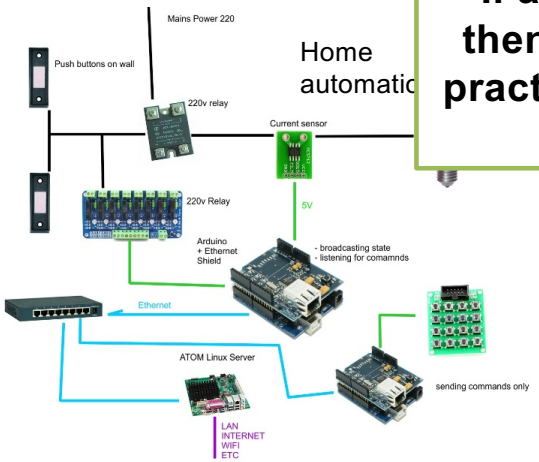


Distributed Energy Management



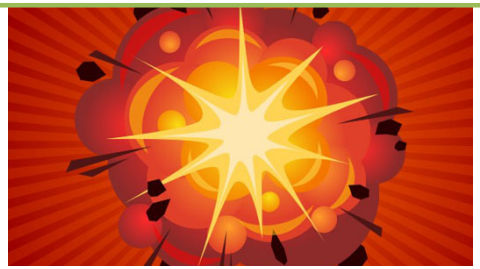
Wholesale Market





Home automatic

If all of these systems have the same objective then it is theoretically possible, and increasingly practical, to coordinate them; or replace them with one system that does it all



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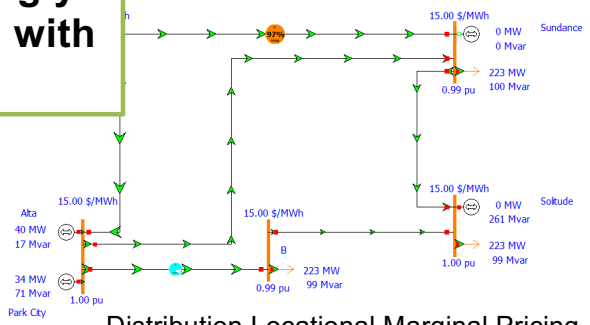

Distribution Locational Marginal Pricing

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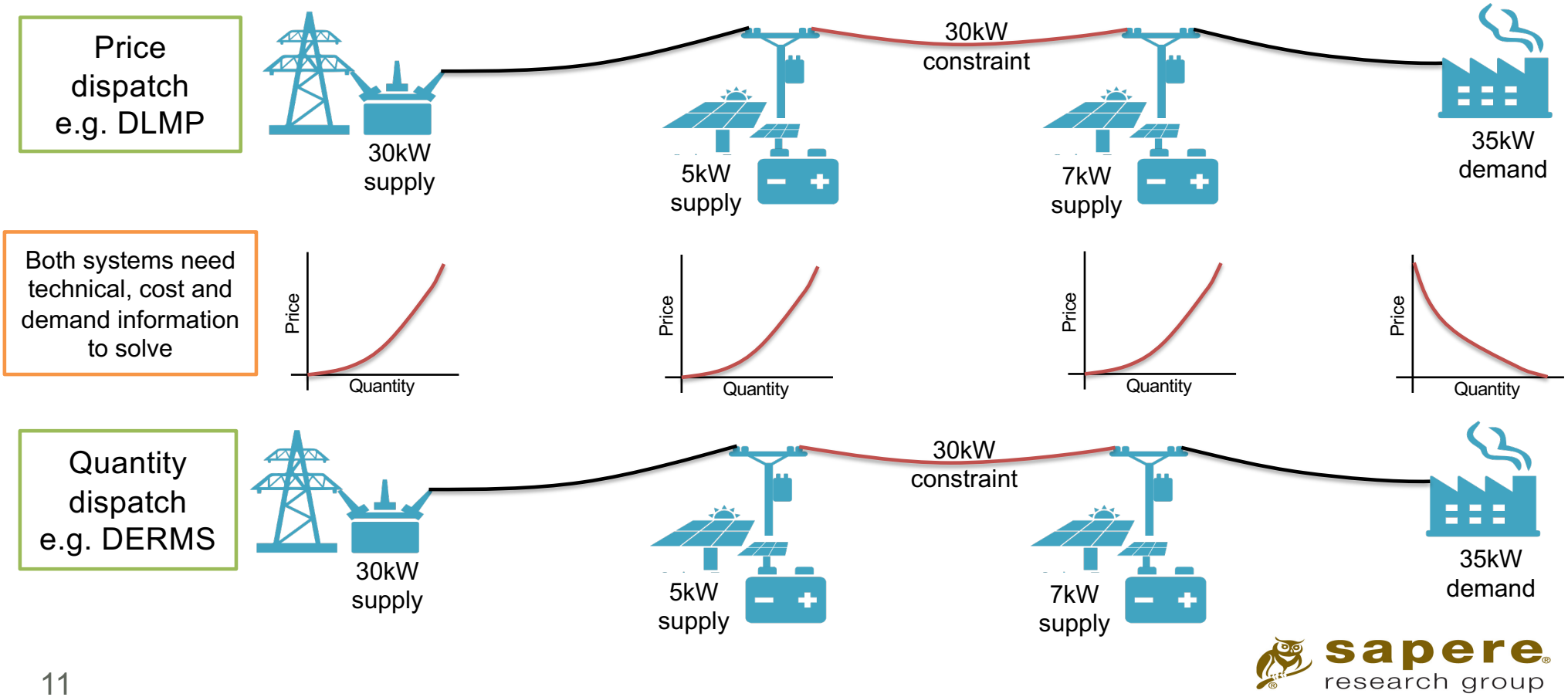
To show how similar they are lets look at two systems that might be considered very different

Comparing transactional framework examples
Price based dispatch versus quantity based dispatch



