SMART WIRES

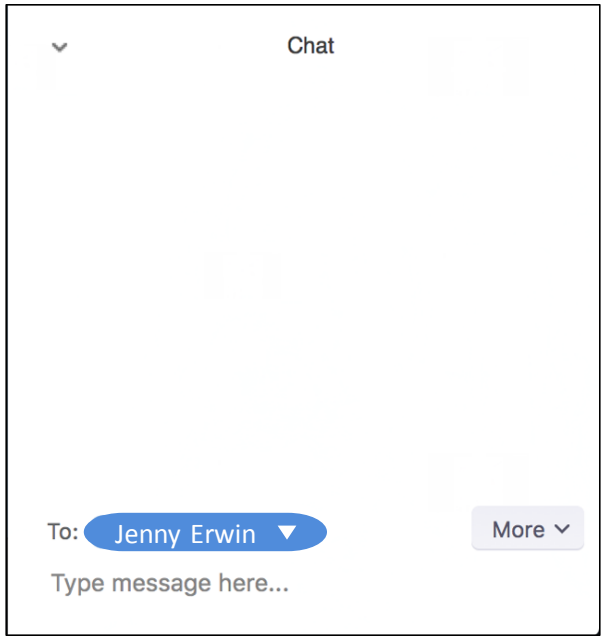
REIMAGINE THE GRID

Cost Benefit Analysis of SmartValve™ Projects

17 April 2020

Announcements

QUESTIONS



NEXT WEBINAR – EN ESPAÑOL

Transmission planning with SmartValve technology in PowerFactory

Thursday, April 30

Mario Patiño
Customer Solutions Engineer, Latin America

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Power Systems Engineer

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Today’s presenters

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Agenda

1. **Technology overview**
2. Cost Benefit Analysis
   - A. Key considerations
   - B. Scalability and deferred investment
   - C. Redeployability
   - D. Speed of deployment
   - E. Security of supply
3. Key takeaways

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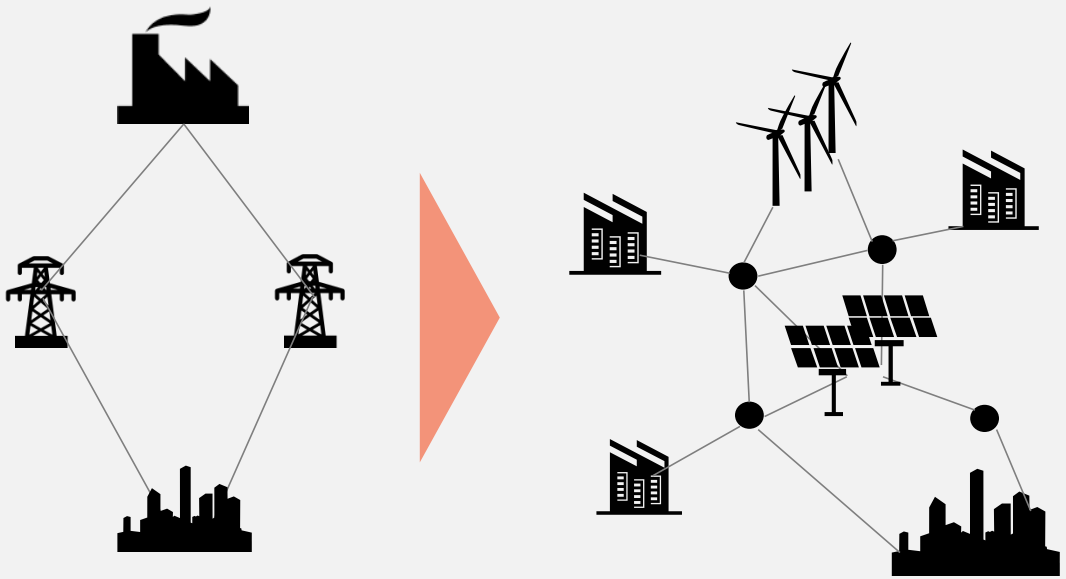
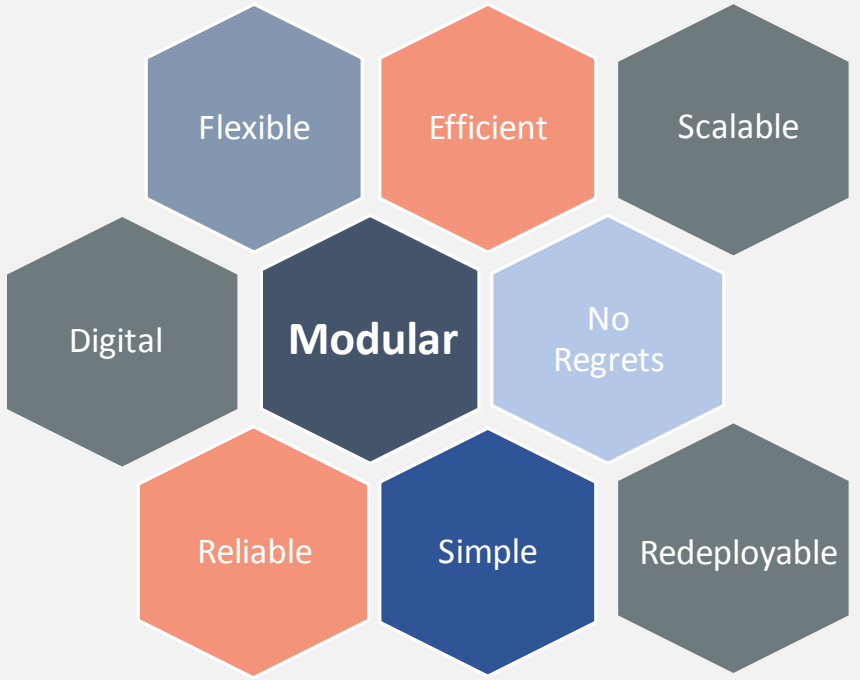
Enabling a new paradigm for planning & operating the grid

Challenges



Dramatic changes in developing grids
Greater uncertainty in the power system and in the political and societal landscape
Need flexible and responsive grids

Benefits



Mitigate uncertainty
Agile system capable of reacting quickly and meet emerging needs

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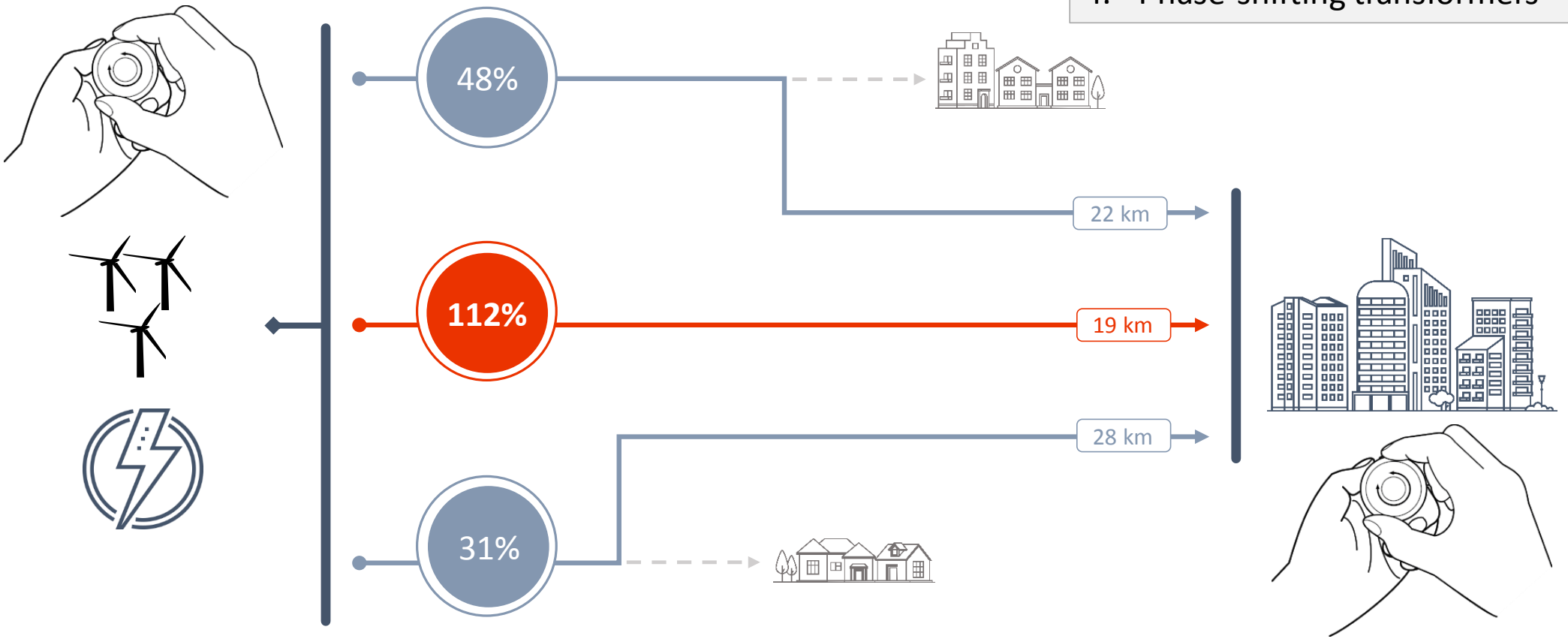
Before Smart Wires

