Project EDGE:
DER and Market Interaction Studies

Network Advisory Group (NAG)

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Power and Energy Systems Group

The University of Melbourne

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Agenda

- Introduction
- Wholesale energy market and local network services co-optimization
  - Fundamental techno-economic principles and methodology
- Increase of network hosting capacity and associated market value
  - Toy examples
- Discussion and feedback

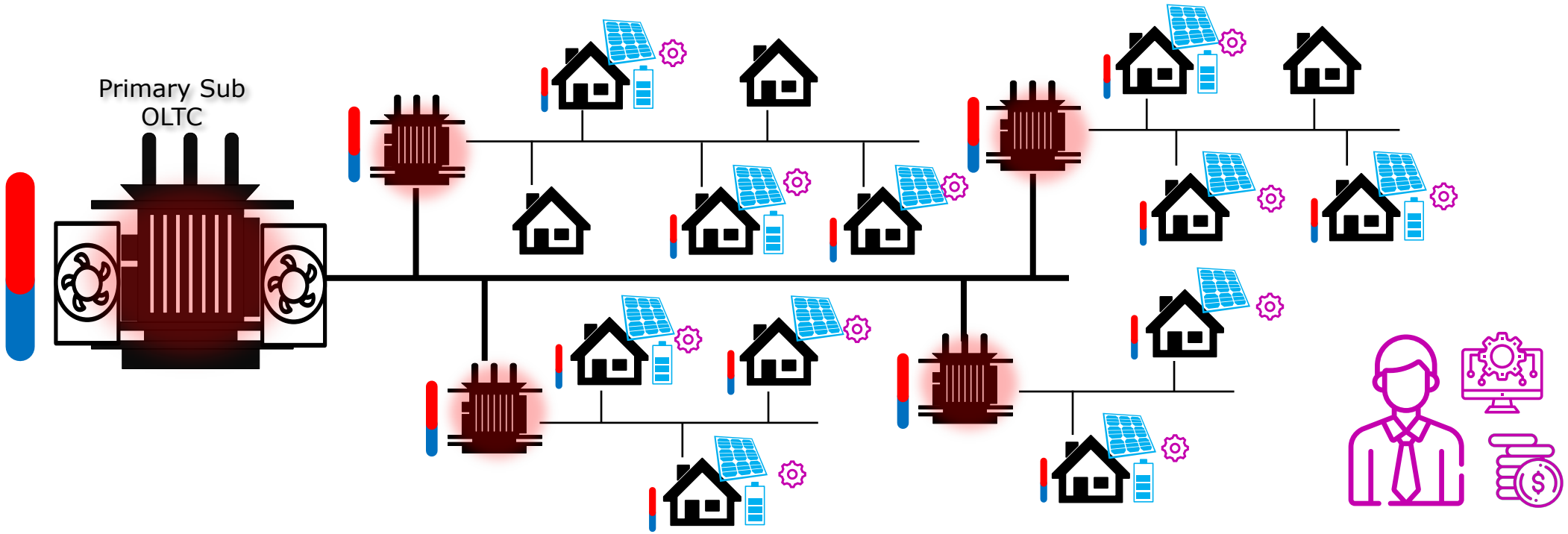
Introduction

- In the context of project EDGE, the University of Melbourne has been engaged by AusNet Services to perform:
  - Network Studies
    - Development of operating envelope algorithms
  - DER and Market Interaction Studies

DER and market interaction studies: Scope and deliverables

- Co-optimization of wholesale energy services and local network services, including consideration for DER provision of active and reactive power
  - Definition of possible use cases
  - Investigation of the effects of DER services on operating envelopes
  - Process flowcharts with techniques for DSO platform implementation
  - Simulation and visualisation of market co-optimisation scenarios

