Methodology for evaluating flexibility as alternative to network reinforcement

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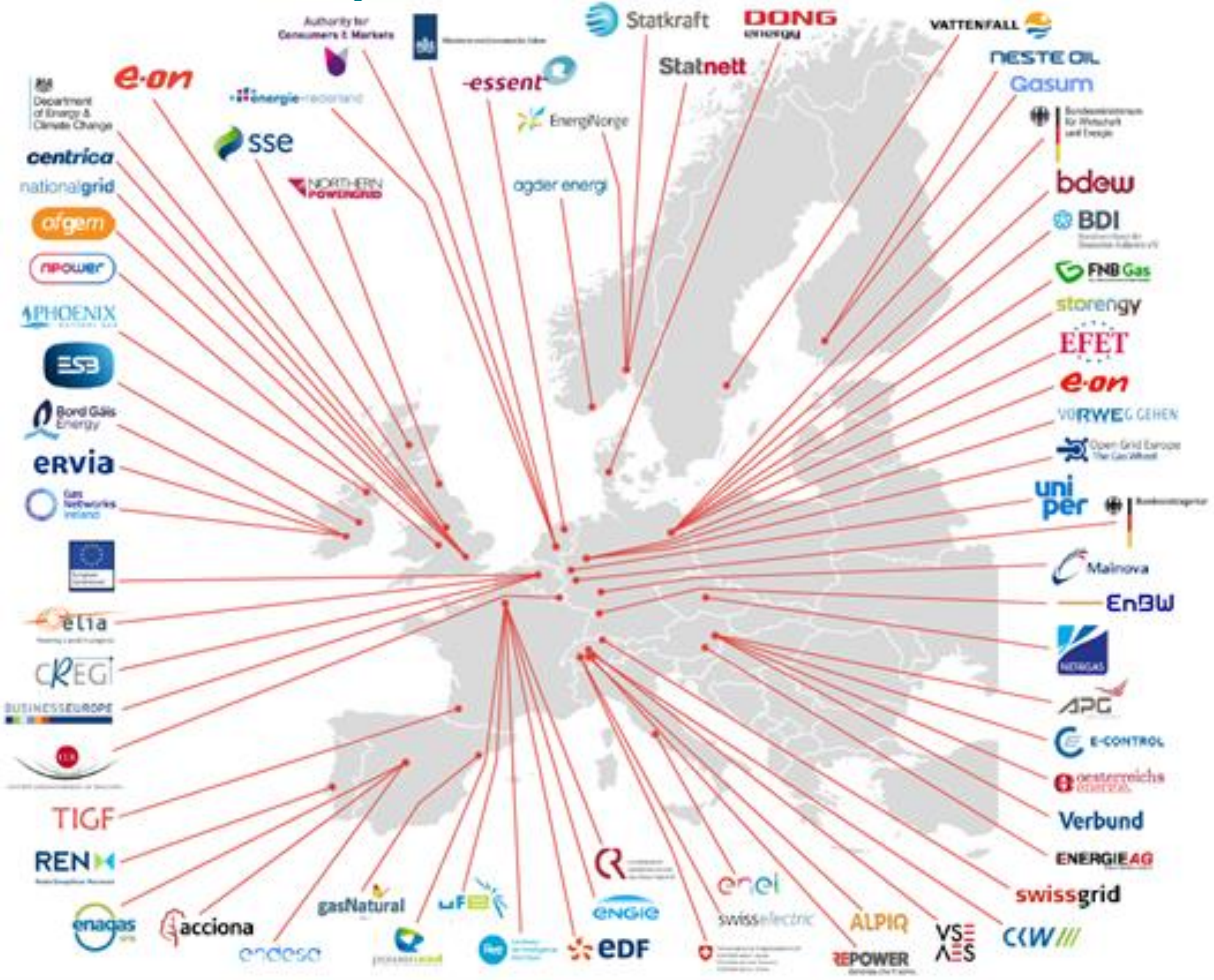
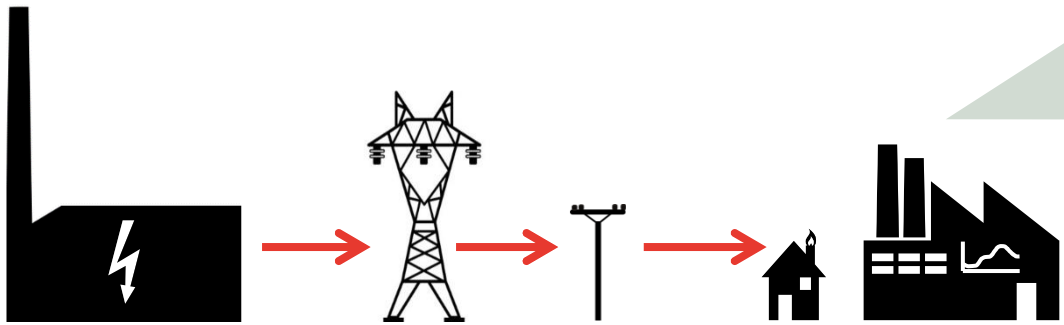