Simplified planning scenario predicts network constraint

Traditional solutions include:

1. Redispatch generation
2. Reconductor constraining element
3. Construction of a new parallel circuit
4. Phase-shifting transformers



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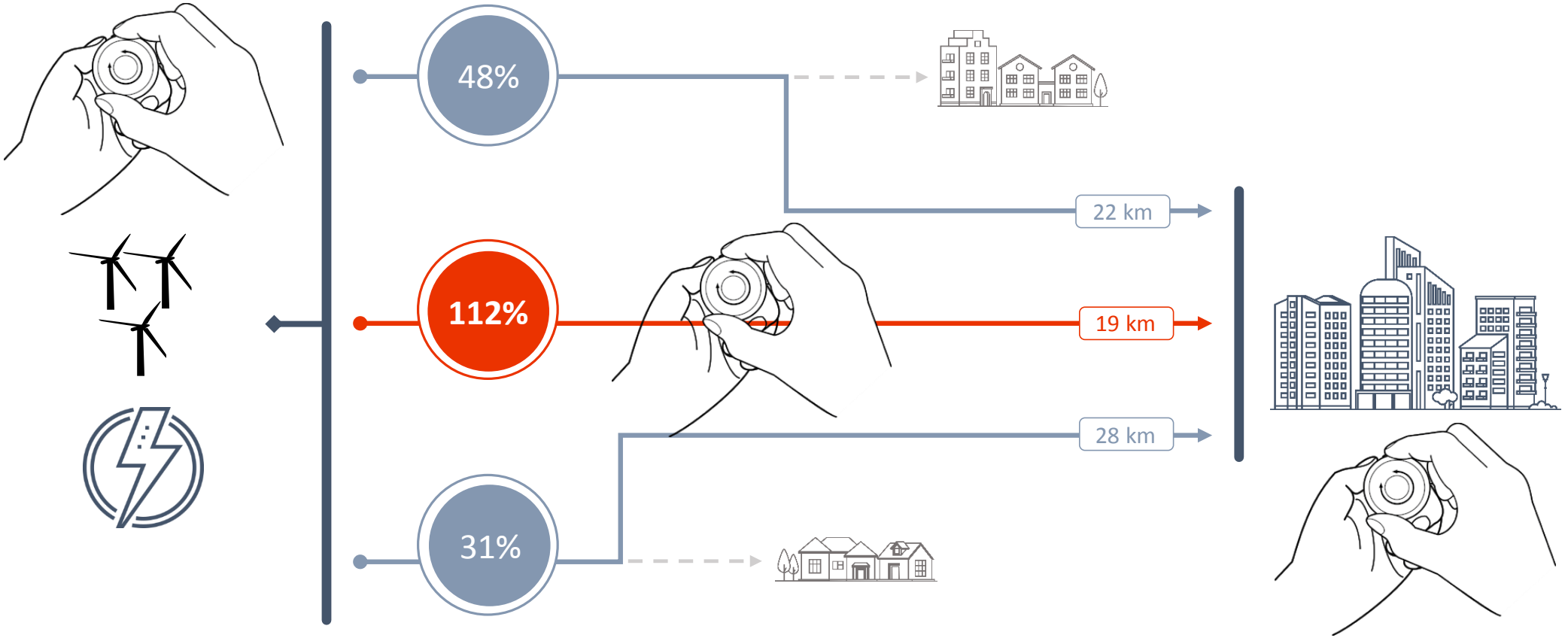
With Smart Wires

Adding a third degree of freedom and fully utilizing existing grid capacity



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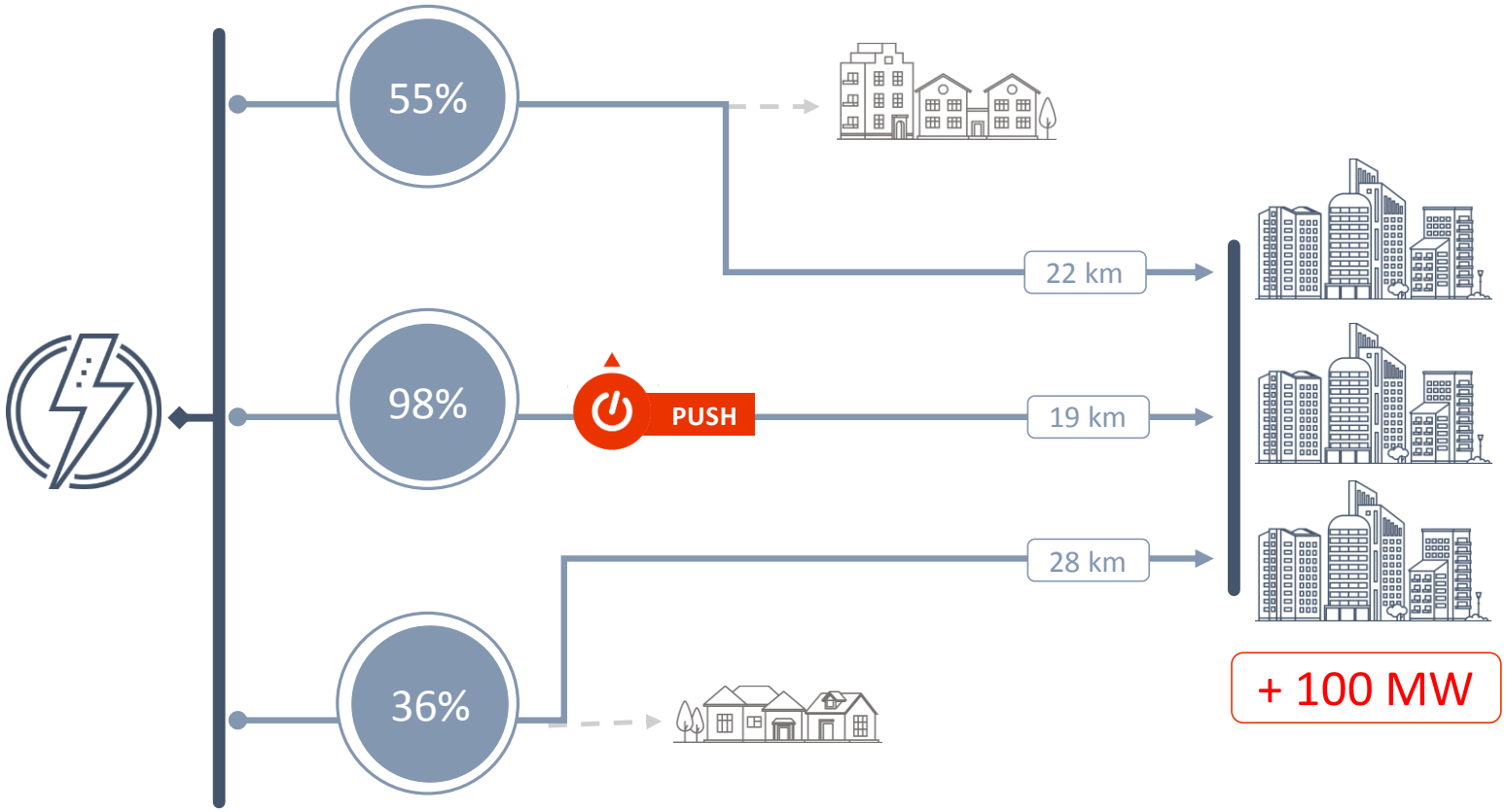
With Smart Wires in push-mode

Power can be **PUSHED** to alternate lines with spare capacity



Smart Wires solution

- Utilizes unused capacity already existing on the grid
- Modular Static Synchronous Series Compensator (SSSC)
- Controls power flow through voltage injection
- Creates an effective impedance change on the line