Bottom-up services and networks impacts



Aggregation of DER → Bottom-Up Services → **Network Problems**

Fundamental principles to value active and reactive power services

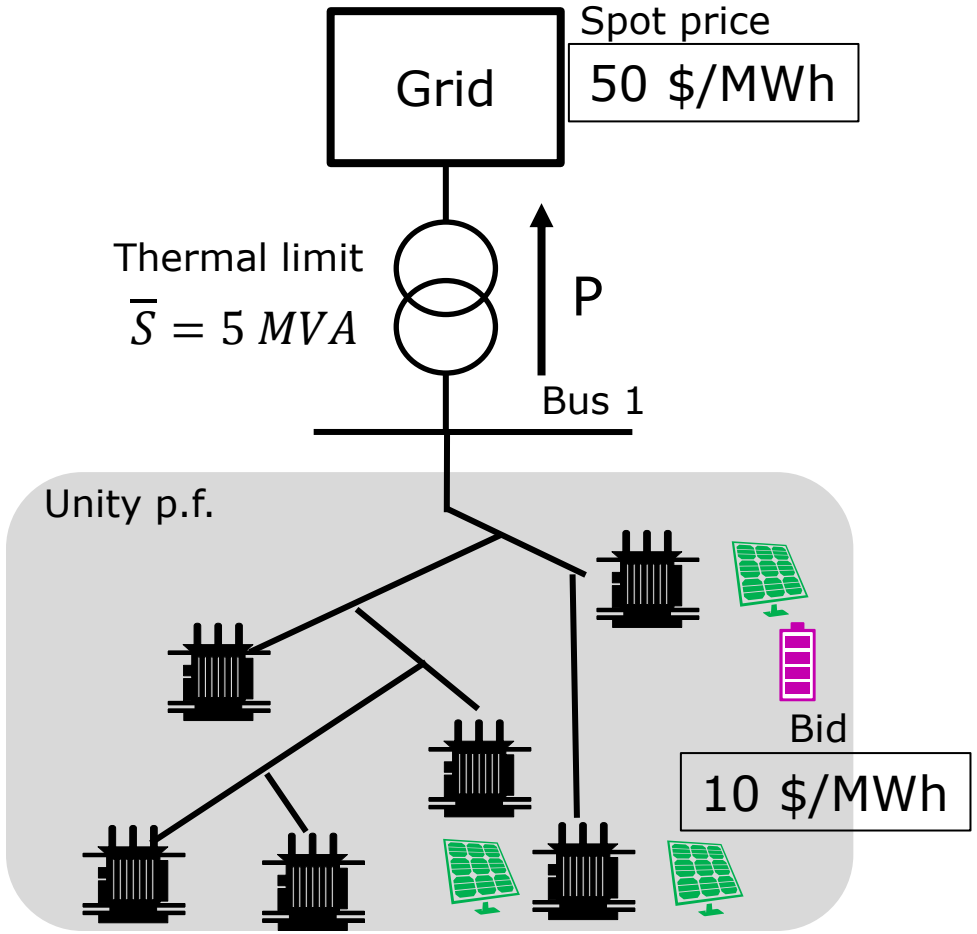
- Thermal and voltage constraints are the main network drivers that affect value in distributed energy systems and markets

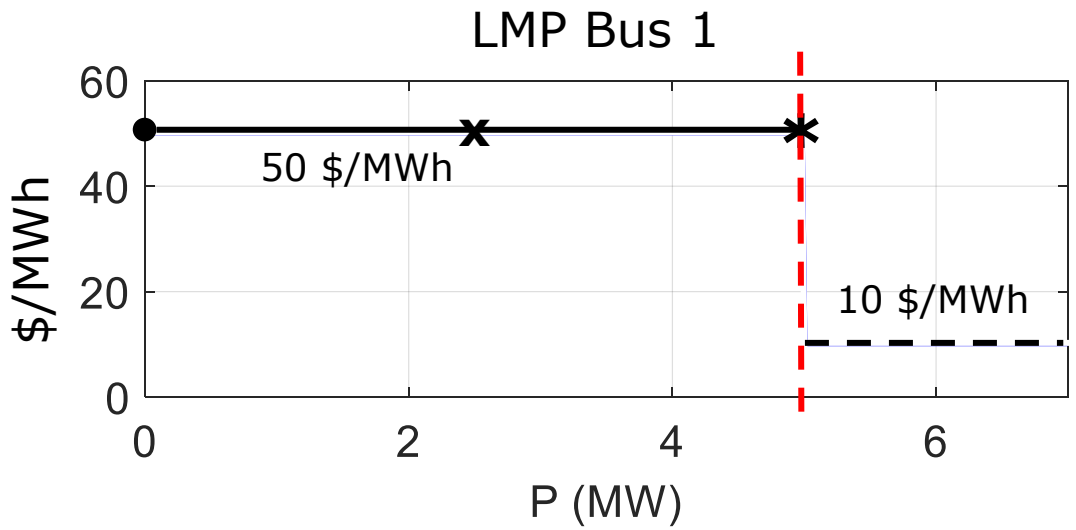
- We need a methodology that can seamlessly and consistently capture:
  - Physical aspects of a complex network (potentially with multi-phase unbalanced features)
  - Locational aspects
  - Intertwined role of active and reactive power injection/absorption and power flows
  - Impact on/of losses
  - Fundamental economic aspects consistent with general energy market principles