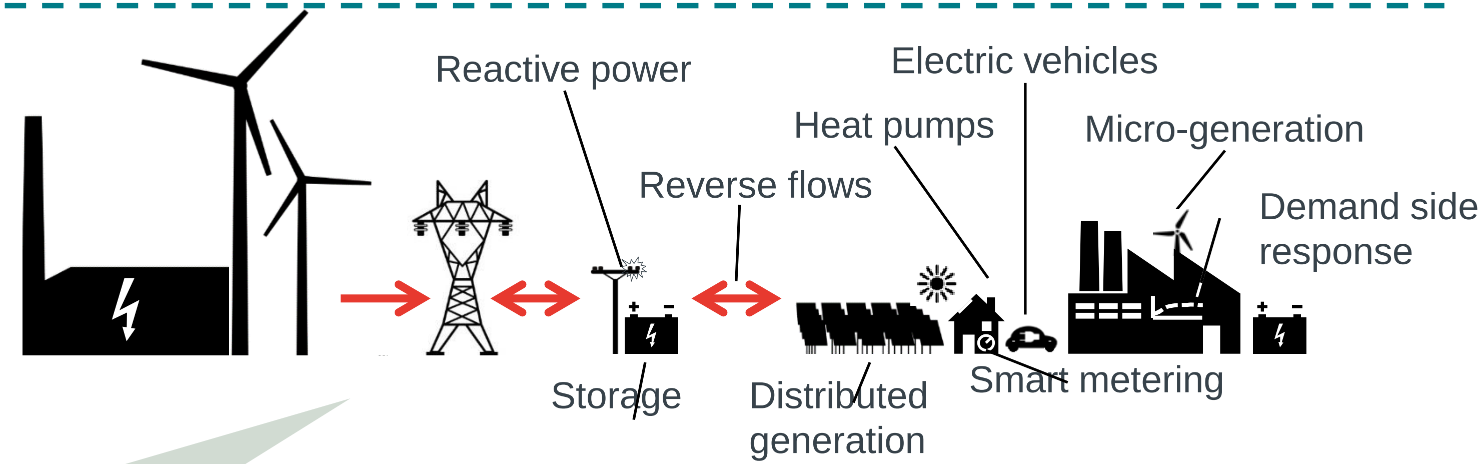
Growing flexibility in the evolving electricity system will mean DSOs face a more complex decision space

Traditional electricity system (Before)



- DNO optimises network to meet exogenous consumer demand for electricity generated upstream
- Relatively simple decision space: Reinforce network or do nothing

Future electricity system (After)



- More investment needed at DNO level
- DNOs (DSOs) will have more access to tools that allow them to manage networks more actively.
- Decision space becomes more complex – need for a framework for build decisions

DSOs will need to "actively" manage more complex power flows and constraints by engaging with distributed energy resources that are able to flexibly alter their consumption/production

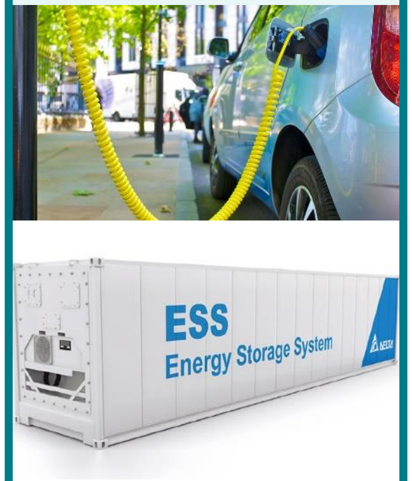
What is ‘Flexibility’?

‘modifying generation and/or consumption patterns in reaction to an external signal (such as a change in price) to provide a service within the energy system’ *Ofgem*