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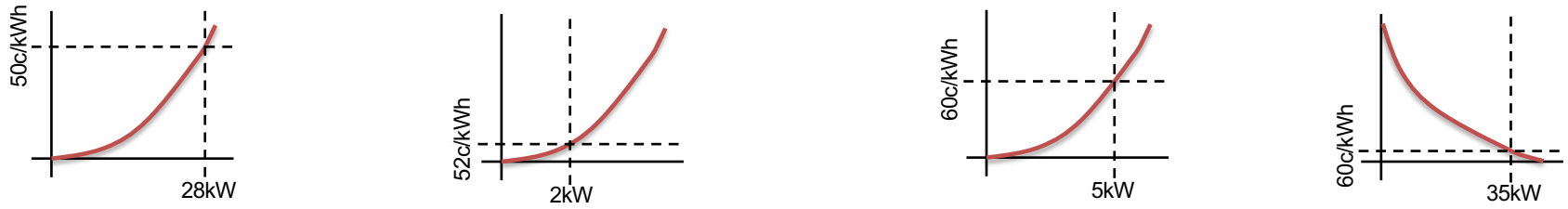
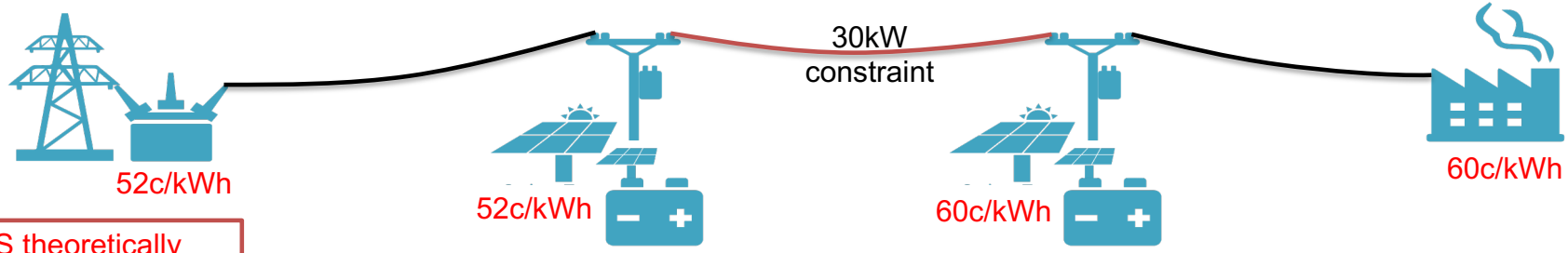
Quantity dispatch – e.g. DERMS*

QUANTITY DISPATCH RULE: suppliers must follow control signal or face severe penalties



Control signal → 28kW → 2kW → 5kW - - - → 35kW

Quantity dispatch e.g. DERMS



SGS theoretically capable of publishing implied prices

* *Ignoring losses*

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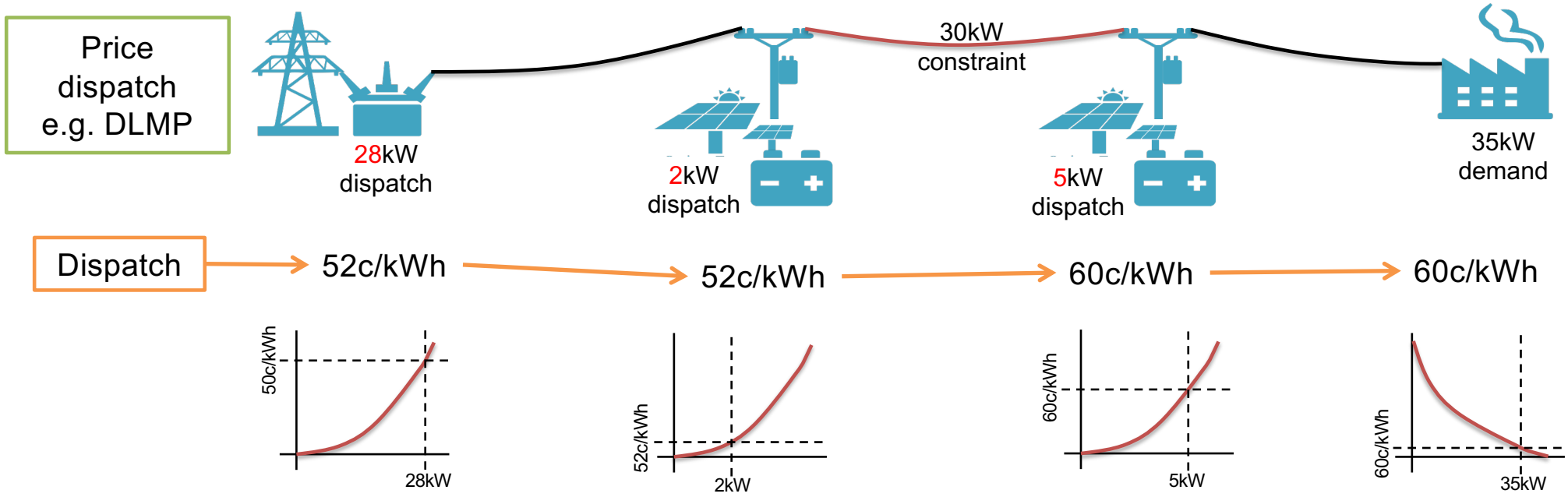
Price dispatch – e.g DLMP*



PRICE DISPATCH RULE: self dispatch but you must follow your supply curve or face severe penalties

** Ignoring losses*

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Economic theory… again…

An Alternating Current Optimal Power Flow (ACOPF) model would underpin all of the transactional systems above, or a single model that did everything

Ideally, every service that could be provided by DER should be incentivised by a correct price for that service

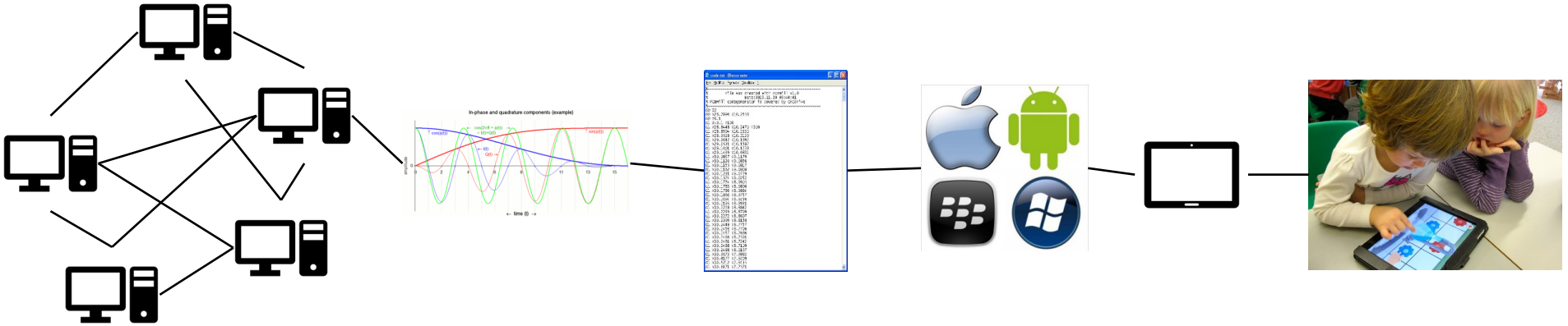
e.g.?