Proposed methodology

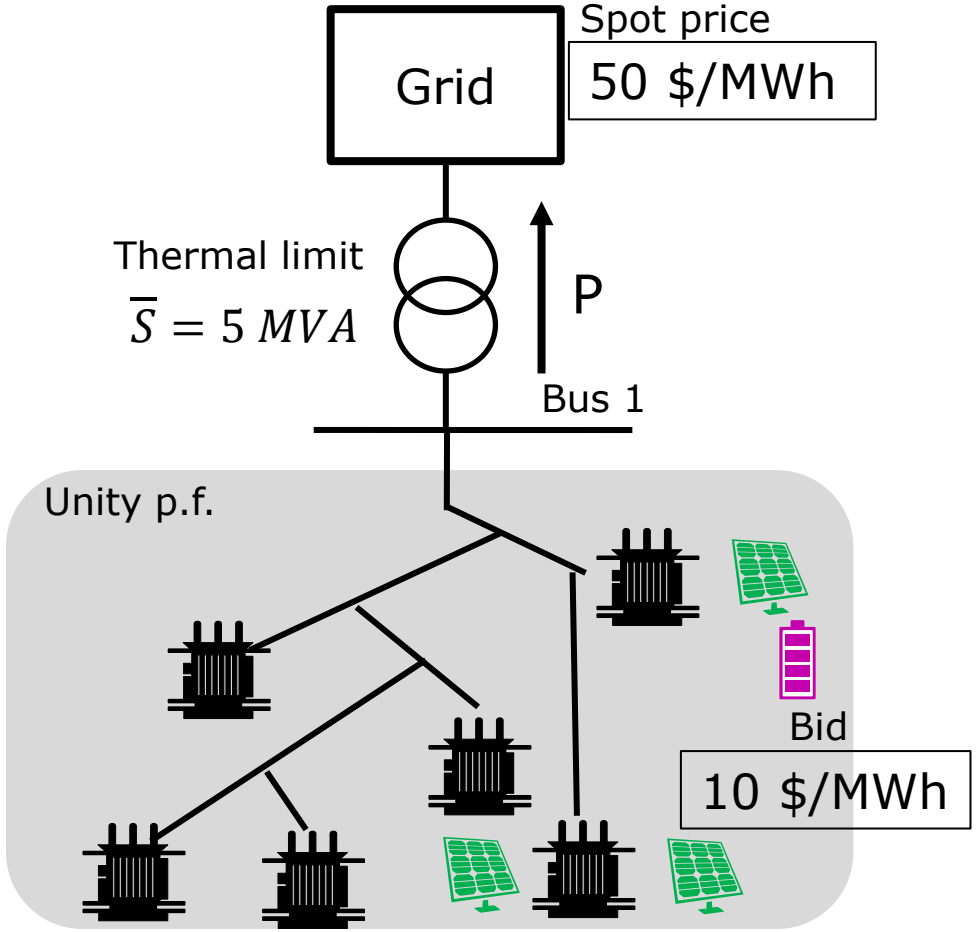
- From transmission systems and wholesale markets, we know that **locational marginal pricing** (LMP) theory can adequately assess the value of active power services at different locations
- Our modelling aims to extend LMP applications to **distribution networks** and **reactive power valuation**
- We use our proposed extension of LMP theory to:
  - Inform on the impact of thermal and voltage constraints on market value
  - Assess the system and local value that could be unlocked by different active and reactive power network and DER solutions
  - Assess the impact of/on losses
- Note:
  - LMPs are not necessarily meant to be used directly as price signals for DER, but rather and more generally to establish a robust *valuation* framework to assess different forms of payments, contracts, etc.