Consumption

Generation

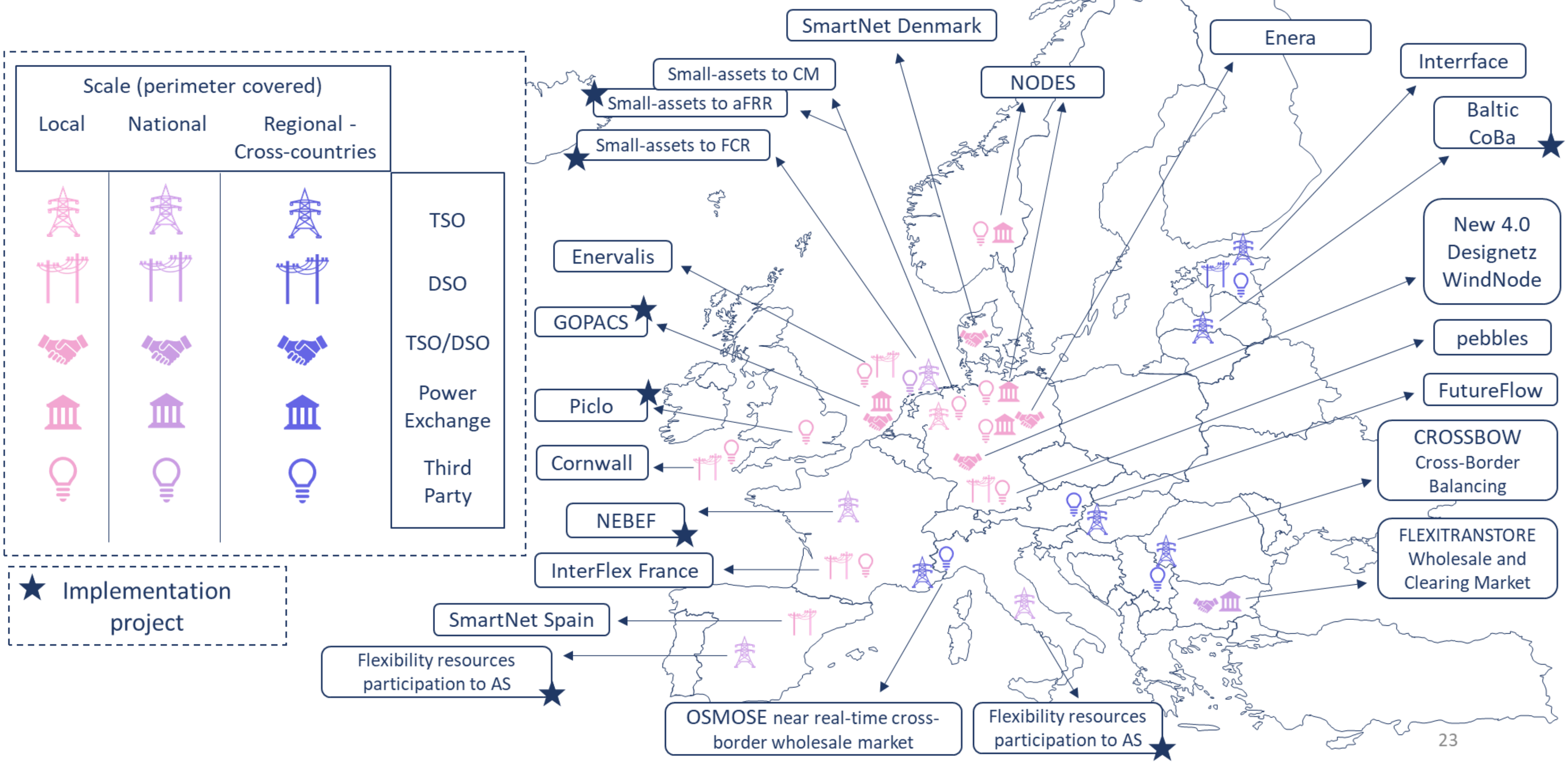
Storage



- Flexibility is identified as a key area where additional regulatory guidance may need to be developed to ensure the adoption of best practices for the planning and operation of the transmission and distribution systems of the future and development of platforms that can support the provision of flexibility services from DER.

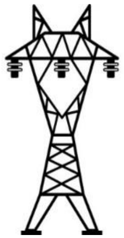
There has been an emergence of platforms across EU member states in recent years where flexibility can be procured

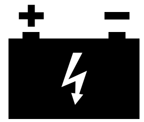
With a few exceptions (e.g., NODES, PicloFlex) many of these are currently being led by TSOs either with the help of DSOs or the DSO coordination is being actively explored



When should DSO commit to a traditional network reinforcement? And when can this be deferred or avoided by using flexibility services?

Demand forecasts suggest capacity in part of the distribution network will be insufficient





Option 1: Traditional Reinforcement

- Conventional capital investment in the site
- E.g build new cables/transformers
- ~4 year build time
- 20 to 40 year life span of assets

Option 2: Flexibility Services

- Purchase services of different types of flexibility providers to ensure supply
- E.g demand side response (DSR), storage, distributed generation
- 4 to 7 year contracts

The GB sector has developed a simple approach – but it does not capture the option value of flexibility procurement

Saving from delaying investment

Net present cost of conventional reinforcement today − Net present cost of conventional reinforcement in 4 years time ≥ CMZ contract cost for 4 years

Cost of flex

If yes → Use flex contract

Problems with this approach:

- Only source of value for CMZ is deferral of capex investment
- Assumes a fixed length of time that CMZ defers need for conventional reinforcement
- Assumes it is always right to go ahead with conventional reinforcement after a fixed length of time
- What if forecasts or other circumstances change in the next 4 years?
- Does not capture the additional optionality of not committing to a conventional reinforcement

This approach will never suggest the right answer is to "wait and see"

Less appropriate when:

- Potential spend is significant
- Uncertainty over future state of the world is high
- Different states of the world may lead to different reinforcement solutions
- Other factors (e.g. replacement) are not relevant

We developed a ‘decision-tree’ approach, drawing on real options valuation, to value the additional flexibility of flexibility contracts

Decision tree framework

A 32-year time horizon made up of eight 4-year periods

4 actions available each period:

- Traditional reinforcement
- Buy flex
- Combination of reinforcement and buying flex
- Do nothing

3 states of the world:

- Low (below forecast) demand growth
- Medium (at forecast) demand growth
- High (above forecast) demand growth

Assemble into a decision tree, and then solve!