Voltage: price c/V, dispatch V setpoint
Current: price c/A, dispatch I setpoint
Capacity: price c/VA, dispatch capacity commitment
Power factor: price c/°θ, dispatch °θ setpoint
Reserve: price c/kW, dispatch reserve kW
Hz keeping; price c/kW, dispatch kW@characteristic
V stability: price c/ΔV/s, dispatch characteristic
F stability: price c/ΔHz/s, dispatch characteristic
Inertia: price c/ΔJ/Hz, dispatch characteristic
Harmonics: price c/%THD, dispatch V@nHz

At every installation, maybe at every appliance

But is this all too much?

Technology translates complexity



TCP/IP protocol

High speed QAM comms

Machine code

OS & Apps

Screen & interface

EASY

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But even when change is fast it is incremental

And can branch

And is unpredictable? Needs to evolve?

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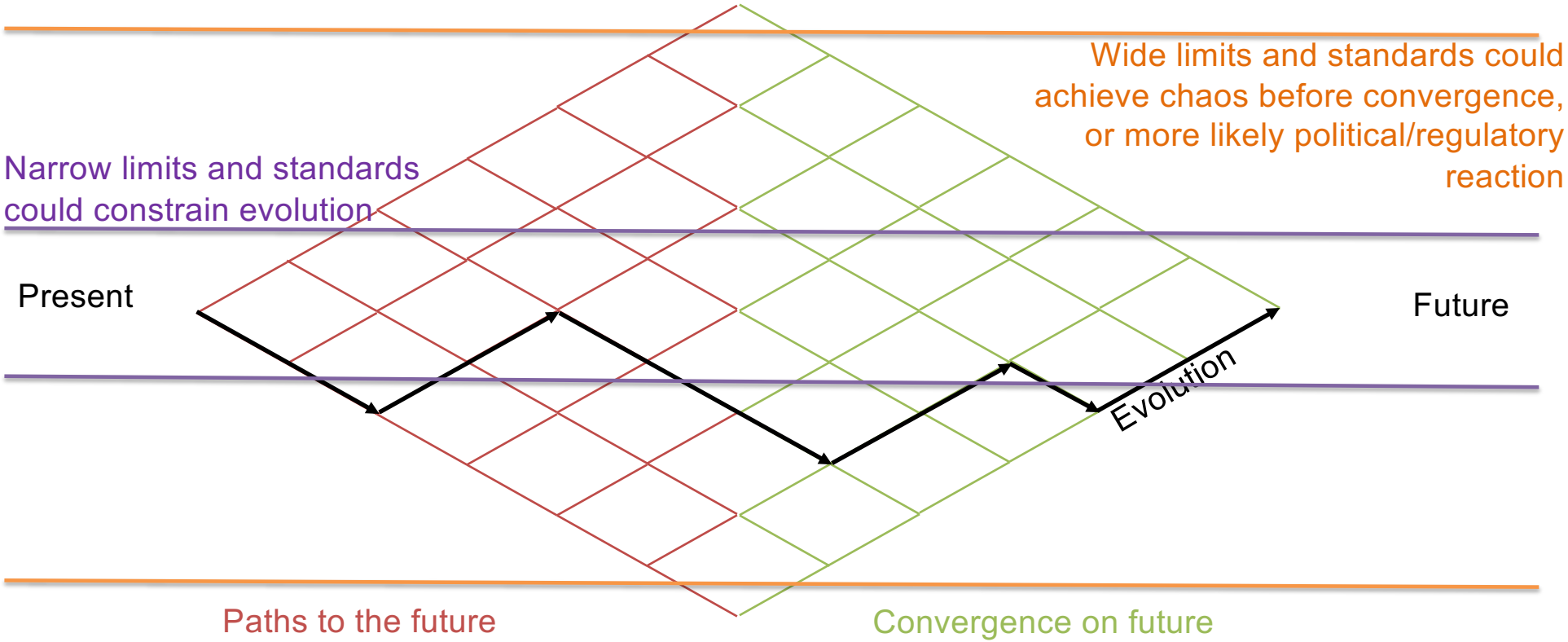
Facilitating evolution



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And we're back to…

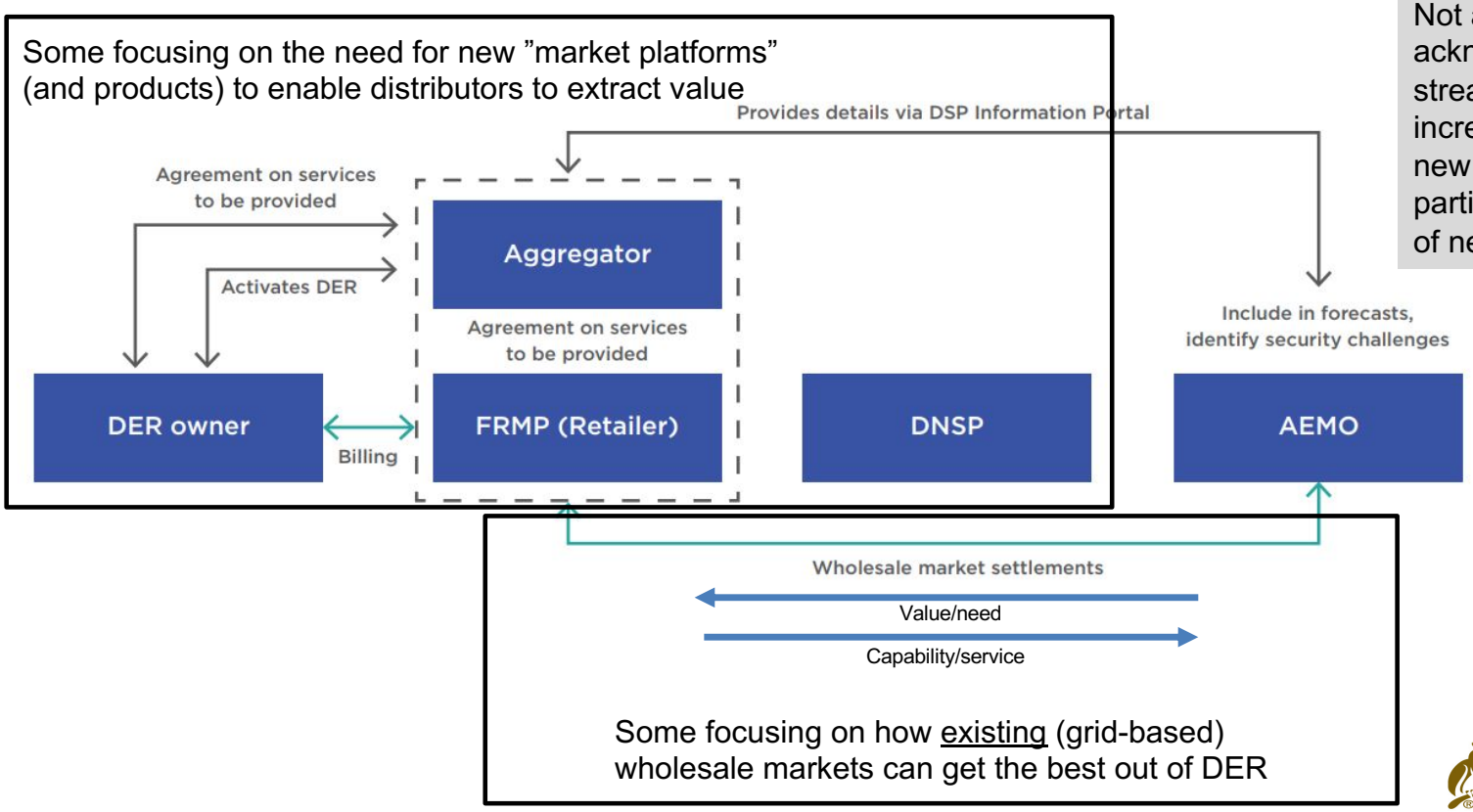
Consumers won't engage until benefits are certain and participation means choice?