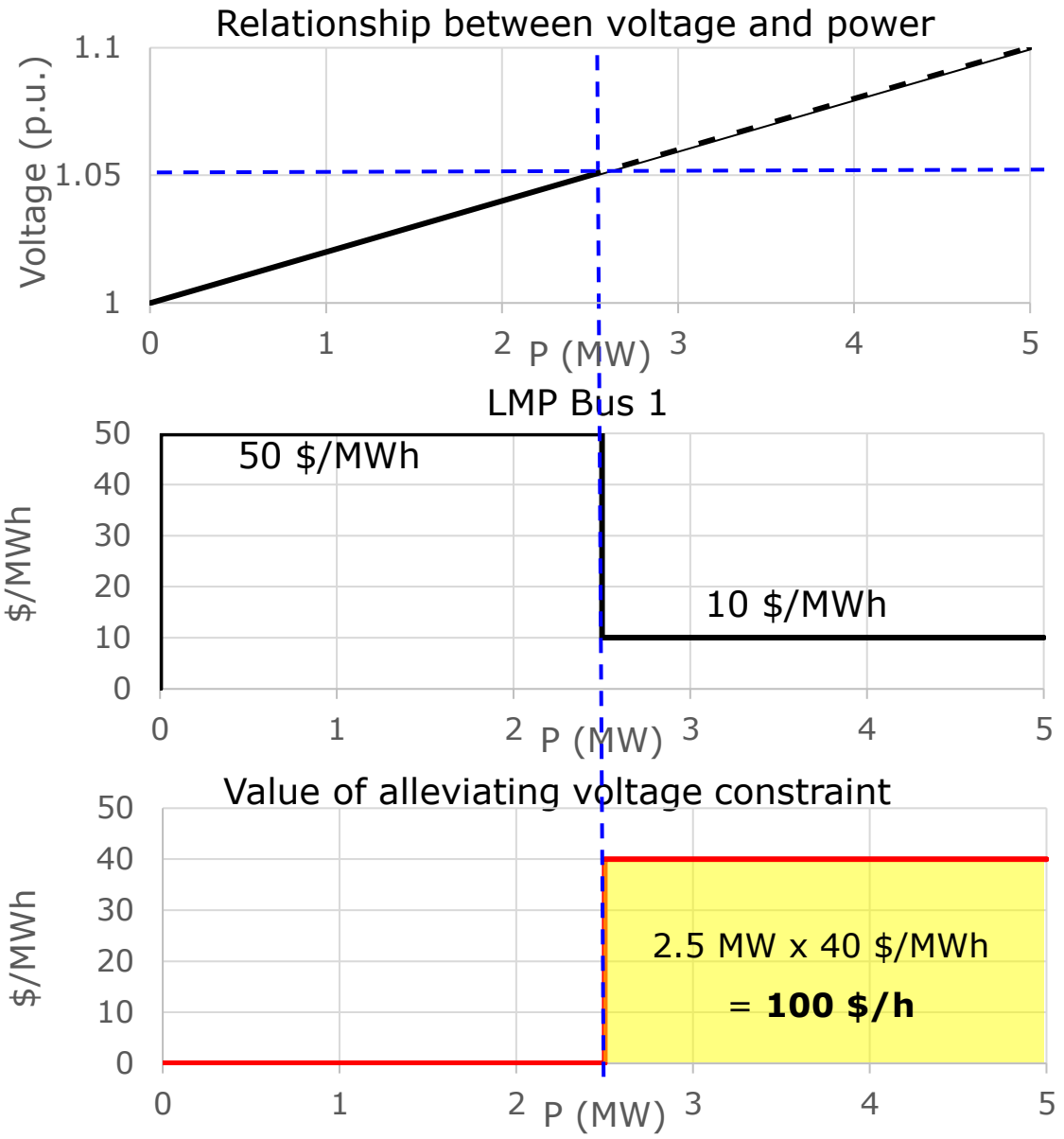
A first toy example: impact of transformer thermal limits on export