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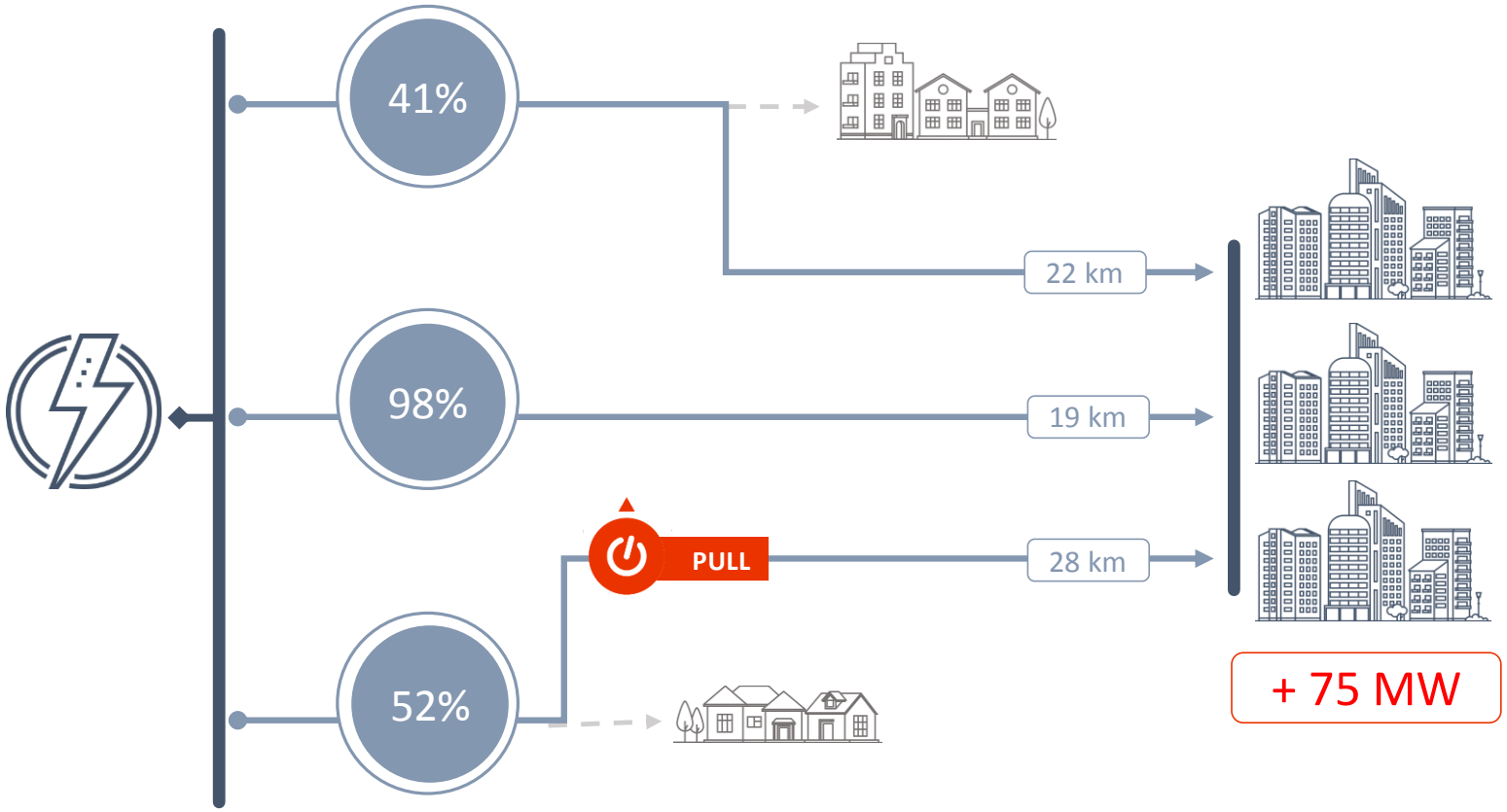
With Smart Wires in pull-mode

Power can be **PULLED** to alternate lines with spare capacity



Smart Wires capabilities

- SmartValve voltage injection allows for:
  - Full range of control
  - Both inductive (push) and capacitive (pull) injection
- Quickly re-deploy to address problems on other facilities
- Voltage agnostic – Deploy/Re-deploy on any line up to 550kV
- Avoids risk of other power flow control devices, such as SSR, VAR consumption, maintenance

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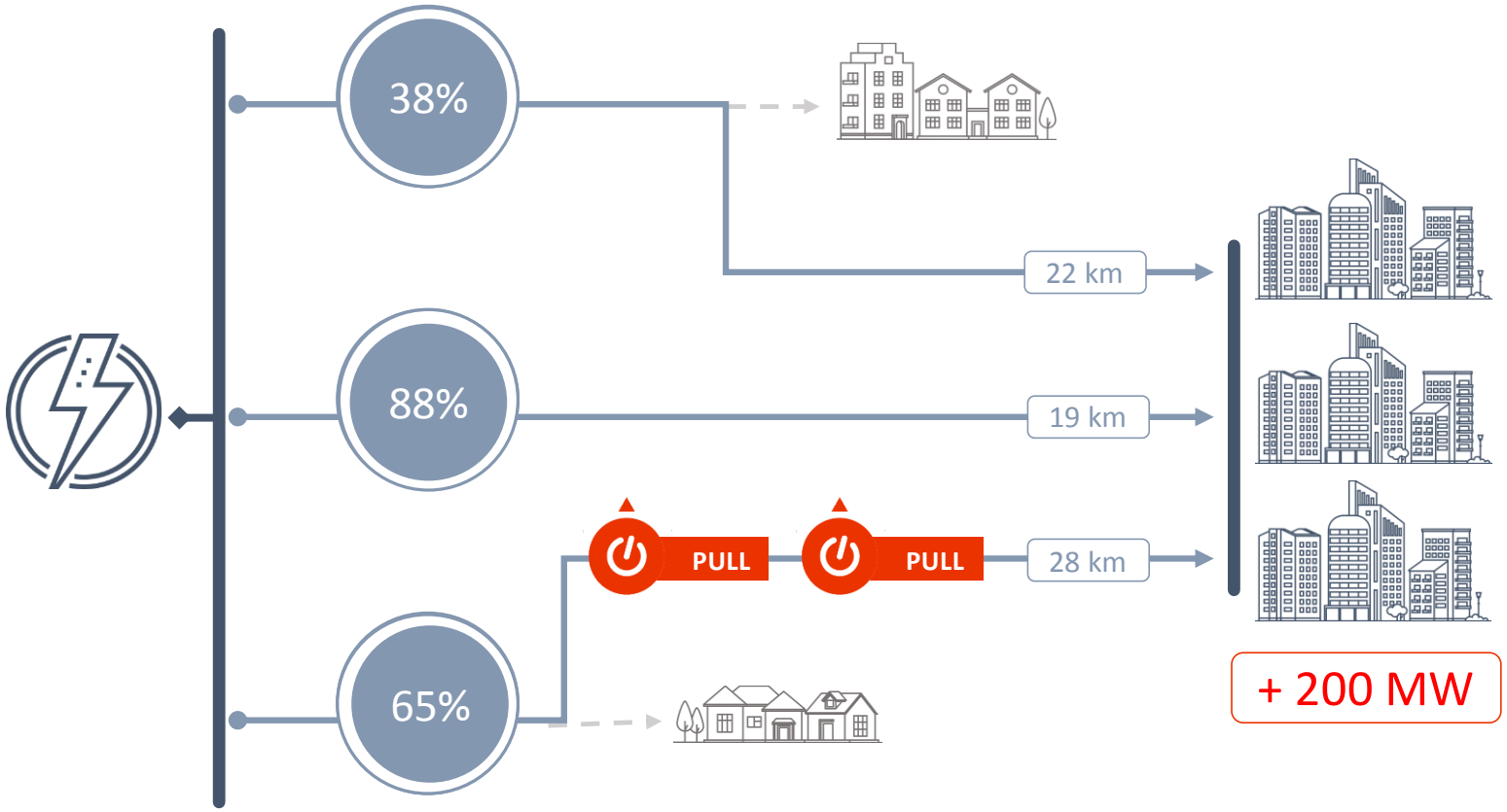
Adjust solution based on changing network needs

Solution can be easily and quickly expanded (or contracted) to adjust topology



Benefits of modular design

- Modular design allows utility to quickly scale the solution to match system needs
- Using standardized equipment, the utility is allowed to build a custom solution
  - Fast lead time (<9 months)
  - Straight-forward design and installation
  - Flexibility in design and installation

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SmartValve deployment methods

Tower-based

Ground-based

Mobile Unit

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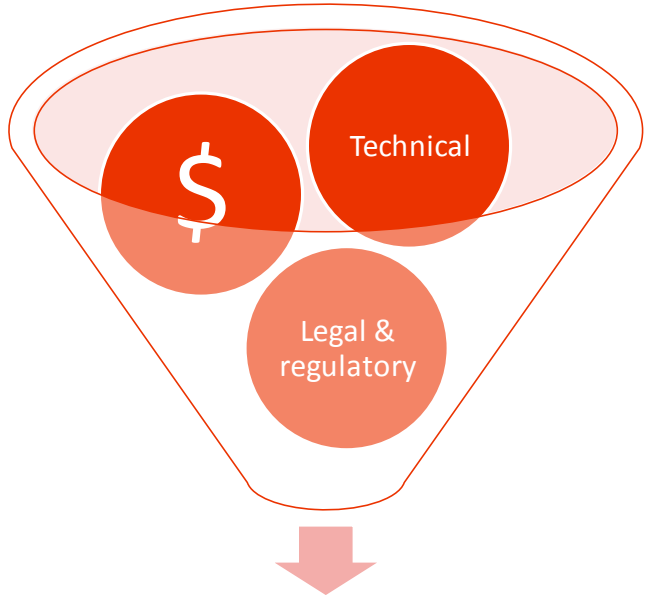
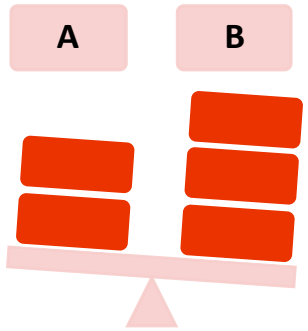
General overview – cost benefit analysis (CBA)

- Multi-criteria assessment method for decision-making
- No single approach, but some best practices
- Not restricted to monetary values
- Includes all relevant criteria

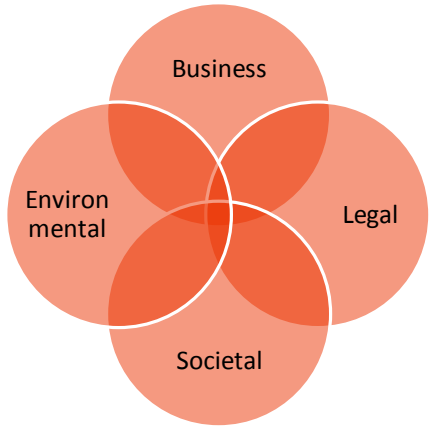


Evaluating infrastructure projects with CBA

Is a project required to resolve an identified need?