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

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

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

Trends in evolution



Not a strict categorisation - most acknowledge the other’s value stream, and all are trying to increase innovation (unlocking new products/services) and participation (better transparency of need/value)

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What are others doing?

Examples of DER participation within existing wholesale markets (VPPs)

- Sonnenbatterie

Amendments to existing (wholesale) markets to facilitate DER participation

- REV/New York ISO
- NERC standard P1547 revision, Hz/Volt technical requirements
- California/Mid-Continent ISOs development of ramping/flexibility products

Establishment of new platforms to facilitate innovation and participation

- AEMO
- Tabors, Caramanis *et al*
- UK Power Networks establishment of “platform”

A lot of conversation, a little less action?

DER participation within existing market structures

Sonnen launched "sonnenCommunity" in Germany in 2015, a nationwide cloud-based network of houses with both solar panels and batteries, as a VPP. It later extended it to houses with a battery only (SonnenFlat). The pricing has evolved over the years, but has always been based on a flat membership fee and some degree of free power. Sonnen, in turn would be able to use the batteries as a form of primary frequency regulation. Sonnen has expanded its products into wider Europe, the UK, Australia, and the US, but their ability to provide grid services (the basis of sonnenFlat) appears to be mixed. They are experimenting with integrating EV charging as well as blockchain in Germany, in collaboration with the system operator, to manage congestion on the German grid (as there is no nodal pricing).

Source: https://greycellsenergy.com/, Sapere

SONNENFLAT PACKAGES

	sonnenFlat 8	sonnenFlat 10	sonnenFlat 12
Minimum solar (kW)	5.0	7.5	10.0
sonnenBatterie eco	8 kWh	10 kWh	12 kWh
Monthly fee	$ 30	$ 40	$ 50
Annual spend[2]	$ 360	$ 480	$ 600
Consumption allowance in kWh	7,500	10,000	12,500

Source: sonnen.com.au/sonnenflat

The realm of Virtual Power Plants – aggregation of DER to provide dispatch-like characteristics at grid scale

- Gets over the hurdle of minimum sizes in market rules
- Requires an aggregator, and often done as part of development of micro-grids (control system embedded)

Sonnen a good example of aggregator over dispersed geography

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Amendments to rules/standards/markets to facilitate DER

Plenty of technical rule reconsideration (e.g., IEEE 1547 – interconnection of DER)

- Dealing with Hz response, voltage etc
- Big focus on data from ISOs – inability to "see" this passive and active resource
- Some markets developing grid products (e.g., California's "Flexi-Ramp", NYISO's ORDC) to meet the challenge of passive DER; others failing (e.g., Texas with inertia product, PJM with RegD)

Proactive/faciliatory work sporadic

- New York ISO has developed a "behind the meter net generation" resource category (BTM:NG) for wholesale participation, but a 2MW minimum capacity still exists
- NYISO has also recently begun work to include its "low" voltage network (100kV+) in the wholesale market model in an effort to provide better signals to DER, as well as (on the retail side) move beyond zonal pricing to a more locationally specific pricing model

Sources: NREL, (2016), NERC functional model workshop presentations;
Orgis and Aggarwal, (2017), "A Roadmap For Finding Flexibility In Wholesale Power Markets"
NYISO, (2018), "2018 Power Trends"

A sidebar on REV LMP + D

Source: rev.ny.gov

NYISO's efforts should be seen in the context of New York's desire to get the "correct" investment signals to owners of DER: "LMP + D":

- This is seen as an interim measure as NY transitions away from net metering
- Underlying price is the wholesale market price at the "bulk power system" boundary…
- …To which is added an administratively determined value of the "full range of benefits" of DER to "Distribution" (V, Hz, losses, emissions, delayed invstement, and even "resilience")
- LMP + D is not a "market" price: it is a dynamic market price plus a static administrated "avoided cost" concept.

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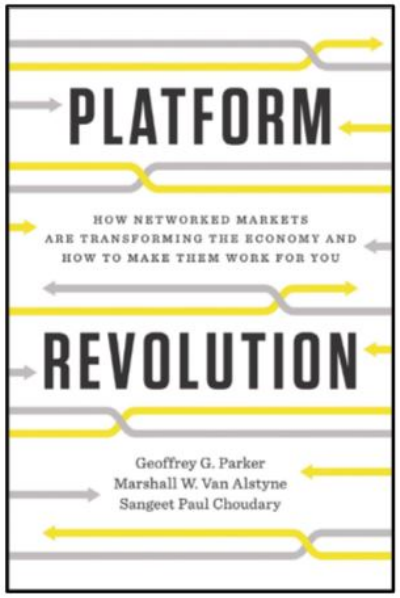
Markets? Transactive Grids?... Platforms?



What is an ECONOMIC Platform?

A platform is a business ecosystem that matches producers with consumers, who transact directly with each other using resources provided by the ecosystem itself. The platform ecosystem provides outside parties with easy access to useful products or services through an infrastructure and a set of rules designed to facilitate interactions among users. A platform's overarching purpose is to consummate matches among users and to facilitate the exchange of goods and services, thereby enabling value creation for all participants.