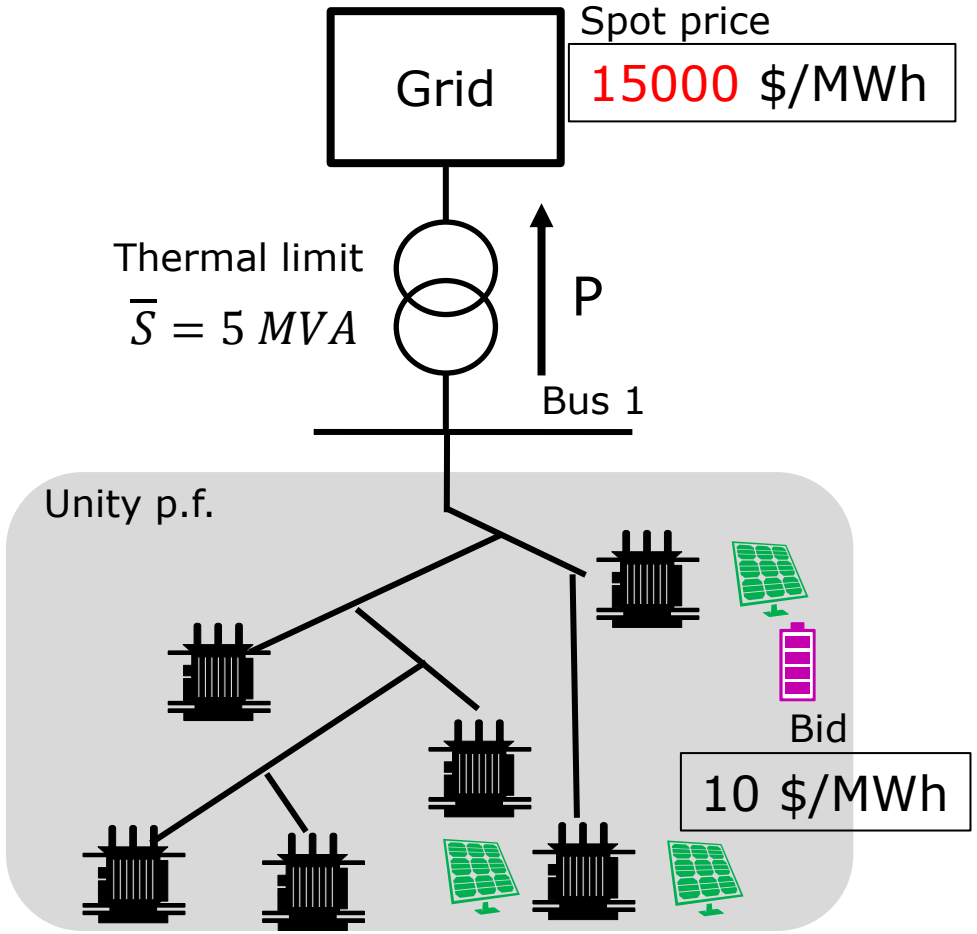


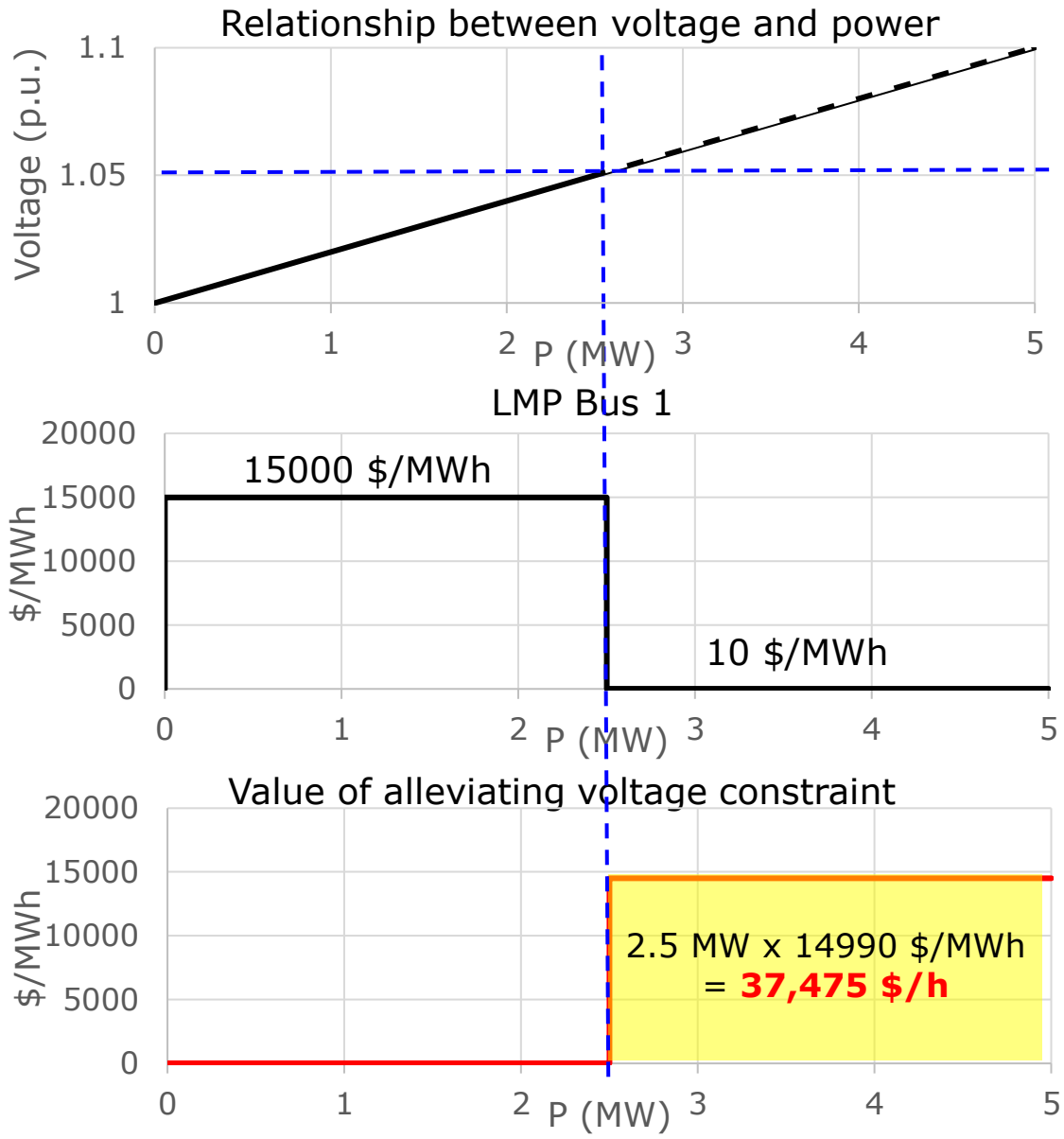
Another toy example: Impact of voltage constraints