Which of the alternative options for a project should be selected?



Assess impacts

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Assessment tools for CBA

- Benefits and costs across the life of the project
  - Easier to monetize costs
- Most common tool: Net Present Value (NPV)
  - Only consider costs and benefits that can be monetized

Assumptions used for all NPVs that follow

Assuming

- All values for simplicity are converted to a PU cost
- Modular SmartValve and Alternative solutions capex costs are the same at 1.0PU
- Benefits are applied proportionate to capacity and the capex of 1.0PU
- O&M per annum nominally 2% of capital cost
- Discount rate is 4%

Excel NPV Formula used:

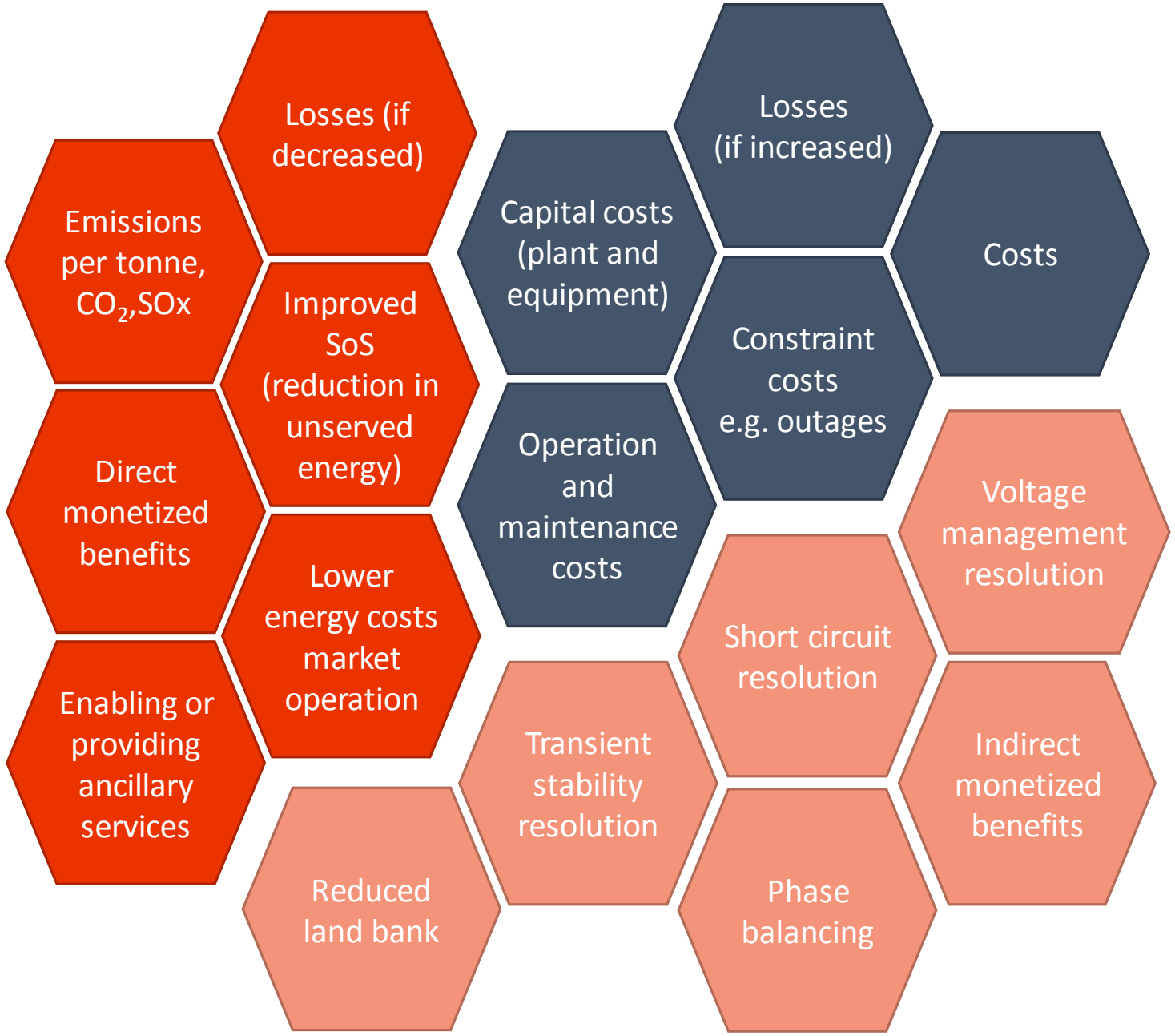
$= NPV(Discount\ Rate, Range\ of\ Values)$

$= NPV(0.04, B3{:}B76)$ -> *Modular Solution*

$= NPV(0.04, C3{:}C76)$ -> *Alternative Solution*

Parameters to consider

- Three categories
- Monetized costs and benefits
- Benefits of modularity providing more than one service
- Opportunity cost of smaller footprint



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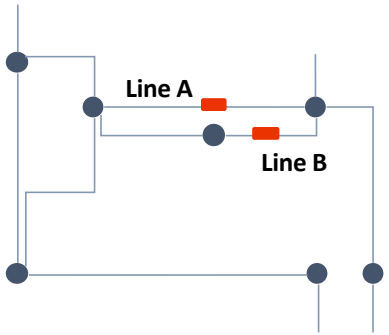
Maximizing a flexible solution

Simplified System Diagram



Substation SmartValve deployment 230 kV

	Line A		Line B	
Scenario	Loading (%)	SmartValve Count	Loading (%)	SmartValve Count
2019 Winter Peak	106	6	98	0
2022 Winter Peak	109	9	101	3
2027 Winter Peak	113	15	103	6

Challenge

- A reliability assessment identified that without sufficient local generation, **thermal overloads** will occur in 2019, 2022 and 2027 in several **different study scenarios**
- Worst-case planning would lead the utility to pursue a **$125 M reconductor project**
- The **exact magnitude and timing of the overload is highly uncertain** and it is quite possible the full extent of the overload condition may never occur

Smart Wires Solution

- Smart Wires developed a solution involving **two multi-staged SmartValve deployments** that resolve the anticipated thermal overloads
- This solution allows the utility to **solve the known near-term need and scale the solution up** (by adding additional devices) if the need grows in the future

Impact

- This modular solution can be installed in less than a year. This ensures the utility **addresses the near-term reliability violation** and allows them to **quickly procure additional power flow control in the future.**
- SmartValve deployments are a **cost-effective** option that provide considerable savings to customers by **deferring the high-cost reconductor**
- **If the utility decides to pursue the reconductor in the future, the SmartValves are a "no regrets" investment that can be easily redeployed elsewhere on the grid**

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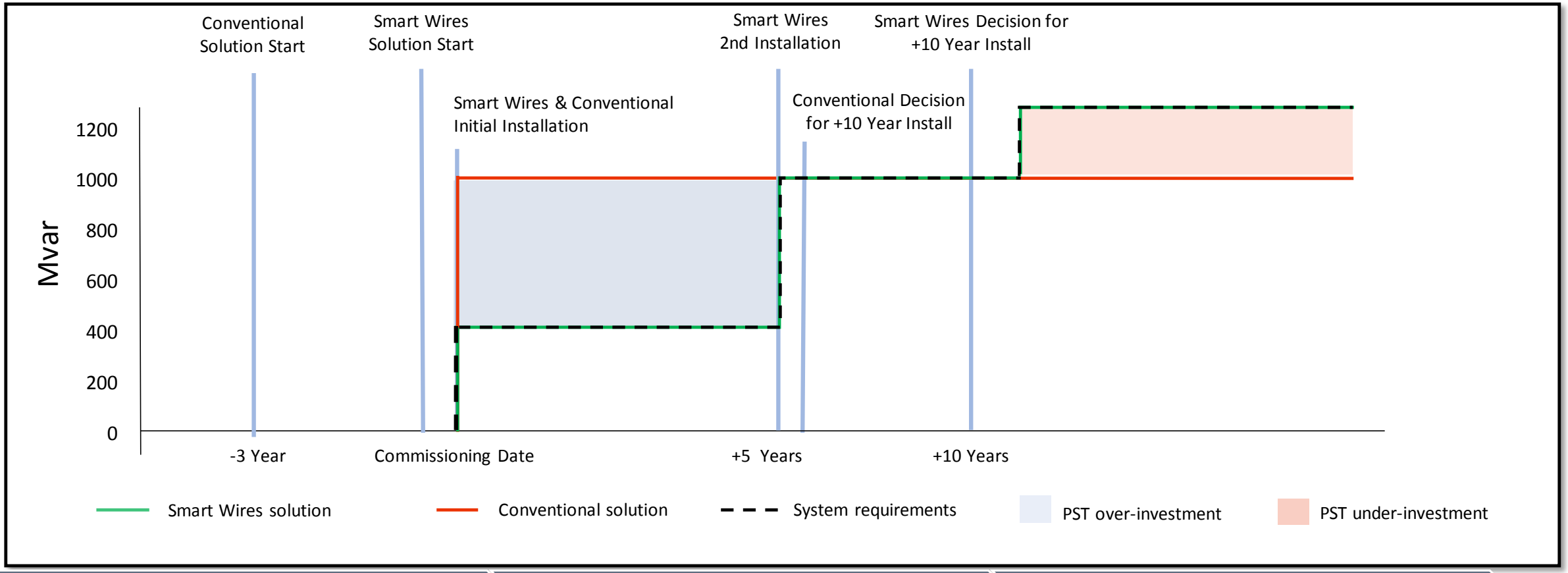
Reflecting impacts from uncertainty