(see: Parker, Van Alstyne and Choudary, ***Platform Revolution***, W.W. Norton & Co. 2016)

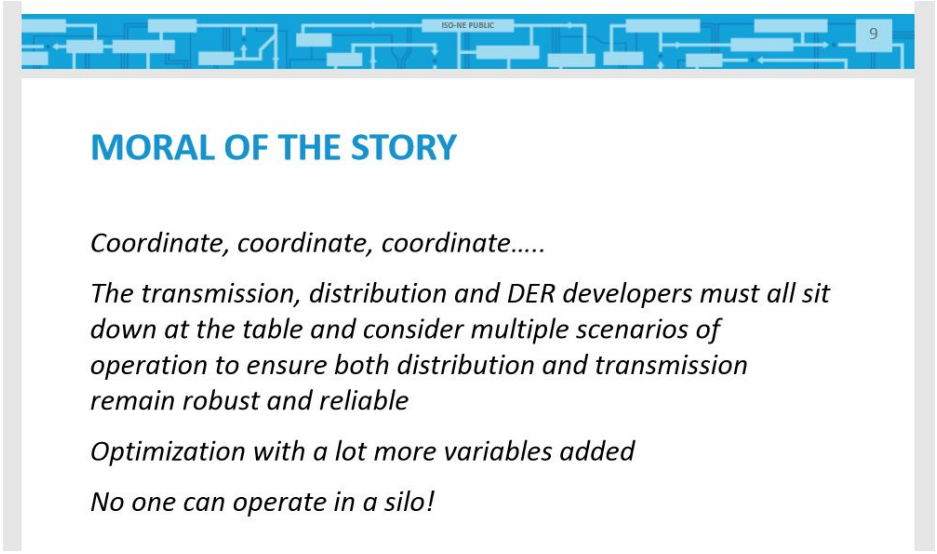
How is a platform different from a market?

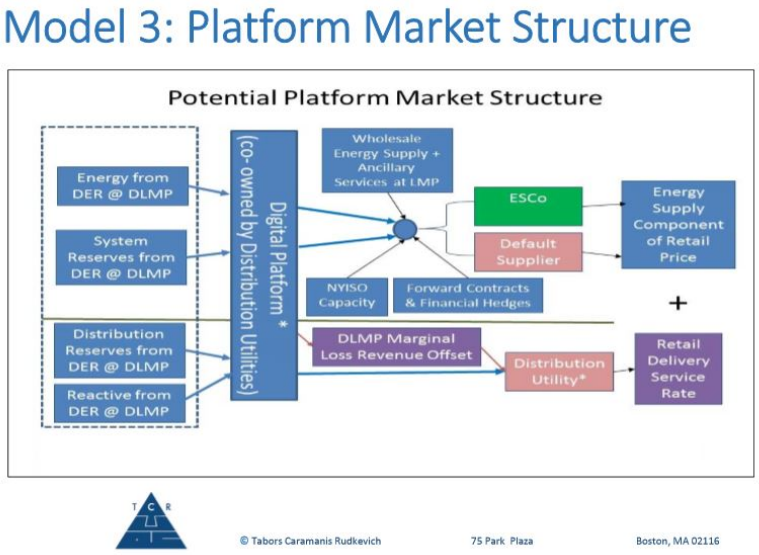
- Some describe as being distinct from e.g., the wholesale market
- UK Power Networks: a more generic capability to "run and settle tenders and shorter term markets…and may also involve proprietary control software"
- E.g., Transpower's DR market?

Source: Caramanis, Tabors (2017), "Valuing Distributed Energy Resources via DLMP"

Establishment of new platforms – the “optimising” bit

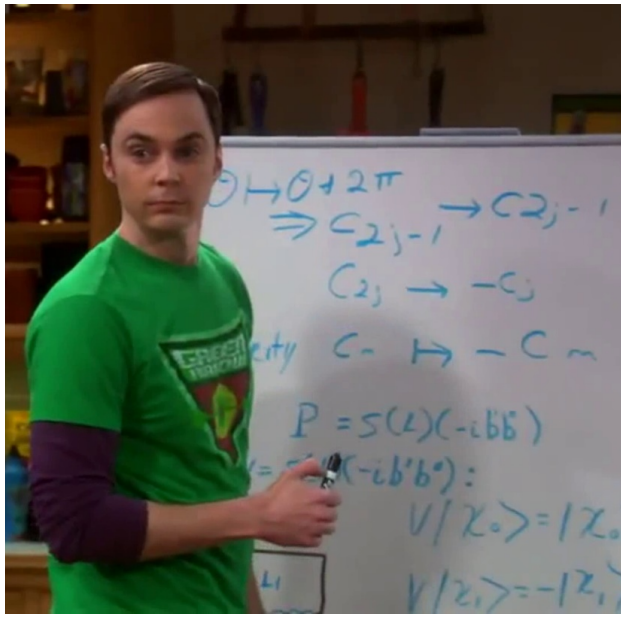
Once you move beyond the existing wholesale market: how to achieve (dynamic) optimal dispatch? Do we expand the reach of the existing framework…or insert something new?

