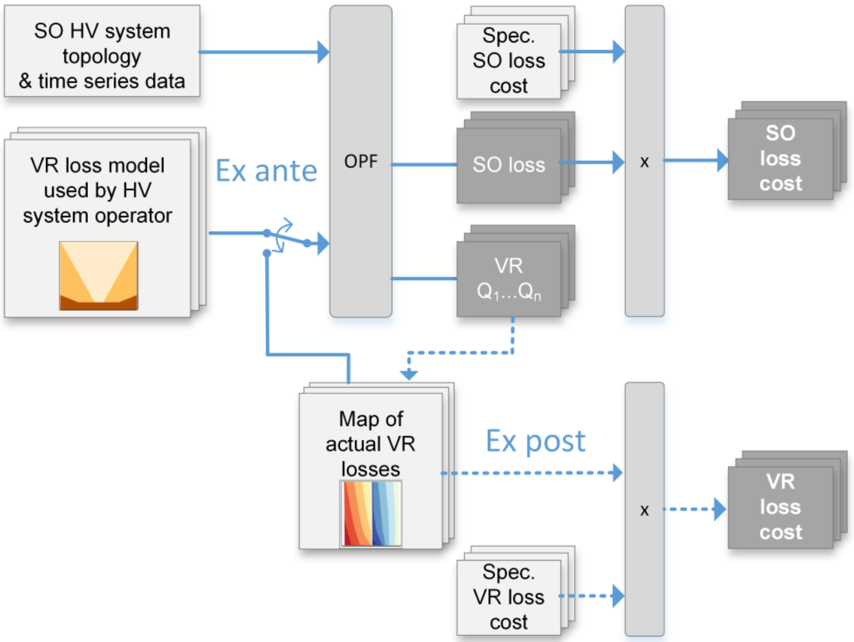
REMUNERATION OF CONTROLLABLE REACTIVE POWER INSIDE SO FAR FREE OF CHARGE RANGES: COST-BENEFIT ANALYSIS



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Remunerate Controllable Reactive Power (Q)?

Growing demand for controllable Q → VR internal loss increase → Overall economical impact of considering VR Q related losses in SO Q dispatch? → Macro-economic / Micro-economic