Scalability and deferred investment



Initially invest for known short/medium term needs

Add or remove units as need changes in time with < 1 year advanced notice

No-regrets-decision with significantly lower lifetime cost

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Scalability and deferred investment

CapEx
OpEx

Modular Deployment

Developed in phases so costs are spread

Build the size needed

50% O&M

50% O&M

10% O&M

50%

50%

10%

YEAR
-3
-2
-1
0 (Commissioning)
.
.
5 (Next phase)
.
.
.
.
10 (New need)
.
.
40 (Decommissioning)

Traditional Deployment

25%
25%
25%
25%

25%
25%
25%
25%

100% O&M throughout

100% O&M

CapEx before commissioning

Unforeseen need to scale the investment

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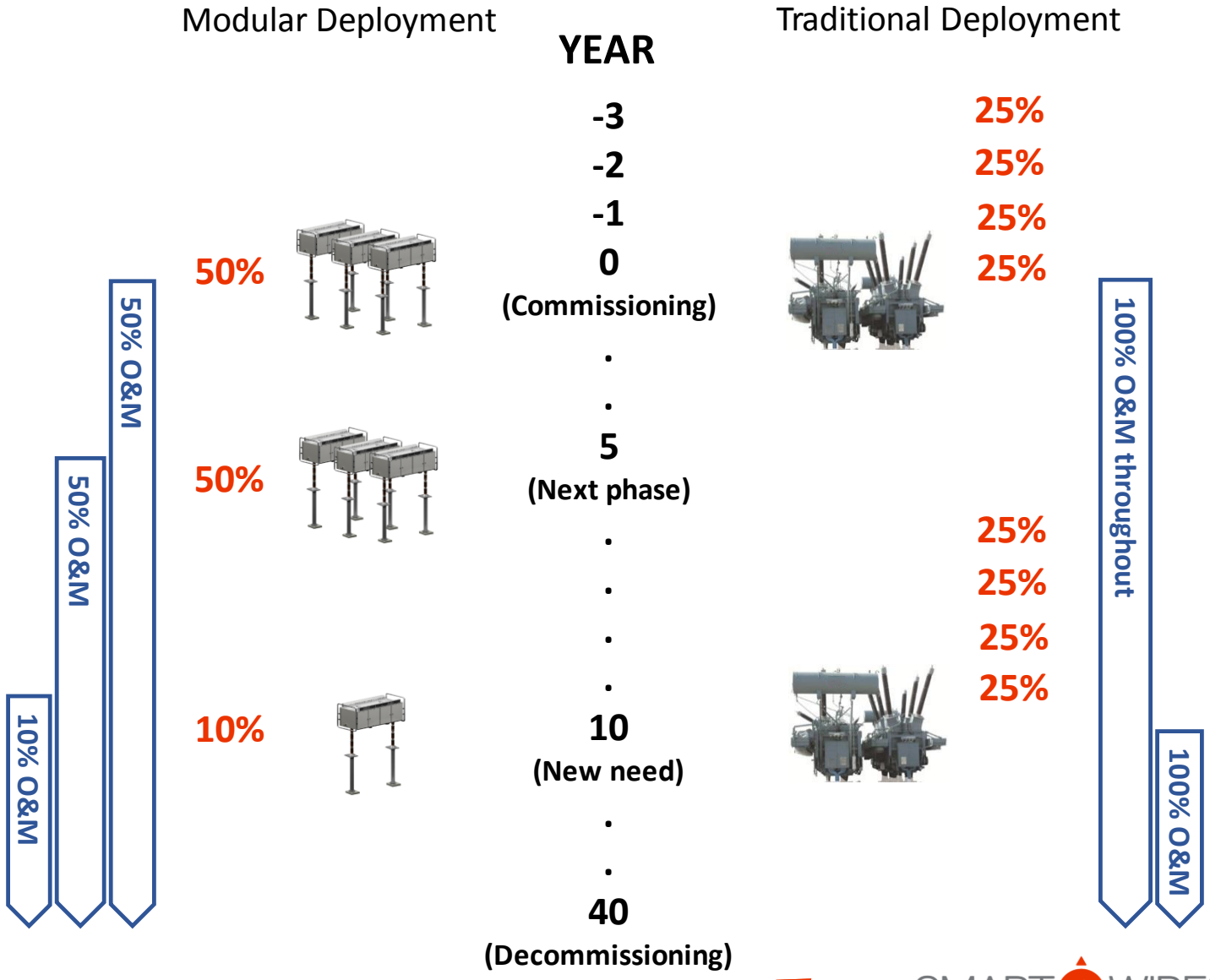
Scalability and deferred investment

A	B	C
Year	Costs in PU	
	Modular	Alternative
2017	0	- 0.25
2018	0	- 0.25
2019	0	- 0.25
2020	- 0.5	- 0.25
2021	- 0.01	- 0.02
2022	- 0.01	- 0.02
2023	- 0.01	- 0.02
2024	- 0.01	- 0.02
2025	- 0.51	- 0.02
2026	- 0.02	- 0.02
2027	- 0.02	- 0.27
2028	- 0.02	- 0.27
2029	- 0.02	- 0.27
2030	- 0.12	- 0.27
2031	- 0.022	- 0.04
2032	- 0.022	- 0.04
….	- 0.022	- 0.04
2059	- 0.022	- 0.04
Total	**-1.199**	**-2.134**
In %	**56%**	**100%**



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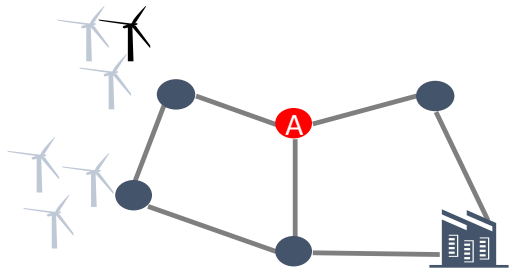
Enable and accelerate wind integration

Before Smart Wires



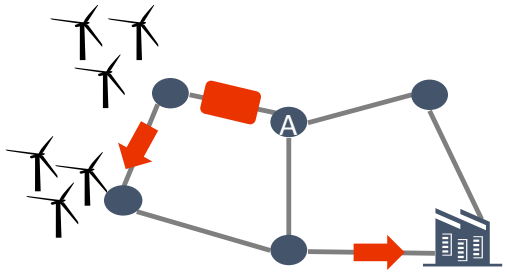
Large load center

New additional power flow

Substation

SmartValve deployment

With Smart Wires



Challenge

- A utility has over **1 GW of wind generation** seeking firm network connection
- Substation A acts as a **bottleneck** and **prevents this generation** from achieving firm access to the market, delaying the connection of a number of wind farms
- A full renovation of Substation A would eliminate the system constraints, but **the project was delayed until 2025 due to challenges securing the necessary construction outages**

Smart Wires Solution

- A SmartValve solution can be installed in less than 1 year
- This redirects power onto parallel lines and **allows up to 50% of the wind generation to connect immediately**
- The **utility can add more SmartValves** to the deployment, **scaling the solution** as wind developers confirm their investments and connect to the network

Impact

- Smart Wires solution enables the immediate firm connection of 550 MW of new wind generation capacity
- **Once the problem is permanently solved by the substation upgrade in 2025, the utility can redeploy the SmartValves to other parts of the grid**

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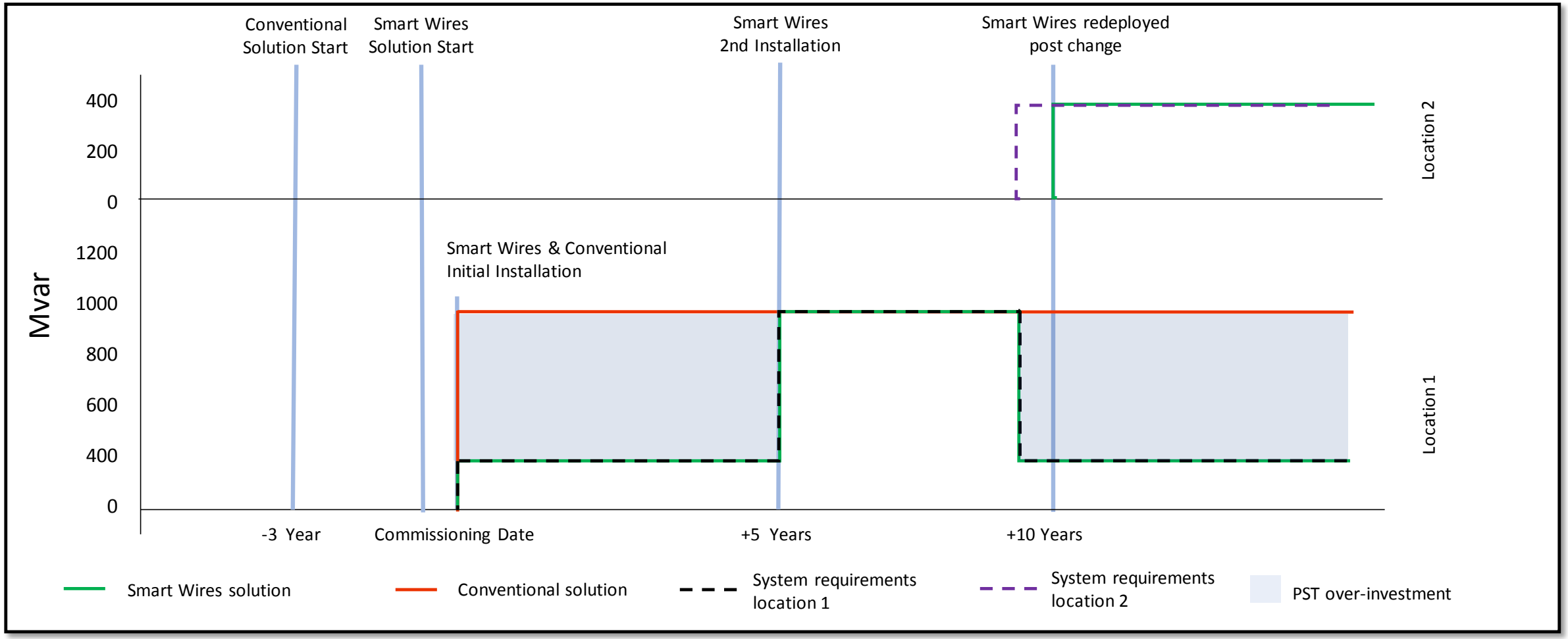
Reflecting impacts from uncertainty