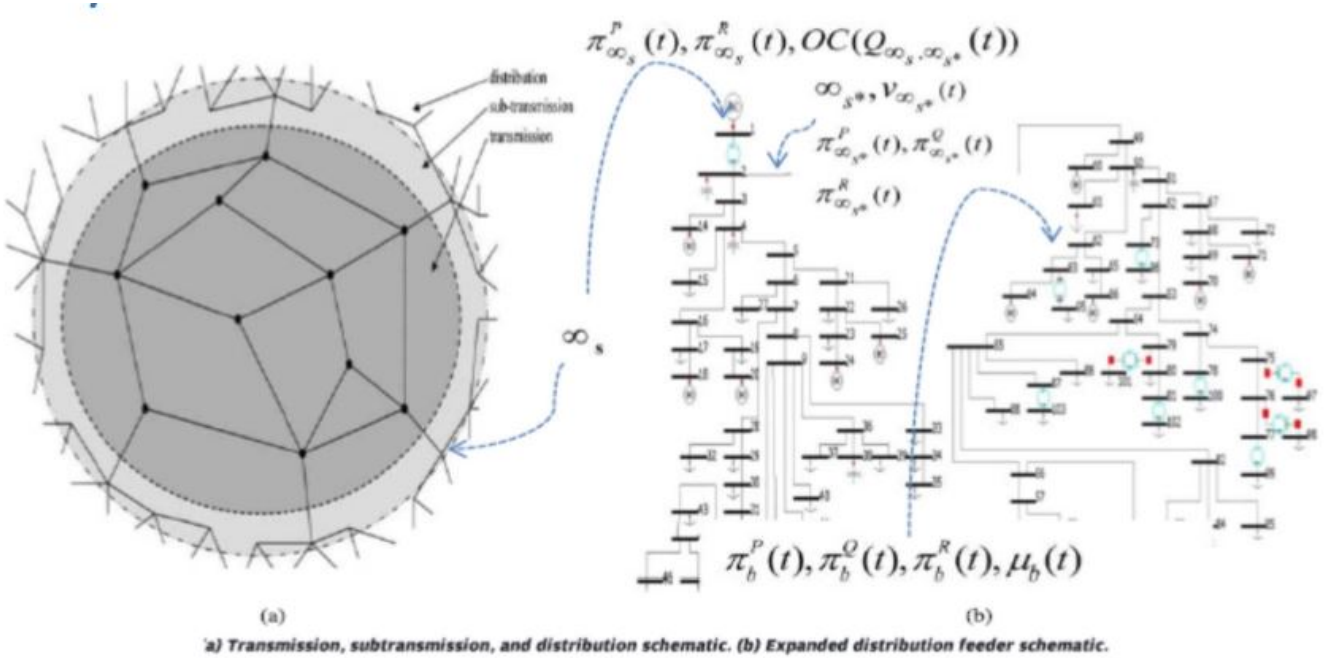




Source: NREL, (2016), NERC functional model workshop presentations

Michael Caramanis' platform pricing





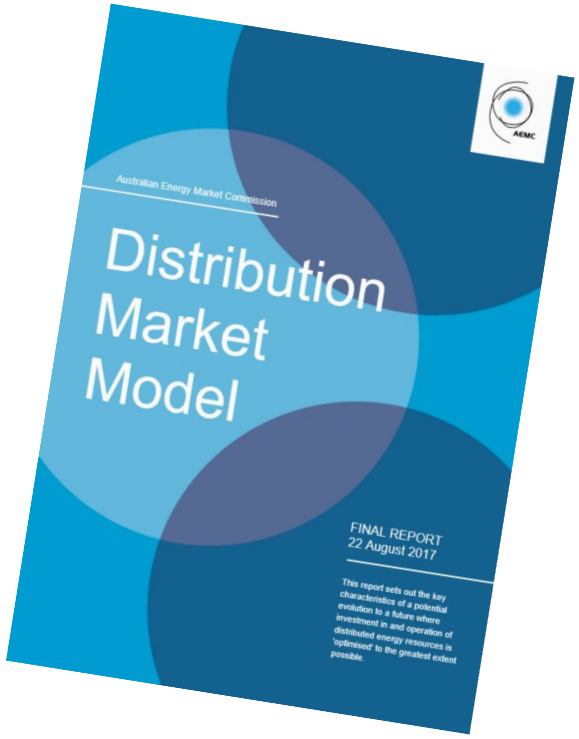
a) Transmission, subtransmission, and distribution schematic. (b) Expanded distribution feeder schematic.

Source: Caramanis, Tabors (2017), "Valuing Distributed Energy Resources via DLMP"

AEMC/AEMO

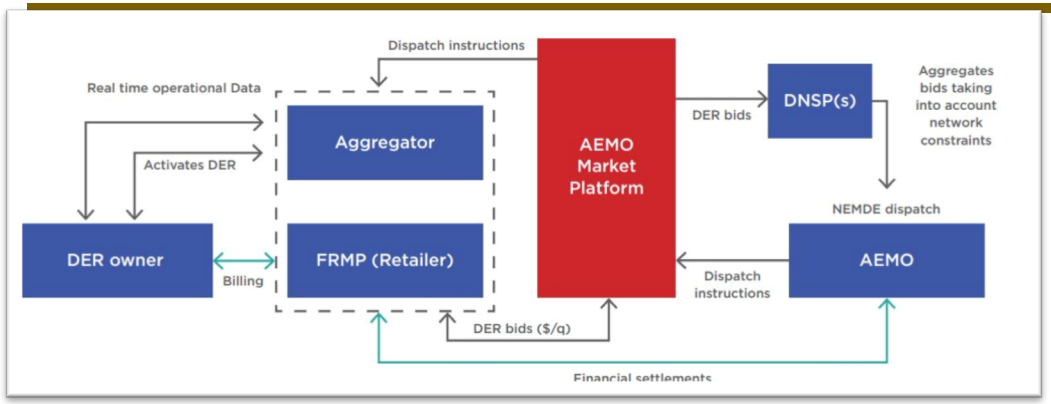
AEMC asked in its “Distribution Market Model Report” (August 2017):

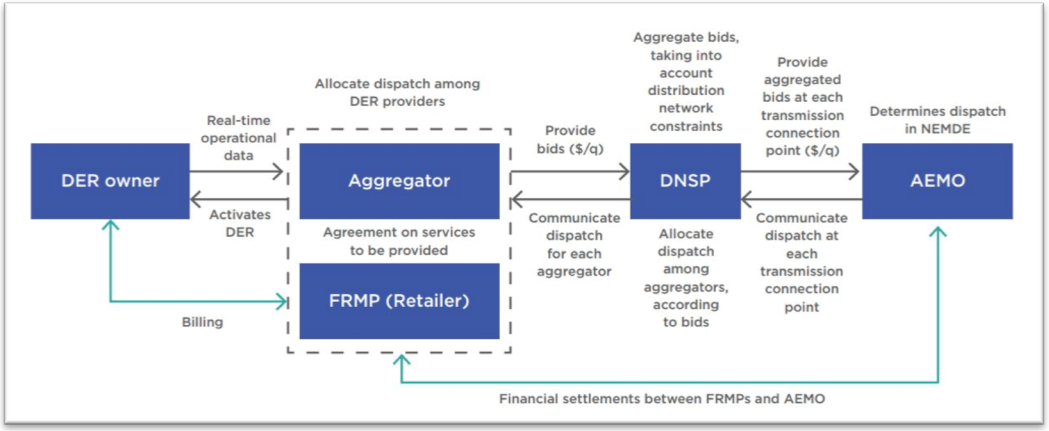
1. How to enable parties providing “optimising services” on the Dx level to be interfacing with the market operator (AEMO)
2. What minimum level of control do distributors need to facilitate DER uptake
3. How to get more dynamic information (about congestion, voltage issues) at more localised level from distributors