Our model looks for optimal decisions over time *given* uncertainty – critically, the optimal solution may be to “wait and see”

1 Inputs

Probability of demand scenarios

- State of the world probabilities 2020-23 (low, medium, high demand growth)
- Conditional state of the world probabilities (e.g. of low demand for 2024-2039, given low demand for 2020-23)

Direct and indirect Costs

- Capex for each option/state of the world (2020-39)
- Opex for each option/state of the world (2020-39)
- CI/CML outage costs for each option/state of the world (2020-39)

2 Decision-making framework

- Minimise expected total societal costs given inherent uncertainty over future scenarios
- Problem solved using a decision-tree framework and analysed by backwards induction

This approach assesses the option value of using flex to delay network reinforcement against a backdrop of inherent uncertainty in demand

3 Outputs

Optimal decision

today (covering period 2020-2023)

Optimal decision

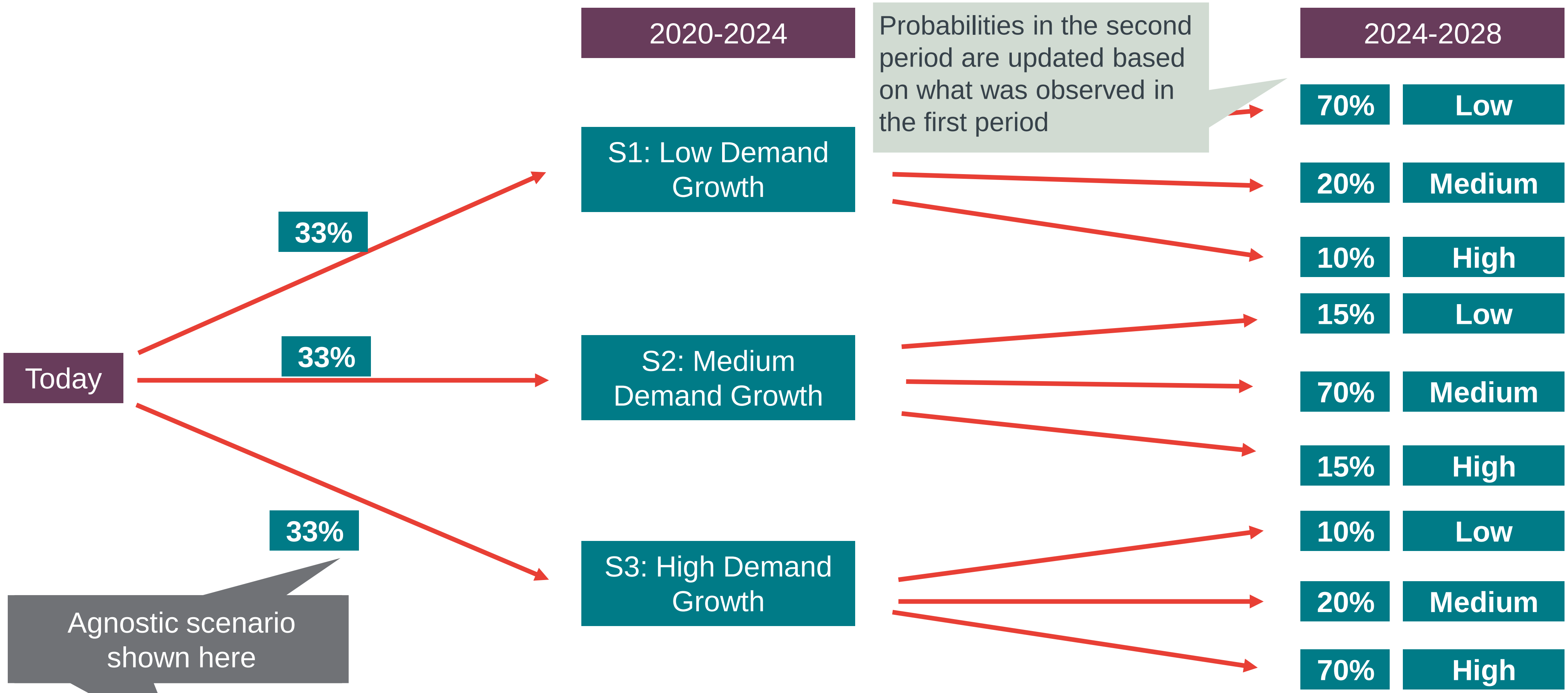
at each future 4-yearly decision points (2024, 2028, 2032 and 2036) given observed state of the world in period 2020-23

The model forces the user to think through the right questions

- There will inevitably be material uncertainty about the inputs – the model cannot be viewed as an automated decision tool
- By imposing a structure on thinking, the model forces thinking about the drivers of the optimal outcome…
- … and therefore helps answer the question “what would I need to believe for this to be the optimal action?”
- Additionally, the model can help highlight key areas of ambiguity to support and be informed by wider stakeholder engagement

1

Inputs - to calculate the expected cost of each investment option, we need to assign probabilities for the demand growth scenarios …



… we have provided for some hypothetical probability scenarios guided by key drivers …

New connections unlikely	S1: 70%, S2: 25%, S3: 5%
Low forecast uncertainty	S1: 10%, S2: 80%, S3: 10%
New connections likely	S1: 5%, S2: 25%, S3: 70%
Agnostic	S1: 33%, S2: 33%, S3: 33%

… as well as how they are updated in the second period

Strong - State realised 2020-2024 strongly likely to be realised again.
Weak - State realised 2020-2024 slightly more likely to be realised again
Asymmetric - High demand growth realised 2020-2024 more likely to be realised again. No updating if low or medium growth realised 2020-2024
No Updating - Probabilities not updated given 2020-2024 load growth

1

Inputs – ... as well as, capex, opex and CI/CML outage costs for the different options and states of the world