VR: Variable renewable power plant

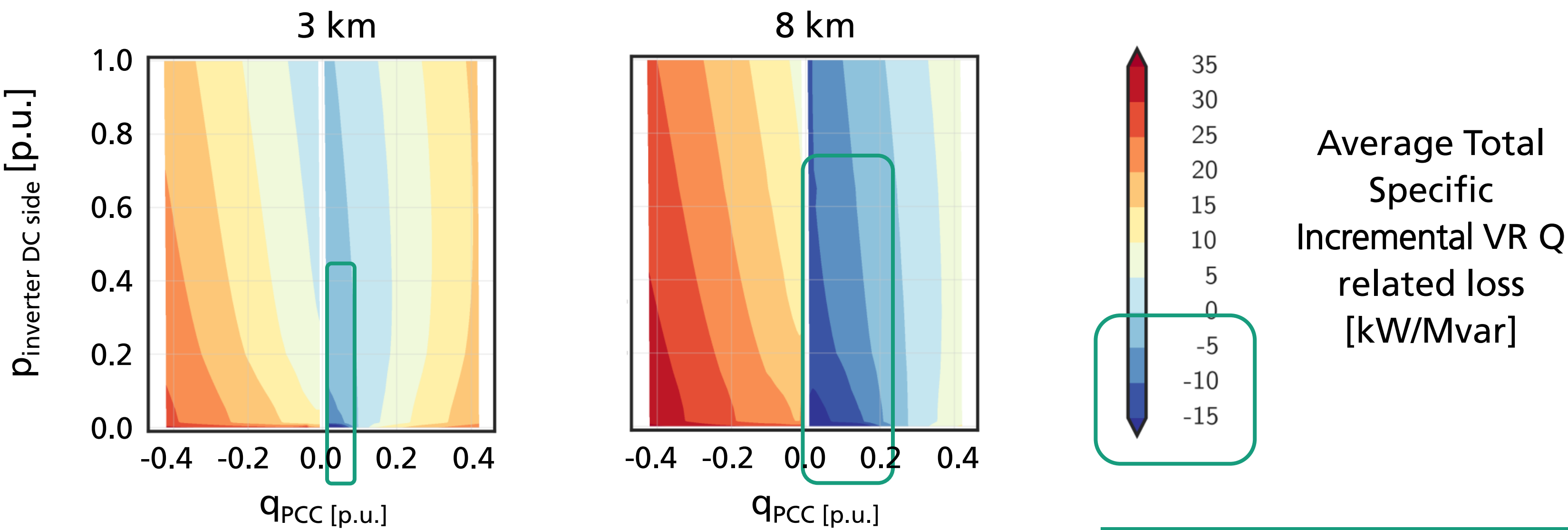
SO: System operator

Focus on HV-connected VR (PV and Wind)

Operational Horizon ➔ Analysis of losses in SO and VR systems

VR Q related losses: Examples of “true“ losses (loss maps)

Length of HV cable to point of common coupling (PCC)



Cost of Q may be negative!

- Derived from generic VR parks – in case of PV, based on central inverter technology
- OPF for tap position & VR Q, followed by tap-change frequency reduction
- Low loss variants may require added investment → 24/7 context

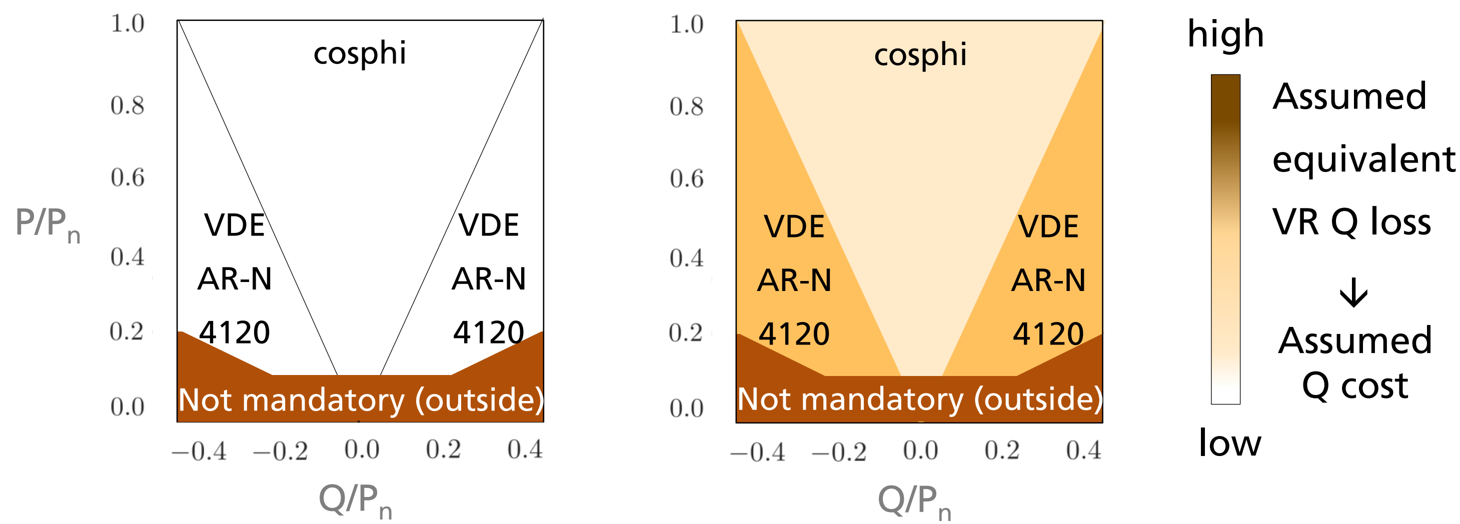
VR Q related losses: Examples of simplified models in DSO OPF

Simulated variants of specific Q related loss combinations	"Today"	"High loss"
	$\frac{kW}{Mvar}, \frac{kW}{Mvar}, \frac{kW}{Mvar}$	$\frac{kW}{Mvar}, \frac{kW}{Mvar}, \frac{kW}{Mvar}$
	(0 , 0 , 12*))	(12 , 24 , 40)

*) Value derived from system perspective:

Magnitude prohibitive for use in SO loss reduction

→Price inelastic demand



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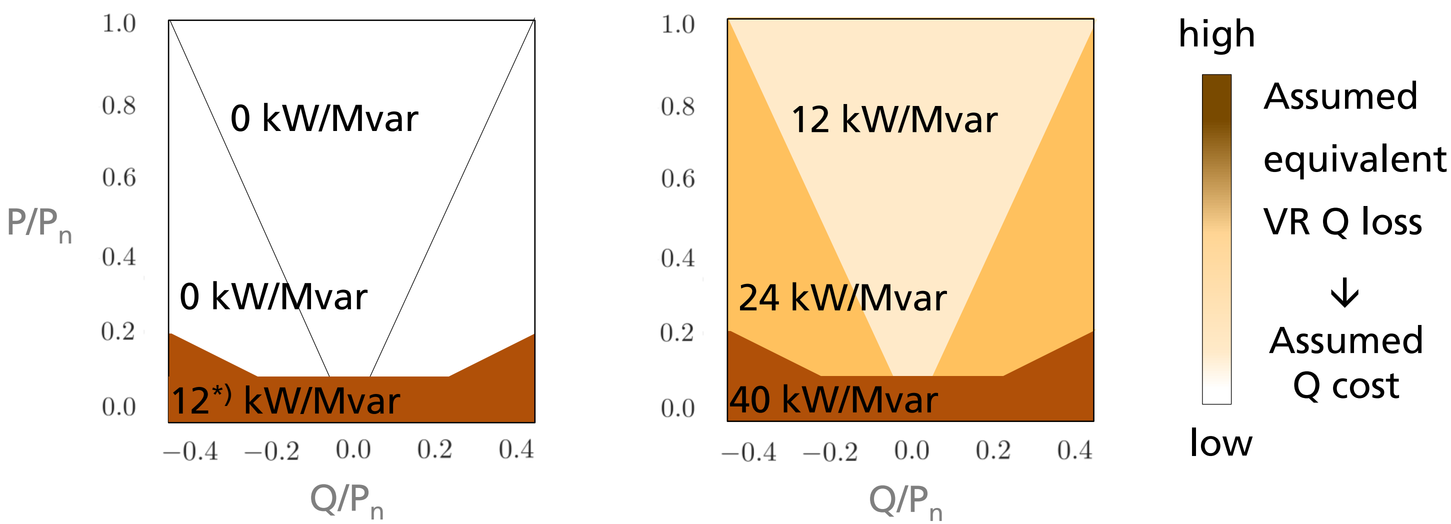
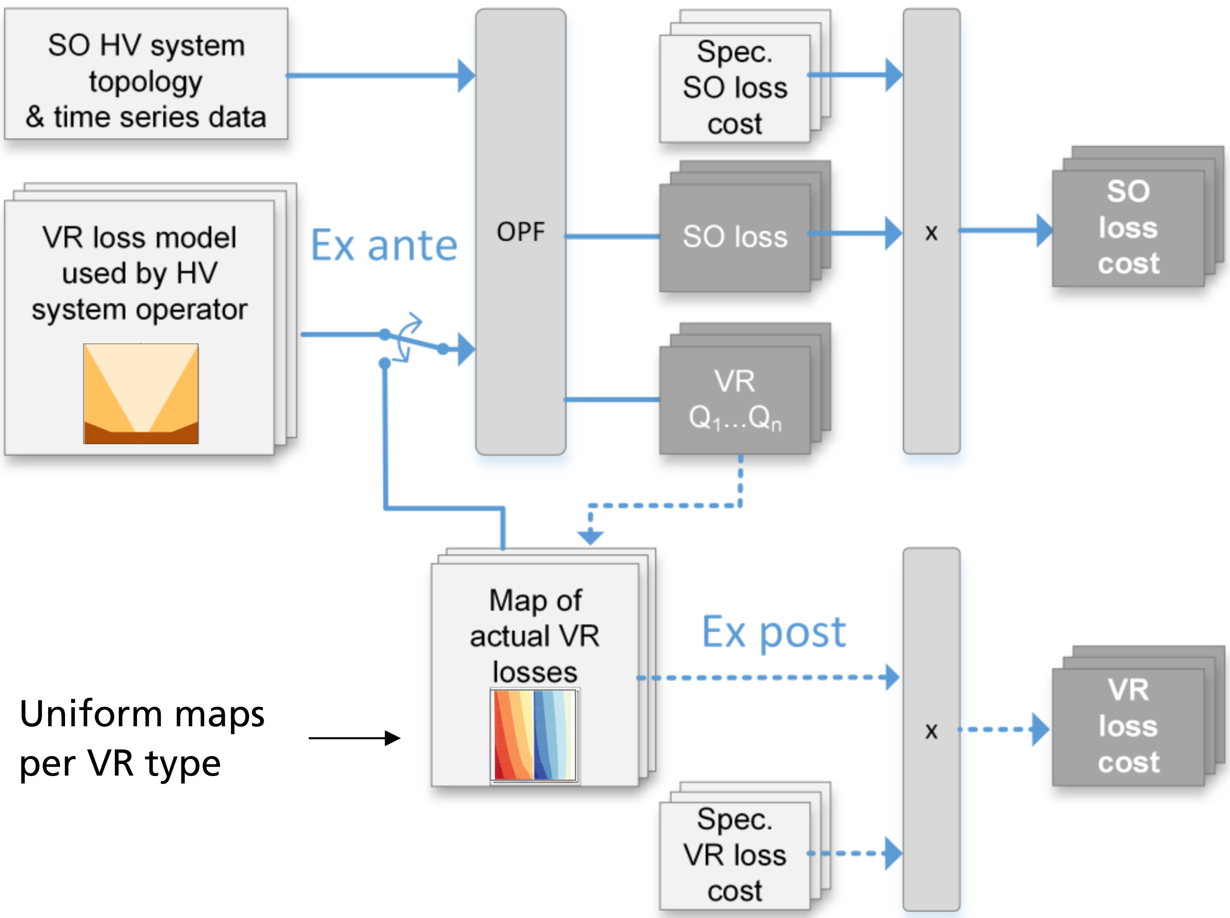
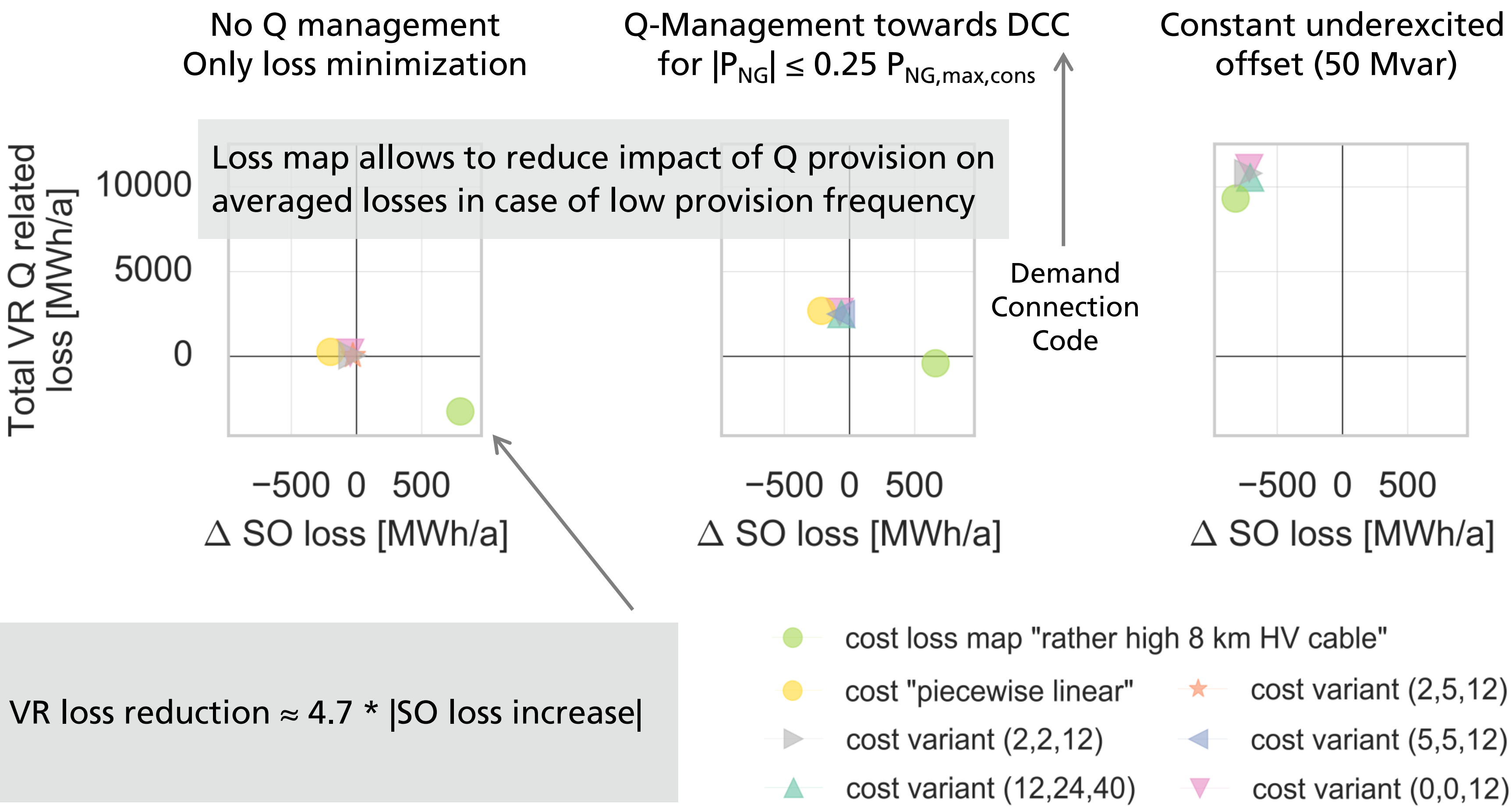