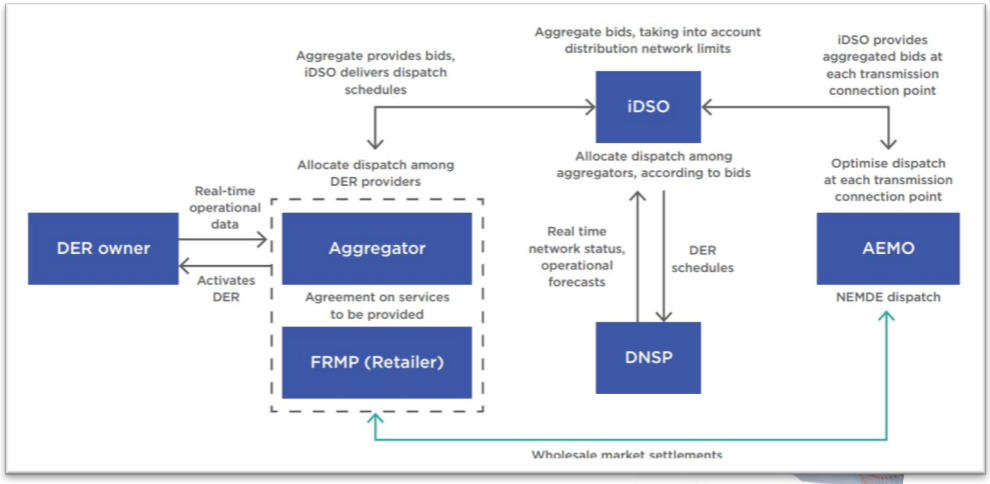


https://www.aemc.gov.au/news-centre/media-releases/distribution-market-model-final-report

AEMO responded by proposing three potential models



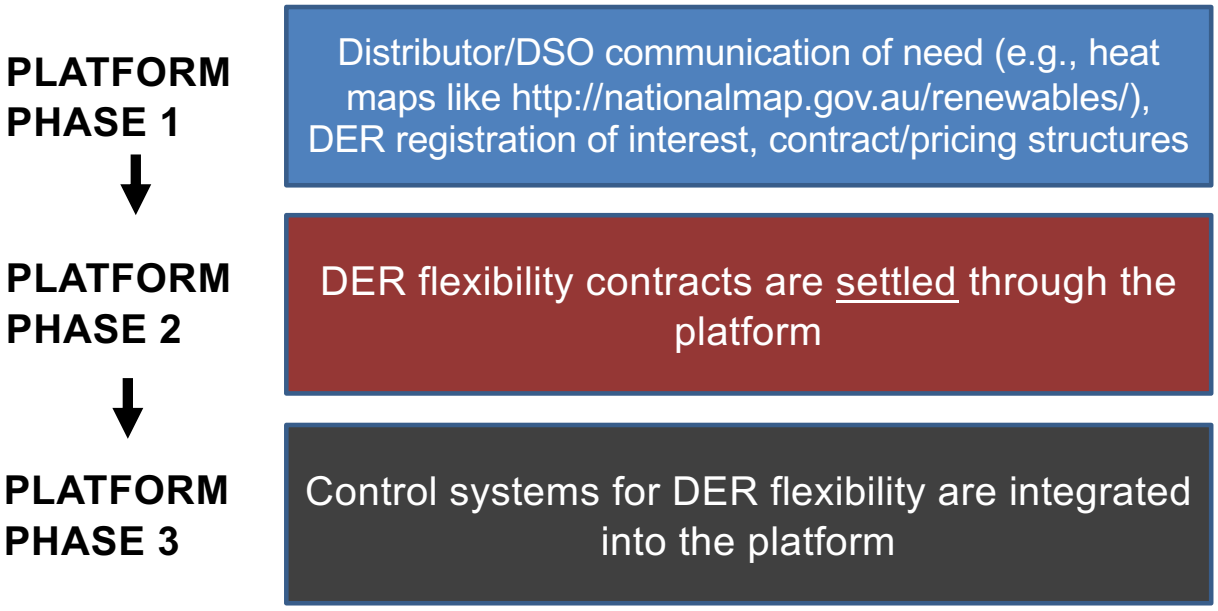




https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2018/OEN-Final.pdf

UK Power Networks Roadmap – moving ahead with DSO and platforms

Distributor-led platform roadmap (cf AEMO)



Roadmap presumes that DER will also be integrated with wholesale value streams (e.g., Hz).

Hence is focused on establishing "flexibility" contracting mechanisms (via a DSO) for distribution-centric value streams (deferral, outage management etc)

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UK Power Networks - products and contracting

Flexibility Products		Reinforcement Deferral	Planned Maintenance	Unplanned Interruptions	
				Pre-Fault Response	Post-Fault Response
Value Drivers		The present value of deferring capital expenditure	Managing unplanned interruption risk during planned maintenance	Customer Interruption (CI) and Minutes Lost (CML) incentives	Avoided cost of temporary generation and potentially CMLs
2023 Flexibility Potential (MW)		206	Available to eligible DER capacity		
High-Level Requirements	Location Specific	Yes			
	Response Time	30 mins maximum		<10 mins preferred, 30 mins maximum	
	Response Duration	Full availability window – case dependent. Pro-rated payment if available for part of window		3 hours. Pro-rated payment if available for part of window	
	DER Type	Generation, Storage and Load Reduction			Generation and Storage
Contracting Principles	Procurement Type	Competitive tenders or administratively set prices if low liquidity		Framework agreement. Optional updating of pricing through contract	
	Procurement Lead Time	6 months ahead and 18 months ahead	Case specific 1–12 months	DER applies if eligible	
	Payment	Availability and Utilisation		Utilisation only	
	Contract Term	1–4 years	Monthly or seasonal	Framework agreement	

Principles, contract forms, tender processes and (some) pricing similar to NZ's System Operator Procurement Plan for ancillary services.

Again, presumes that DER may also be obtaining benefit streams from wider wholesale market (ETSO).