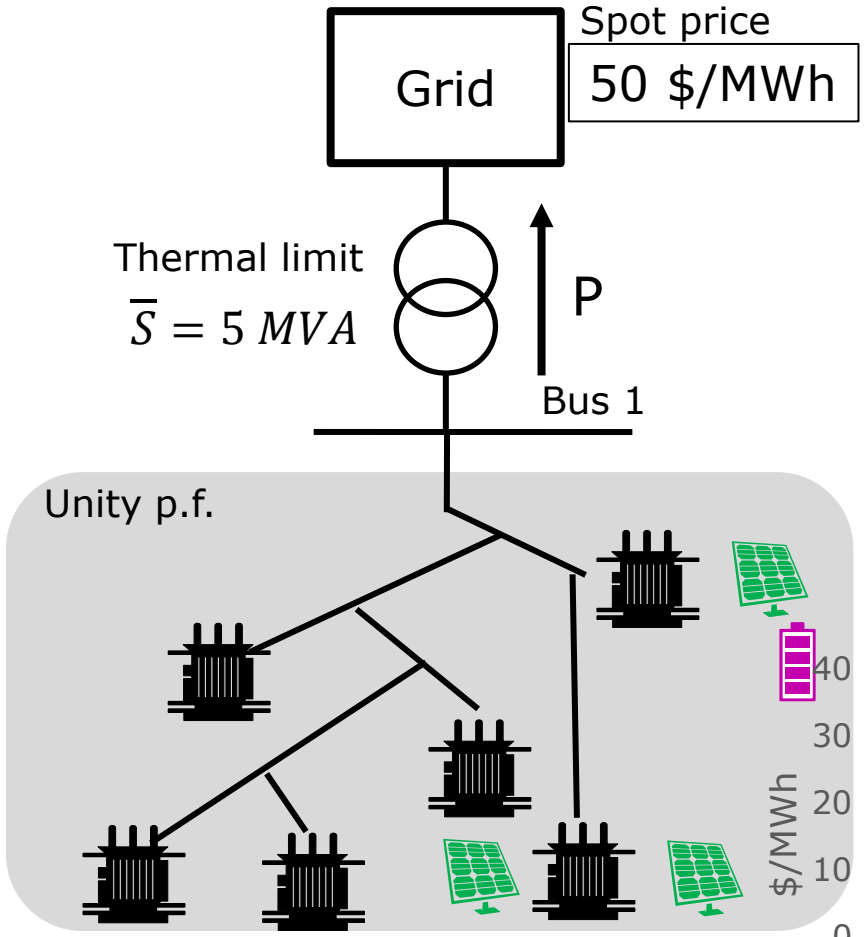


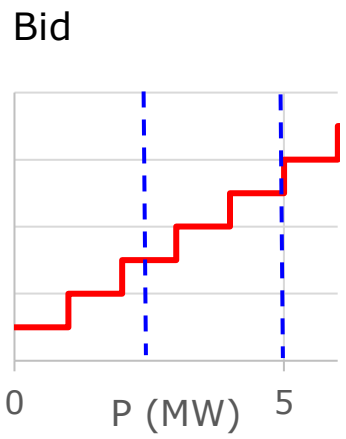
Impact of voltage constraints with peak price