States of the world (demand scenarios)		All figures annual	Investment options being evaluated: 1. No intervention (“wait and see”)	2. Traditional network reinforcement	3. Flexibility	4. Combination
	S1 (low)	Capex in S1 (2020-39)				
		Opex in S1 (2020-39)				
		CI/CML outage costs in S1 (2020-39)				
	S2 (medium)	Capex in S2 (2020-39)				
		Opex in S2 (2020-39)				
		CI/CML outage costs in S2 (2020-39)				
	S3 (high)	Capex in S3 (2020-39)				
		Opex in S3 (2020-39)				
		CI/CML outage costs in S2 (2020-39)				

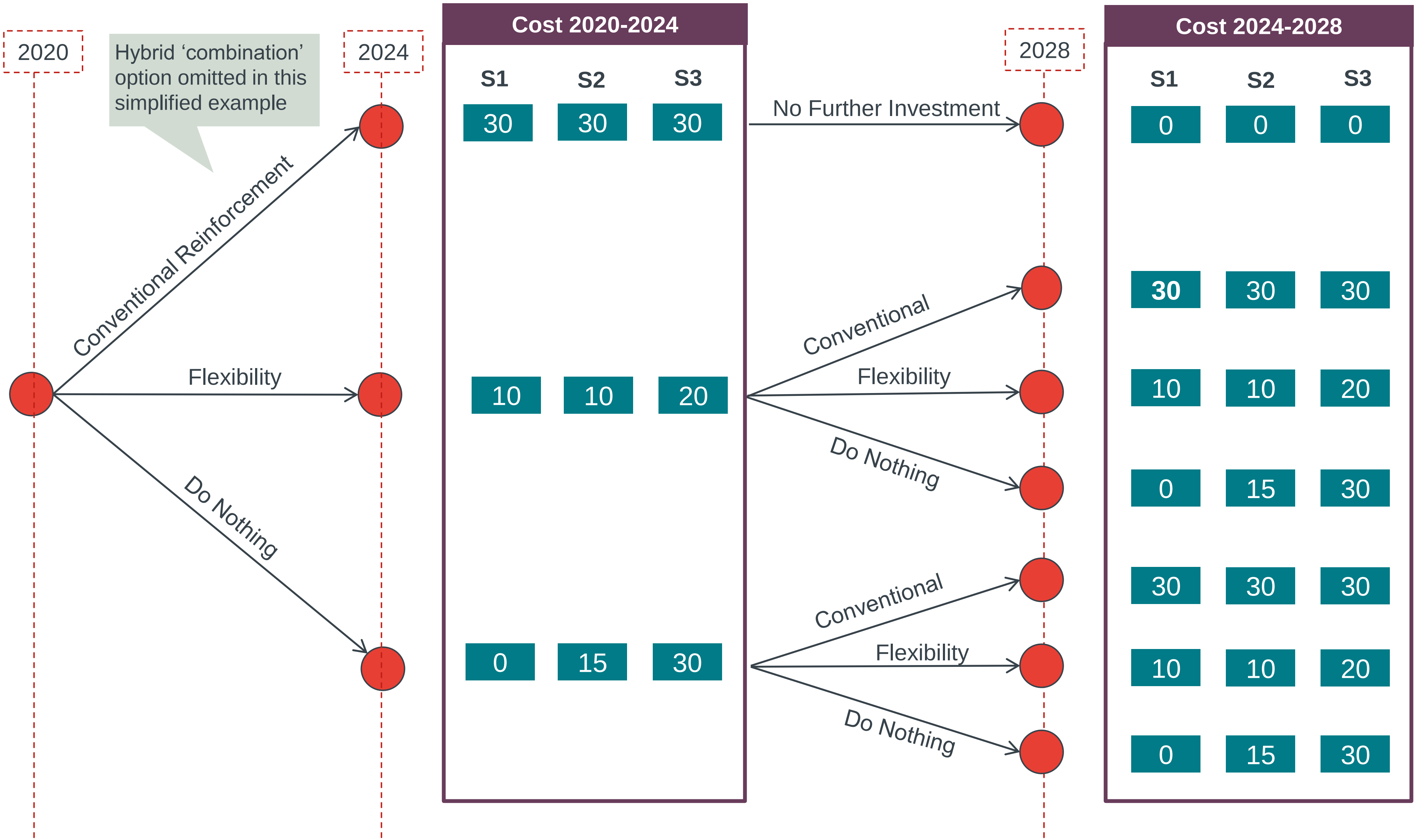
Provides for a combination of 2. and 3. (minor reinforcement + CMZ) that we expect to develop in the future

Could adapt the indirect costs to instead look at whole system effects

While these inputs are fixed in the current version of the model, it is possible to adjust the model to look at a range of values