Redeployability



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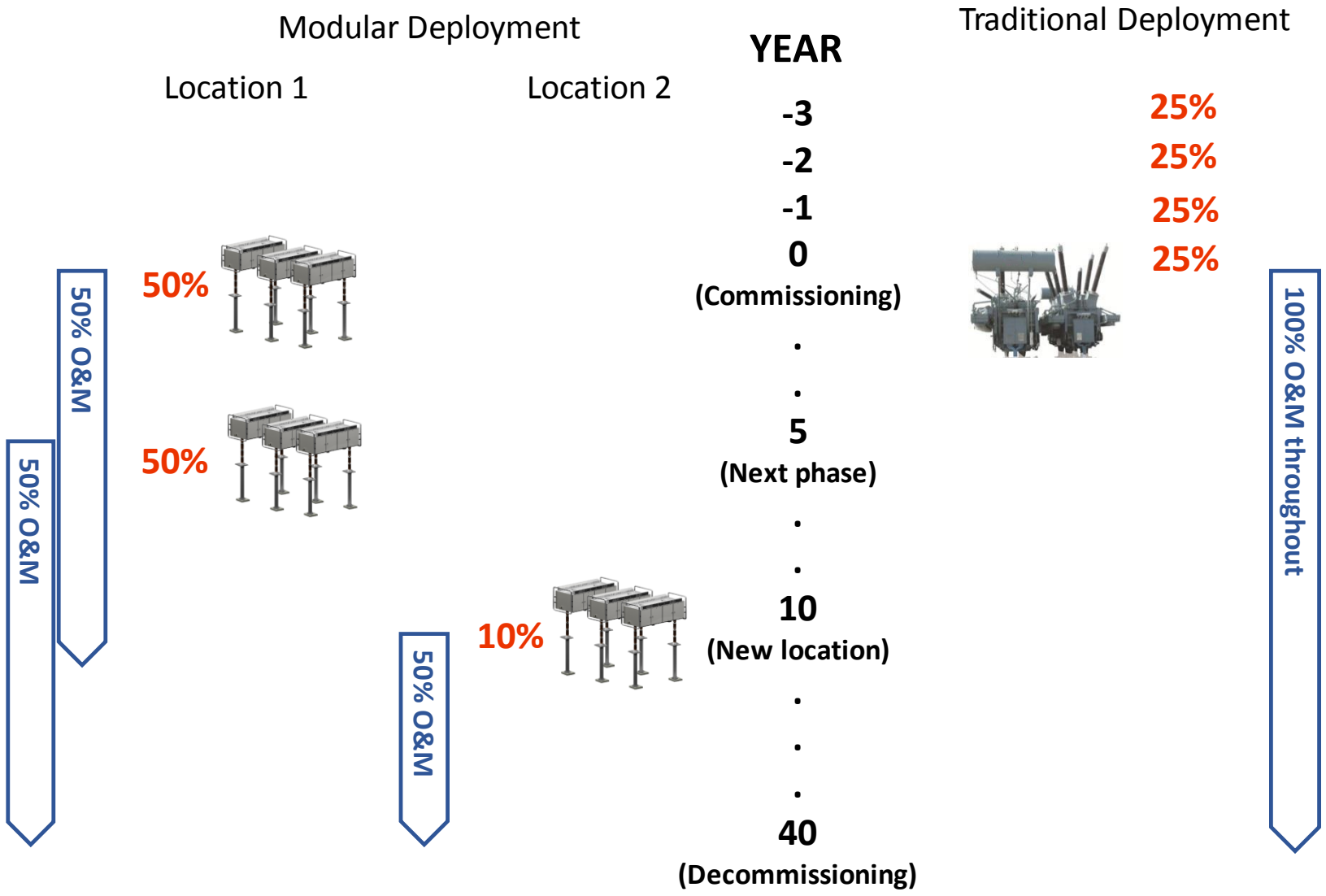
Redeployability - Costs

CapEx
OpEx

A	B	C
Year	Costs in PU	
	Modular	Alternative
2017	0	- 0.25
2018	0	- 0.25
2019	0	- 0.25
2020	- 0.5	- 0.25
2021	- 0.01	- 0.02
2022	- 0.01	- 0.02
2023	- 0.01	- 0.02
2024	- 0.01	- 0.02
2025	- 0.51	- 0.02
2026	- 0.02	- 0.02
2027	- 0.02	- 0.02
2028	- 0.02	- 0.02
2029	- 0.02	- 0.02
2030	- 0.12	- 0.02
2031	- 0.022	- 0.02
2032	- 0.022	- 0.02
….	- 0.022	- 0.02
2059	- 0.022	- 0.02
Total	**-1.199**	**-1.292**
In %	**93%**	**100%**



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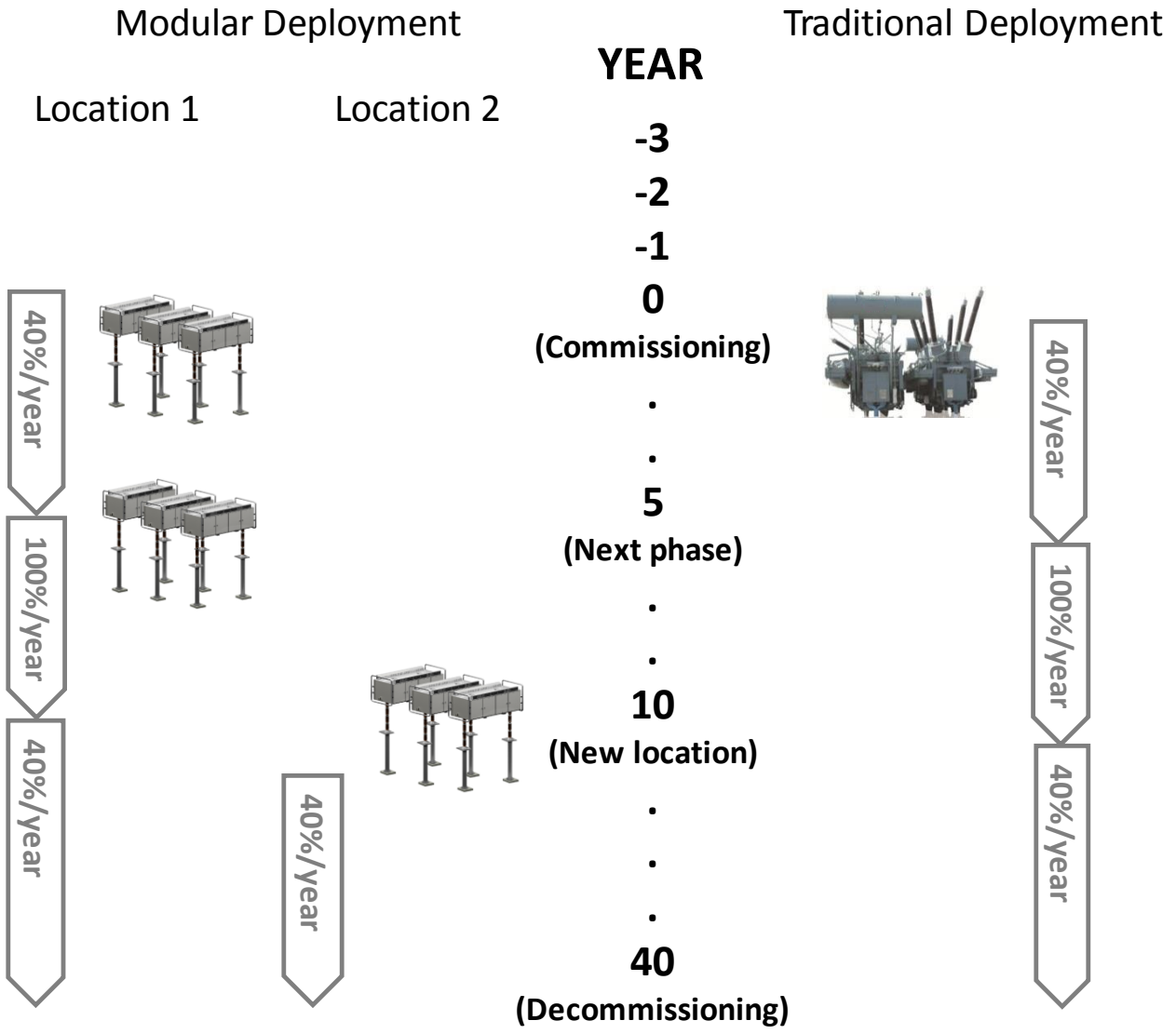
Redeployability – Costs & benefits