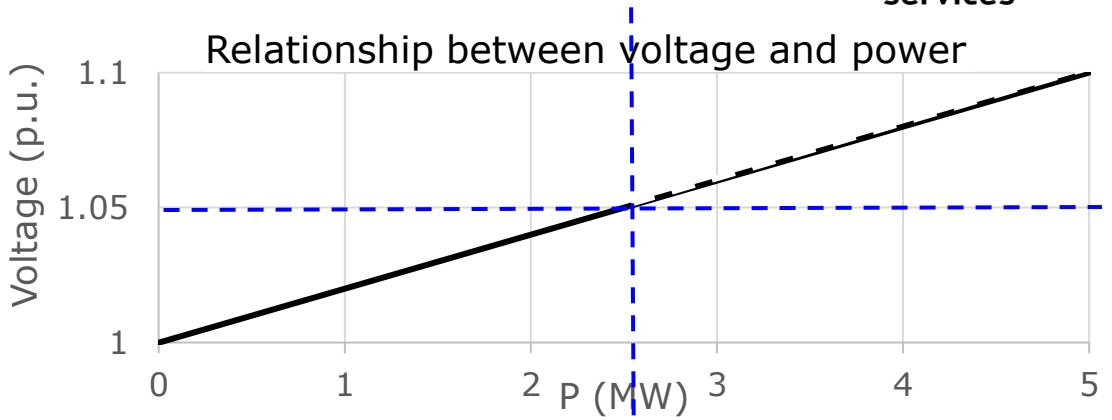


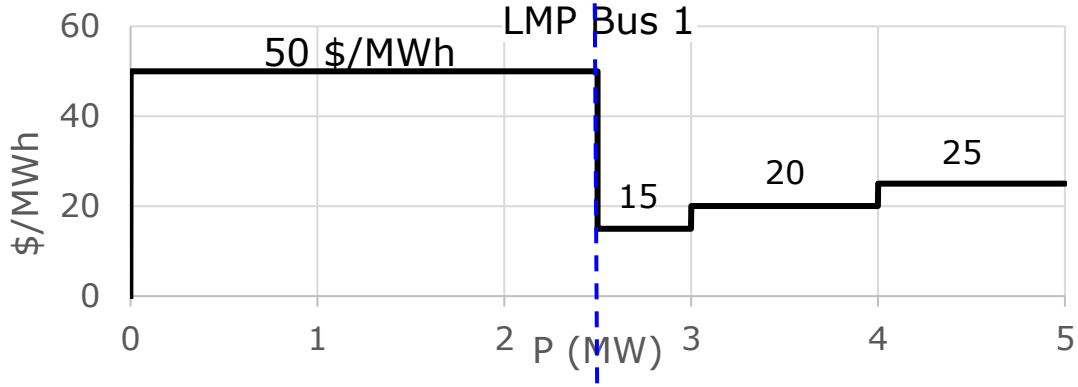


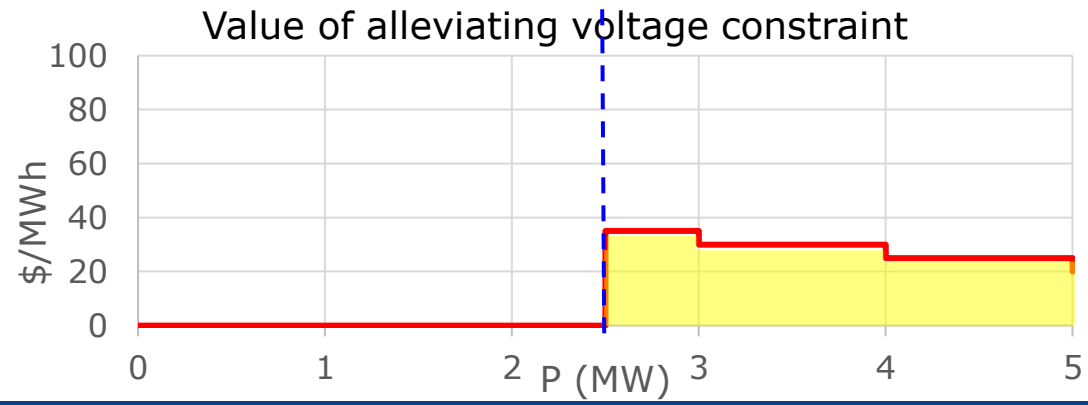
Impact of aggregator bids



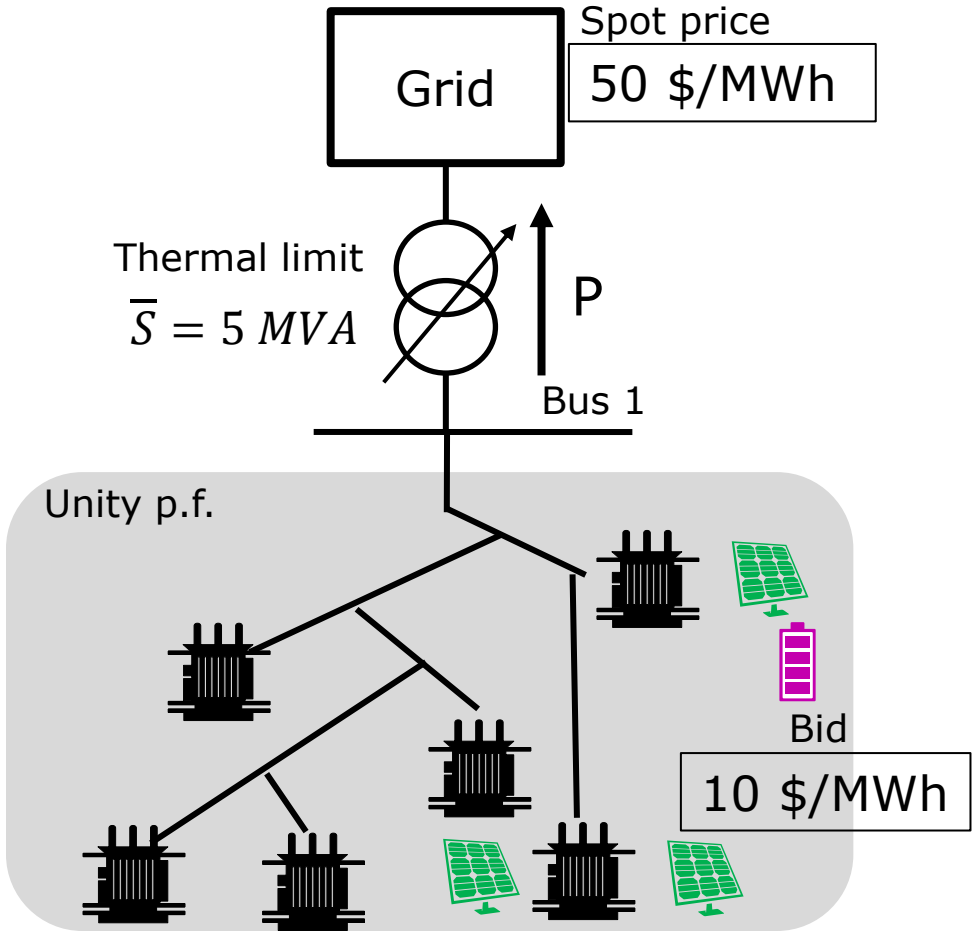