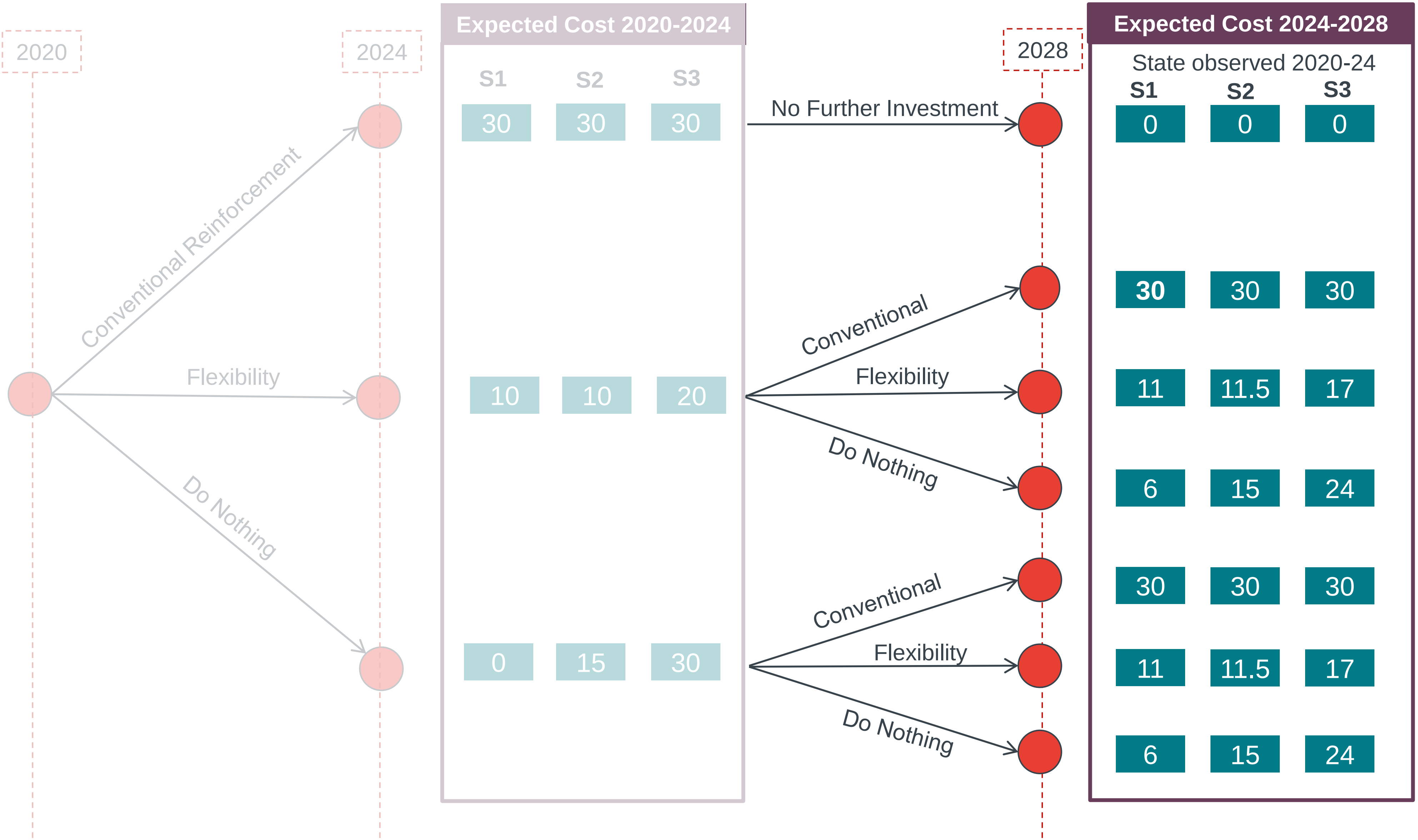
2

Framework - the model uses a decision tree structure where an investment decision is made every four years…

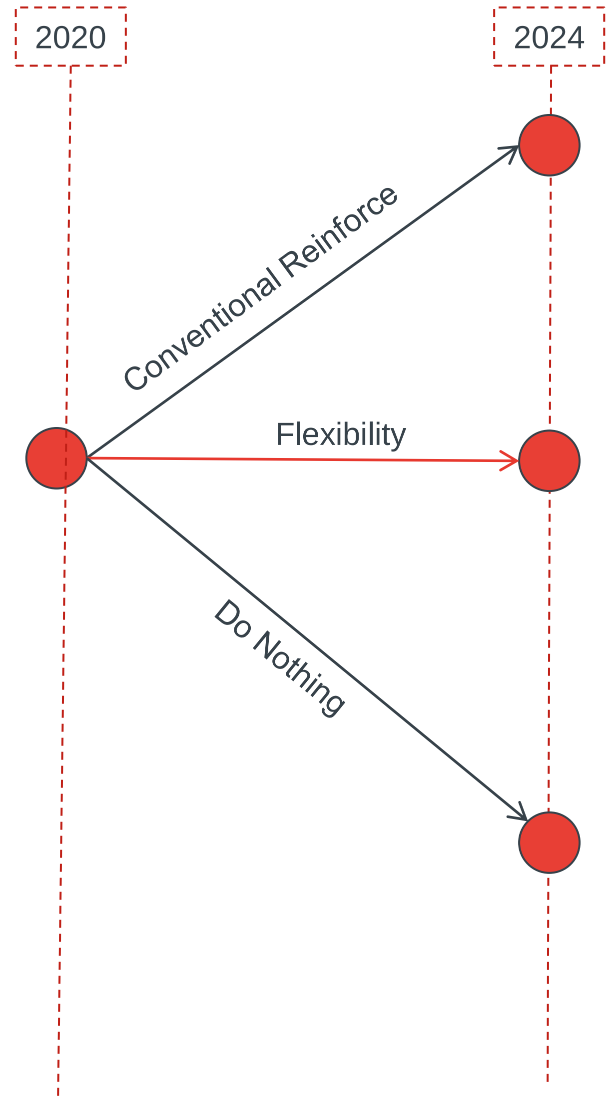


2

Framework - we calculate expected cost per period, where probabilities (and so expected cost) in period 2 depends on state in period 1…