A	B	C	D	E
Year	Values in PU			
	Modular Cost	Modular Benefit	Alternative Cost	Alternative Benefit
2017	0	0	- 0.25	0
2018	0	0	- 0.25	0
2019	0	0	- 0.25	0
2020	- 0.5	0	- 0.25	0
2021	- 0.01	0.4	- 0.02	0.4
2022	- 0.01	0.4	- 0.02	0.4
2023	- 0.01	0.4	- 0.02	0.4
2024	- 0.01	0.4	- 0.02	0.4
2025	- 0.51	0.4	- 0.02	0.4
2026	- 0.02	1.0	- 0.02	1.0
2027	- 0.02	1.0	- 0.02	1.0
2028	- 0.02	1.0	- 0.02	1.0
2029	- 0.02	1.0	- 0.02	1.0
2030	- 0.12	0.4	- 0.02	0.4
2031	- 0.022	0.8	- 0.02	0.4
2032	- 0.022	0.8	- 0.02	0.4
….	- 0.022	0.8	- 0.02	0.4
2059	- 0.022	0.8	- 0.02	0.4
Total	**-1.199**	**12.64**	**-1.292**	**8.56**
B+C	**11.44**		**7.26**	
B/C Ratio	**10.54**		**6.62**	



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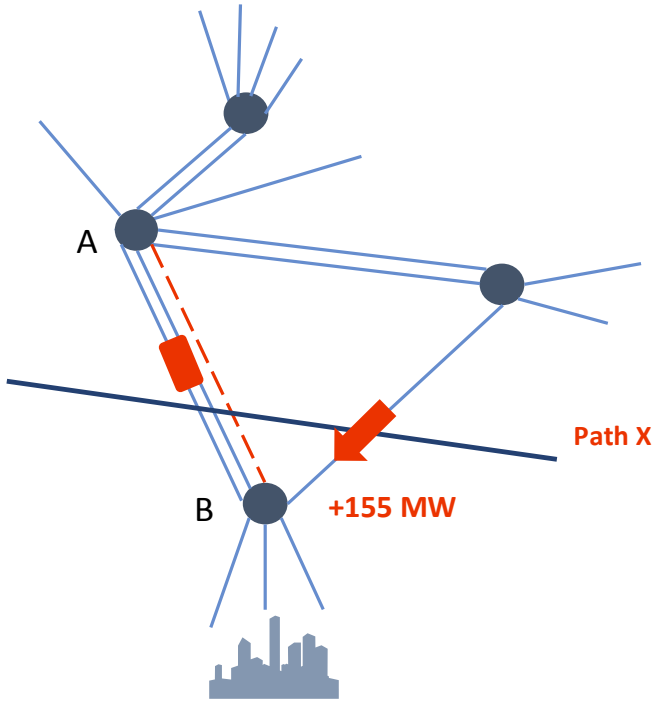
Bridge Solutions Solving Near-Term Needs



Substation
230 kV
New line
SmartValve deloyment
New additional power flow

Challenge

- A utility **plans to build a 3rd line from A to B**. This will add 400 MW of transfer capacity across Path X and **serve the load center's growing demand**
- However, the **new line** faces major **political opposition** and will take at least 5 years to acquire requisite permits and approvals
- Today**, the growing load is already causing frequent overloads** and will pose a reliability risk in the near-term (1-2 years) leaving the utility with limited options to solve the problem

Smart Wires Solution

- **A deployment of SmartValves can be installed within 9 to 12 months**. This will add 155 MW of transfer capacity to the Path.
- The **variable reactance of the solution can resolve all post-contingency overloads**, solving the near-term reliability problems
- **Once the new line is built, the SmartValves can be redeployed to solve other problems on the network**

Impact

- **The utility can solve the near-term reliability issues in a quick and cost-efficient way**, while still pursuing the long-term regional investment plan
- This bridge **solution increases transfer capacity today** and also avoids 5 years of congestion costs
- This solution provides a **high degree of operational flexibility** which allows the utility to vary the line reactance and protect the system under all post-contingency scenarios

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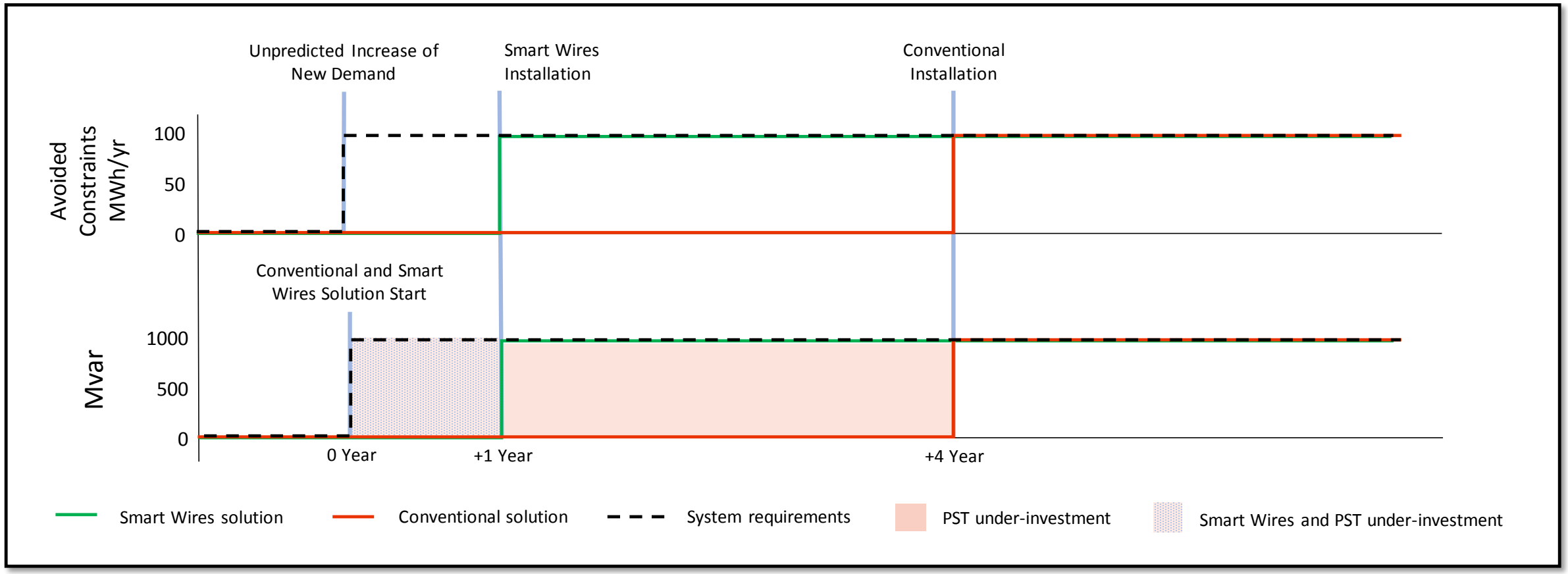
Reflecting impacts from uncertainty

Speed of deployment



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Speed of deployment

A	B	C	D	E
Year	Values in PU			
	Modular Cost	Modular Benefit	Alternative Cost	Alternative Benefit
2020	0	0	- 0.25	0
2021	-1	0	- 0.25	0
2022	- 0.02	0.1	- 0.25	0
2023	- 0.02	0.1	- 0.25	0
2024	- 0.02	0.1	- 0.02	0.1
2025	- 0.02	0.1	- 0.02	0.1
2026	- 0.02	0.1	- 0.02	0.1
2027	- 0.02	0.1	- 0.02	0.1
2028	- 0.02	0.1	- 0.02	0.1
2029	- 0.02	0.1	- 0.02	0.1
2030	- 0.02	0.1	- 0.02	0.1
2031	- 0.02	0.1	- 0.02	0.1
2032	- 0.02	0.1	- 0.02	0.1
2033	- 0.02	0.1	- 0.02	0.1
2034	- 0.02	0.1	- 0.02	0.1
2035	- 0.02	0.1	- 0.02	0.1
….	- 0.02	0.1	- 0.02	0.1
2060	- 0.02	0.1	- 0.02	0.1
Total	**-1.338**	**1.88**	**-1.284**	**1.70**
B+C	**0.54**		**0.42**	
B/C Ratio	**1.41**		**1.33**	

CapEx
OpEx
Benefits

Modular Deployment

Traditional Deployment

YEAR

100%

0

1

(SmartValve Commissioning)

3

(PST Commissioning)

40

(Decommissioning)