Workflow: VR loss models in SO dispatch → Ex Post Weighting

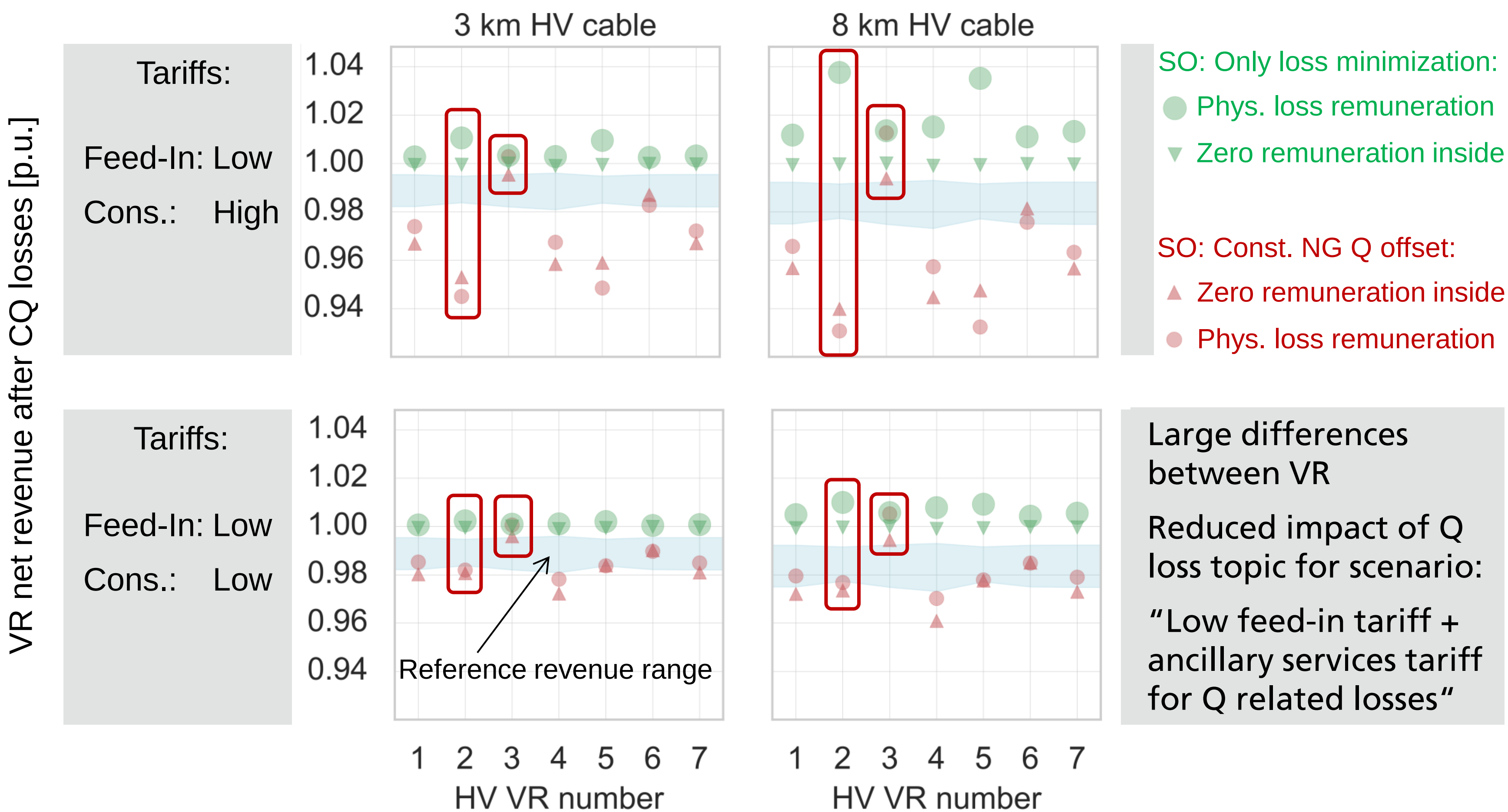


Goal: Assess benefits of different loss models

Results – Overview of tradeoff: SO loss vs. VR loss



Results - Impact of SO Q dispatch on annual VR revenue

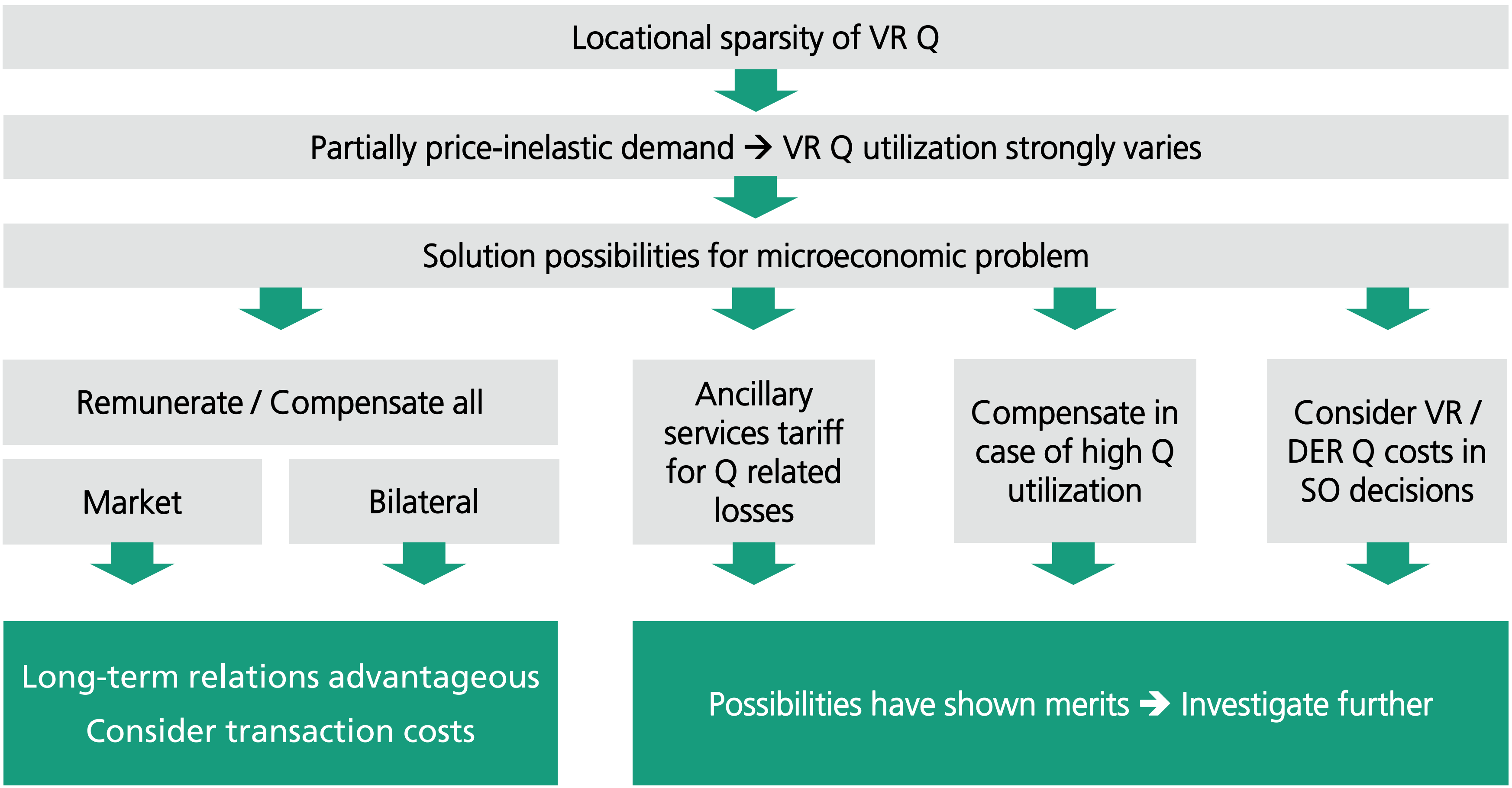


Large differences between VR

Reduced impact of Q loss topic for scenario:

“Low feed-in tariff + ancillary services tariff for Q related losses“

Microeconomic impact of VR remuneration



Macroeconomic impact of VR remuneration

Annual optimized time series simulations of different VR loss models