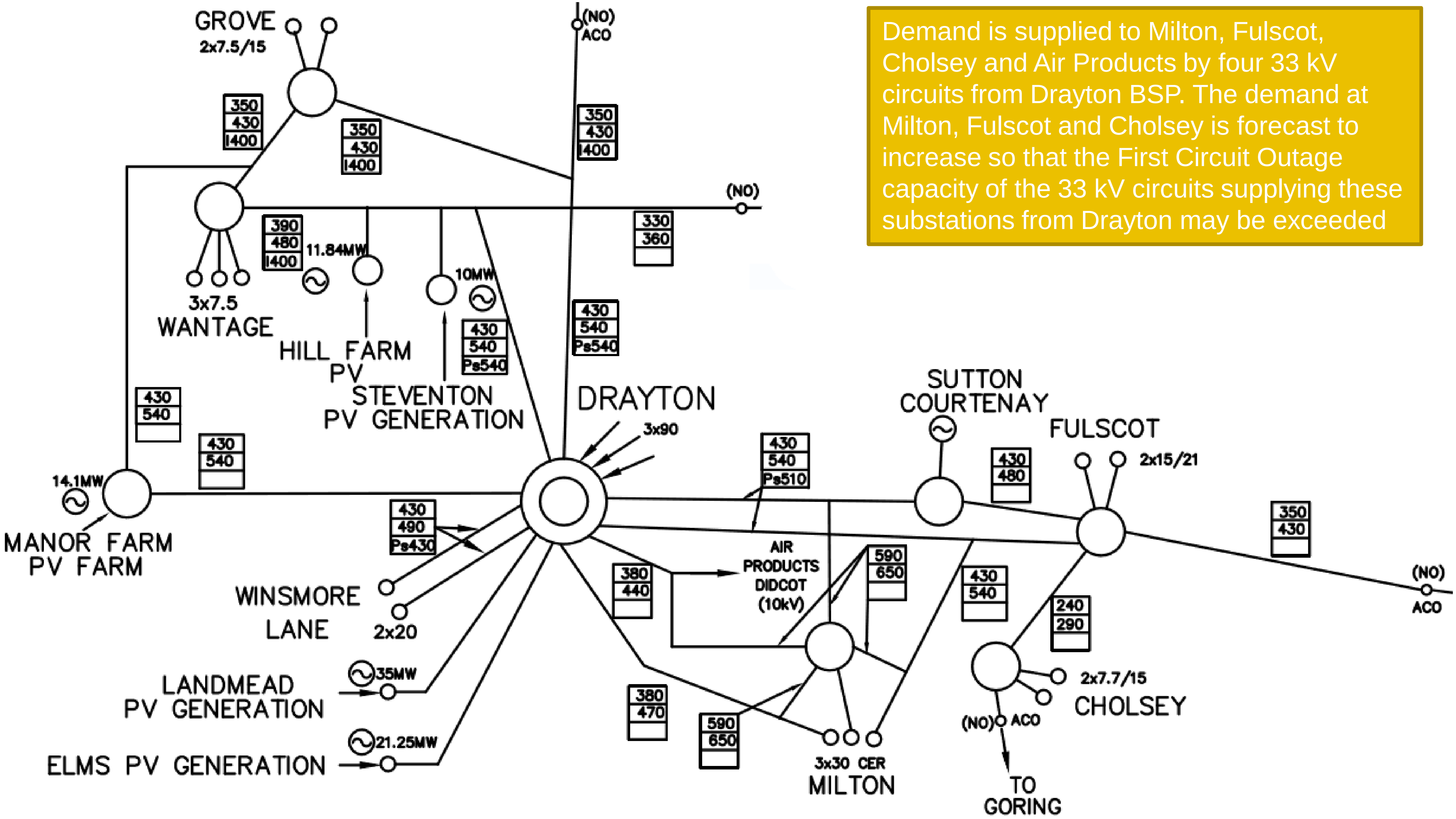
Framework - working backwards, we can then find the total expected cost to each path through the decision tree, and hence the optimal path



2020-24	2024-28					Total
30	No Further Investment	+ (1/3) 0	+ (1/3) 0	+ (1/3) 0	=	30
13.3	Conventional	+ (1/3) 30	+ (1/3) 30	+ (1/3) 30		
	Flexibility	+ (1/3) 11	+ (1/3) 11.5	+ (1/3) 17	=	24.8
	Nothing	+ (1/3) 6	+ (1/3) 15	+ (1/3) 24		
15	Conventional	+ (1/3) 20	+ (1/3) 20	+ (1/3) 20		
	Flexibility	+ (1/3) 11	+ (1/3) 11.5	+ (1/3) 17	=	26.5
	Nothing	+ (1/3) 6	+ (1/3) 15	+ (1/3) 24		

Lowest total expected cost is not the only metric to consider. Can be easily adapted to consider instead maximum or least regret

We applied this framework to a recent project on the SSE network: Drayton network and context



Demand is supplied to Milton, Fulscot, Cholsey and Air Products by four 33 kV circuits from Drayton BSP. The demand at Milton, Fulscot and Cholsey is forecast to increase so that the First Circuit Outage capacity of the 33 kV circuits supplying these substations from Drayton may be exceeded