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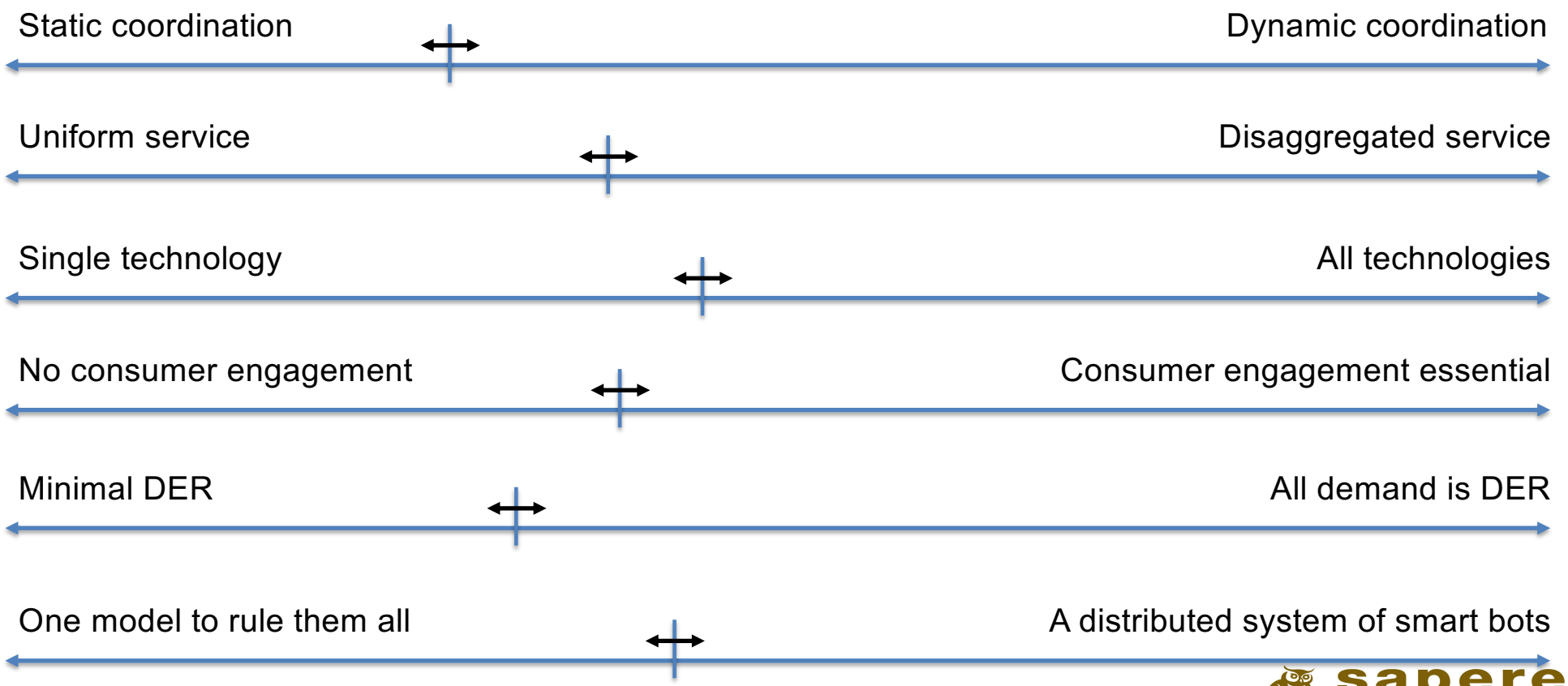
Transition settings
Short term and as we evolve



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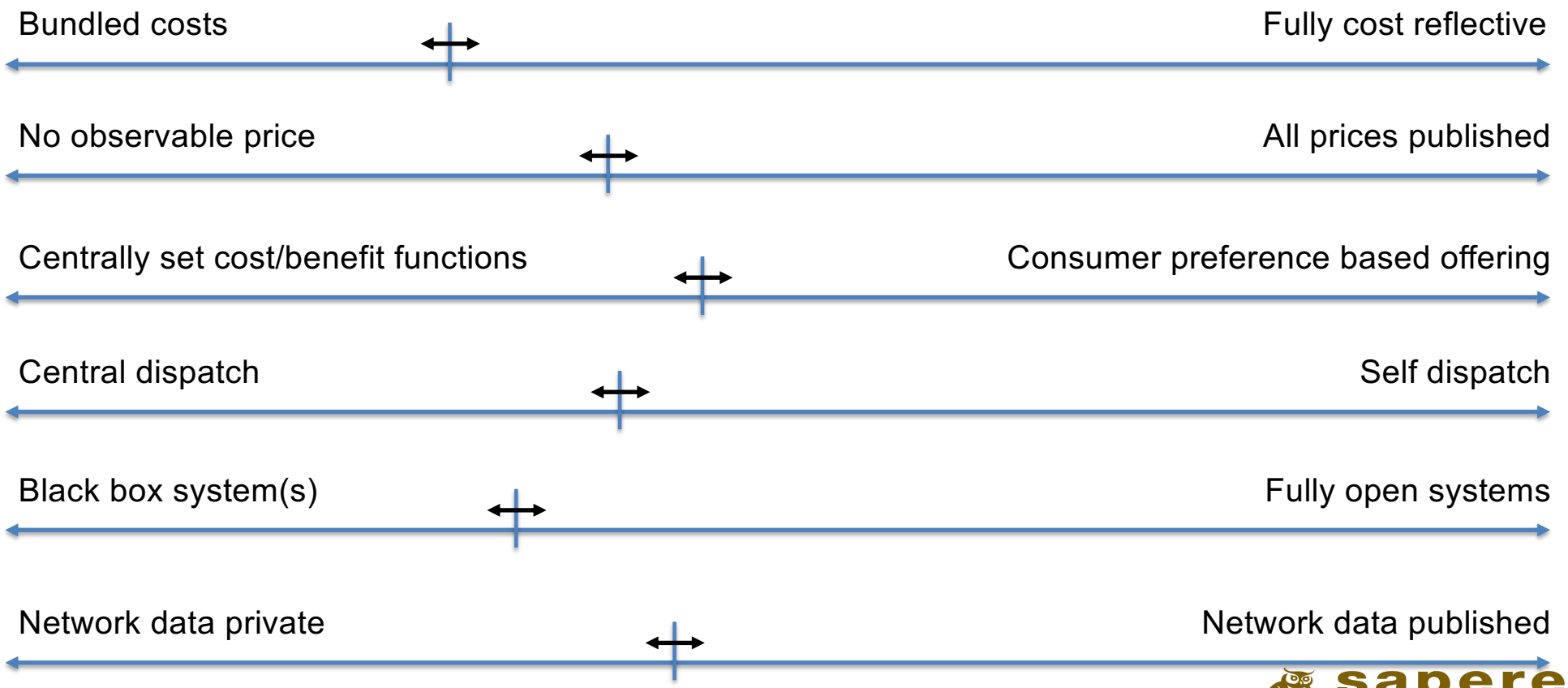
Transition settings continued
Short term and as we evolve



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During transition and as we evolve

What does the consumer need?

What does the distributor need?

What does the retailer need?

How does the evolving distribution system interact with the market?

What does the SO need?

What does the regulator need?

What do the innovators need?

David Reeve
Stephen Batstone
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