25%
25%
25%
25%

100% O&M

100% Avoided Congestion

100% O&M throughout

100% Avoided Congestion

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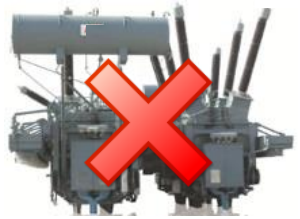
Security of supply

CapEx
OpEx

- Planning criteria sets that N-1 must be maintained
- PST: loss of one component is loss of entire PST
- SmartValve: loss of one component is loss of 1 SmartValve per phase
- Solution: add a second PST, but need only one additional SmartValve per phase
- Reduction in:
  - Footprint
  - Capital and operational costs
  - Losses

	Modular Deployment	Traditional Deployment
Issue	100%  O&M 100%/yr	100%  O&M 100%/yr
Solution	+20%  O&M 20%/yr	+100%  O&M 100%/yr
Total	CapEx: 120% O&M: 120%/yr	CapEx: 200% O&M: 200%/yr

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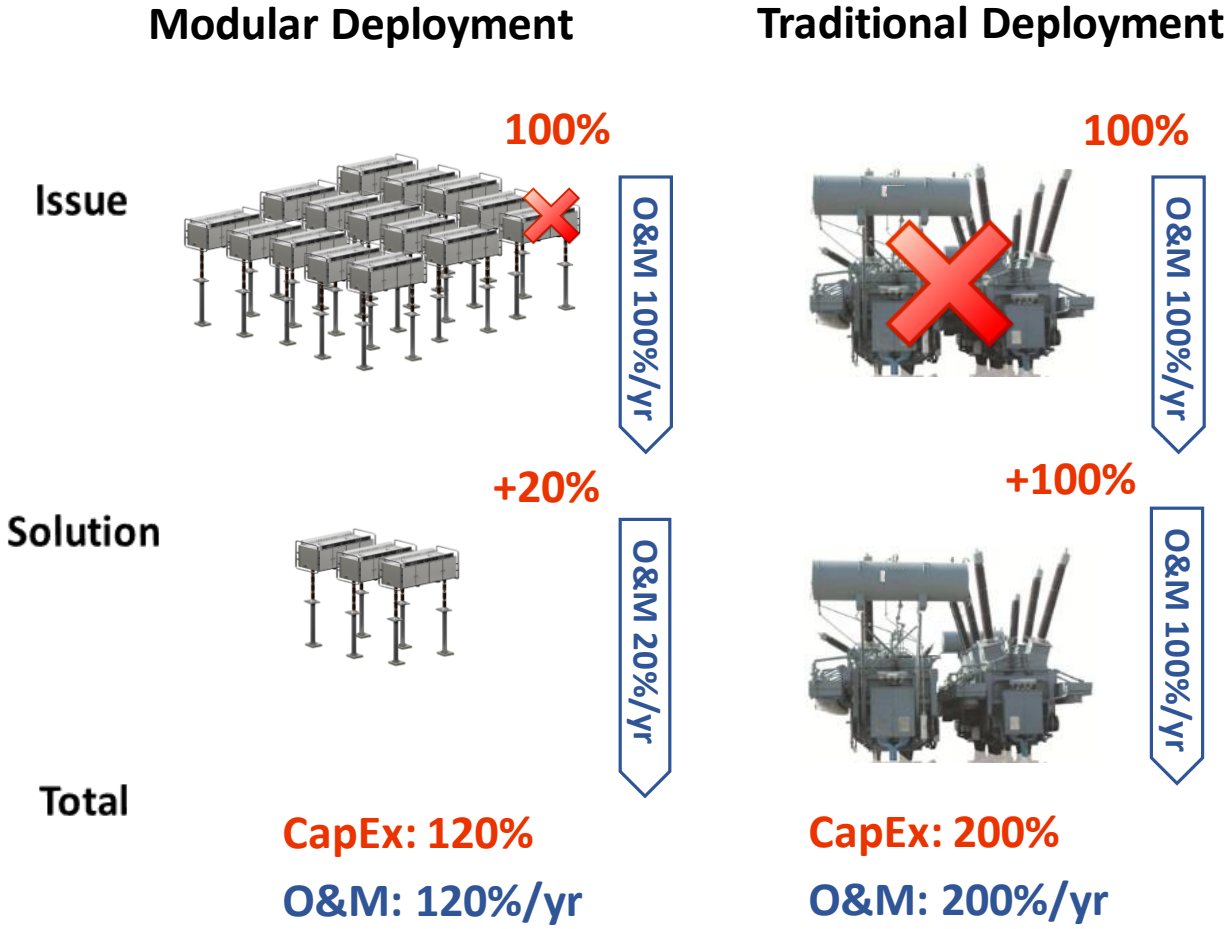
Security of supply

A	B	C
Year	Costs in PU	
	Modular Cost	Alternative Cost
2017	0	- 0.5
2018	0	- 0.5
2019	0	- 0.5
2020	- 1.2	- 0.5
2021	- 0.024	- 0.04
2022	- 0.024	- 0.04
2023	- 0.024	- 0.04
2024	- 0.024	- 0.04
2025	- 0.024	- 0.04
2026	- 0.024	- 0.04
2027	- 0.024	- 0.04
2028	- 0.024	- 0.04
2029	- 0.024	- 0.04
2030	- 0.024	- 0.04
2031	- 0.024	- 0.04
2032	- 0.024	- 0.04
….	- 0.024	- 0.04
2059	- 0.024	- 0.04
Total	**-1.485**	**-2.584**
In %	**57%**	**100%**



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Agenda

1. Technology overview
2. Cost Benefit Analysis
   - A. Key considerations
   - B. Scalability and deferred investment
   - C. Redeployability
   - D. Speed of deployment
   - E. Security of supply
3. **Key takeaways**

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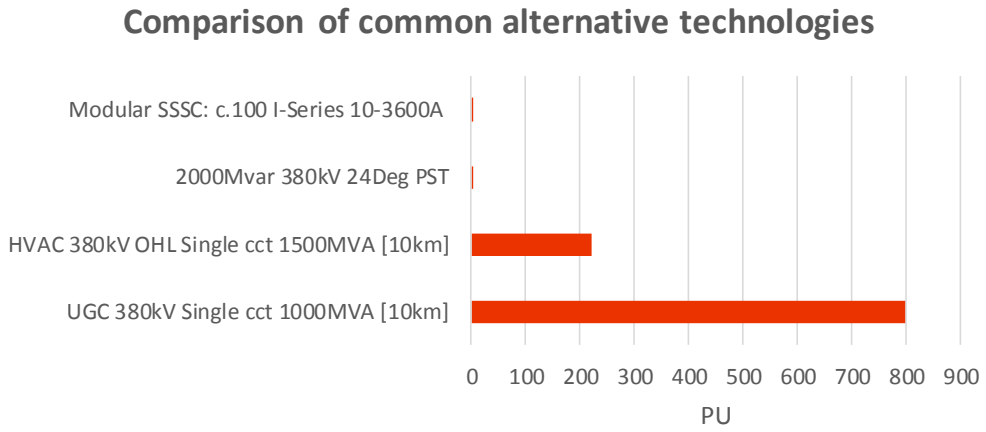
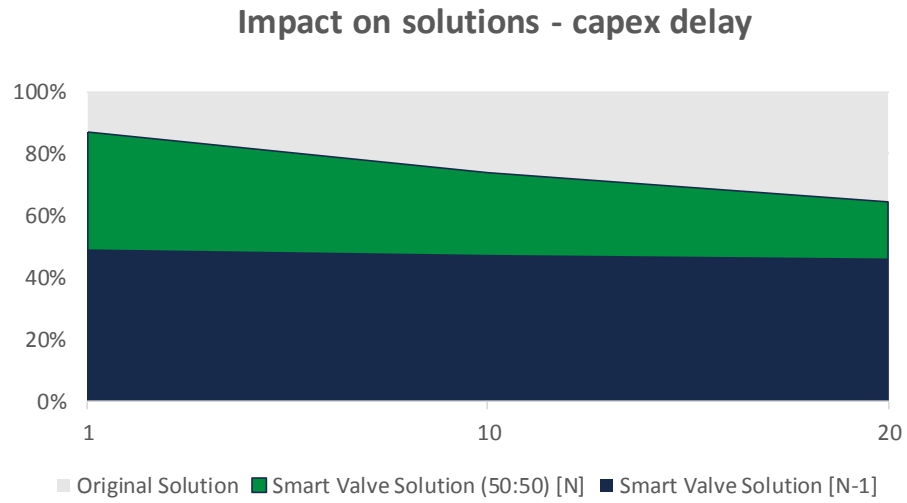
NPV precision considerations

- NPV generally answers two questions:
  - Is a project required to resolve an identified need?
  - Which of the alternative options for a project should be selected?
- Is the NPV greater than not doing a project or the alternatives?
- A reduced NPV CBA assessment can often provide an robust answer without considering all costs and benefits, for example:
  - When operational costs are known to be low and the variation in capital costs are dominant
  - Where the benefits are the same only costs need be considered
  - A comparable total capex modular project split into phases will always be cheaper



Source: EC Realisegrid project report 3.2.2



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Smart Wires: the right economic decision

- Solution is right-sized for need and can be easily expanded (or contracted) as need changes.
- Redeployment increases investment value as system requirements change
- Short lead times with low risk: 9 – 12 months from order to commissioning.
- Modular nature reduces security risk.

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