Outputs - The model assesses an optimal solution based on inputs around costs and probabilities of future demand growth (1)

Assuming high probability of slow demand growth …

Optimal investment choice at each stage

2020-2024	State of the World Observed 2020-2024	2024-2028	2028-2032	2032-2036	2036-2040
	S1-Low	No Investment	No Investment	CMZ	CMZ
CMZ	S2-Medium	CMZ	CMZ	CMZ	CMZ
	S3-High	Conventional	Continue Conventional	Continue Conventional	Continue Conventional

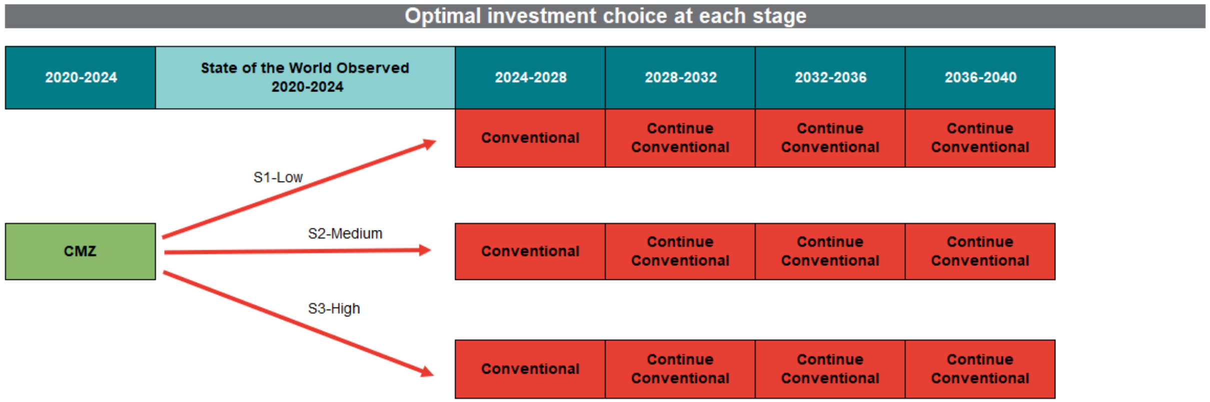
Assuming high probability of faster demand growth …

Optimal investment choice at each stage

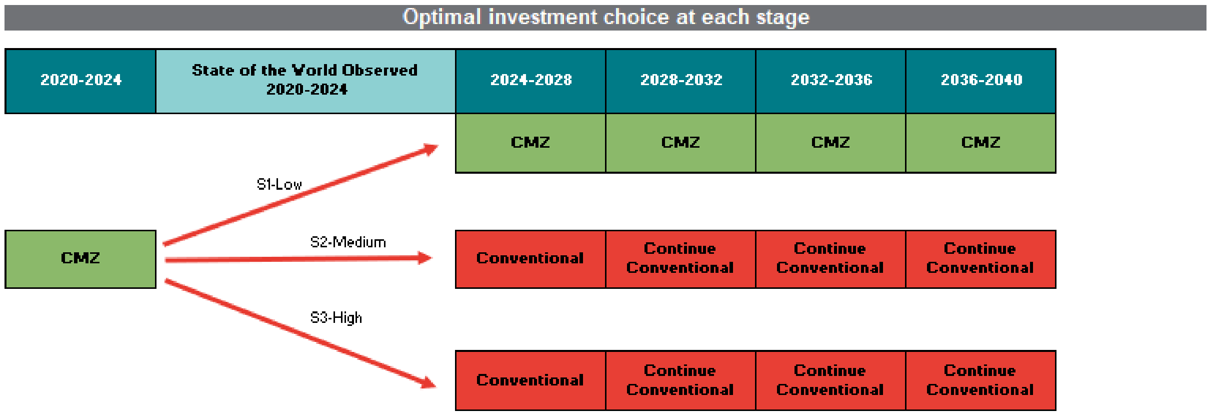
2020-2024	State of the World Observed 2020-2024	2024-2028	2028-2032	2032-2036	2036-2040
	S1-Low	Continue Conventional	Continue Conventional	Continue Conventional	Continue Conventional
Conventional	S2-Medium	Continue Conventional	Continue Conventional	Continue Conventional	Continue Conventional
	S3-High	Continue Conventional	Continue Conventional	Continue Conventional	Continue Conventional

Outputs - The model assesses an optimal solution based on inputs around costs and probabilities of future demand growth (2)

No probability updating – each scenario always equiprobable



"Strong updating" – if S1-S3 realised in 2020-24, significantly more likely to be realised again thereafter



- CMZ is the optimal solution in period 1 under both "no probability updating" and "strong updating"
- However, there are different results for subsequent periods:
  - **No updating:** there is no learning in period 1 (i.e. no updating of the probabilities of the different growth scenarios for periods 2-5 given what has occurred in period 1, all stay at 1/3), and conventional reinforcement is the best option under all load growth scenarios
  - **Strong updating:** in this scenario there is strong learning in period 1 (i.e. the probability of the load growth in periods 2-5 is influenced significantly by what is observed in period 1). There is additional option value from using CMZ in period 1, as this gives you the flex to choose again in periods 2-5

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