Operational horizon

Q provision frequent / relevant

At times of price-inelastic demand for controllable Q:

Low η difference between loss models

Q provision rare / low

For VR with long HV connecting cable:

Overall economic η increase using ‚True' loss models

Planning horizon

Q provision frequent / relevant

Operationally inelastic Q demand becomes price-elastic

Consideration of VR losses inside so far free-of-charge ranges:

Highly relevant for planning of reactive compensating equipment ➔ Dependency of losses with |Q|

Quo vadis Q-remuneration: Game Changers?

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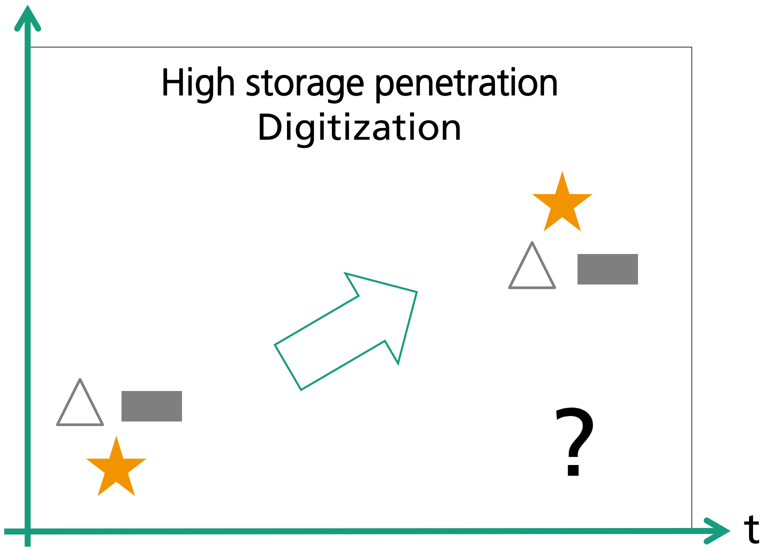
Sym bol	VR with low Q utilization	VR with high Q Utilization
△	No compensation Consider VR Q related losses in SO operation & planning	Compensation
▬	Compensate low, fix, or ancillary services tariff	Compensation
★	Remunerate via Q-Market	

Economic attractiveness of Q remuneration type



Increased Market liquidity
Increased offer price spread
VR voltage control with P and Q
Decreased specific transaction costs
Existing locational ancillary services market