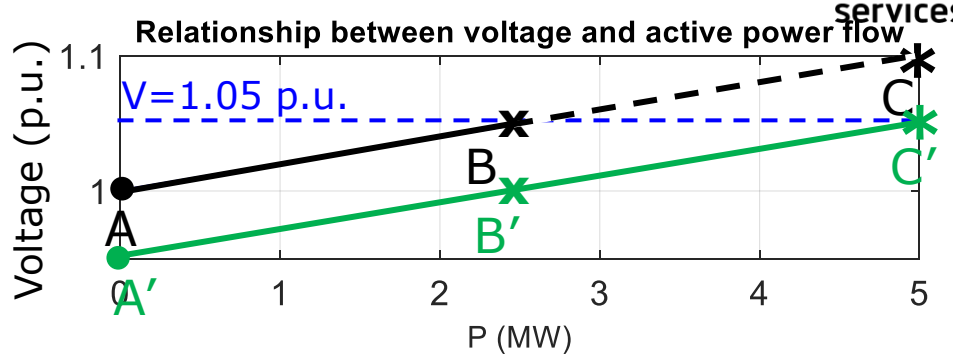


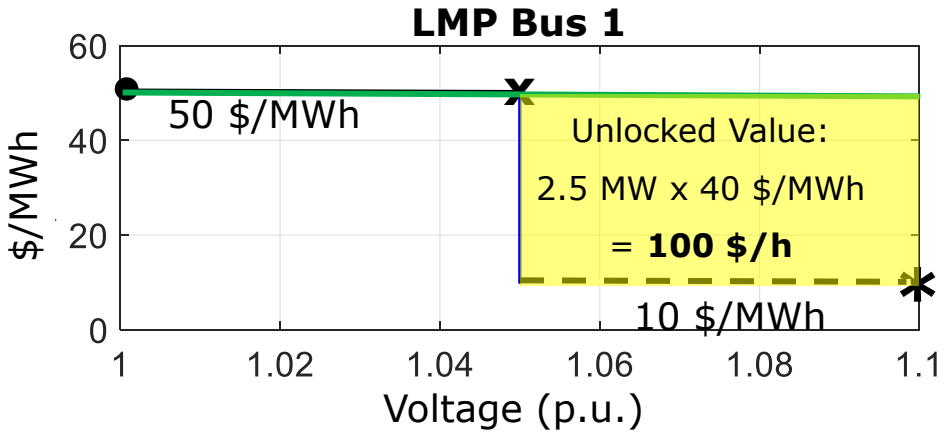


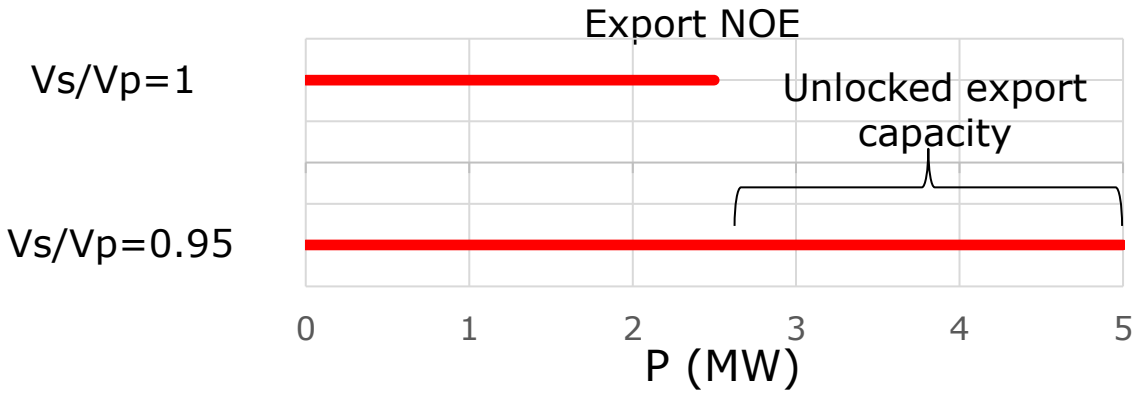


Value of OLTC operation to increase export capacity

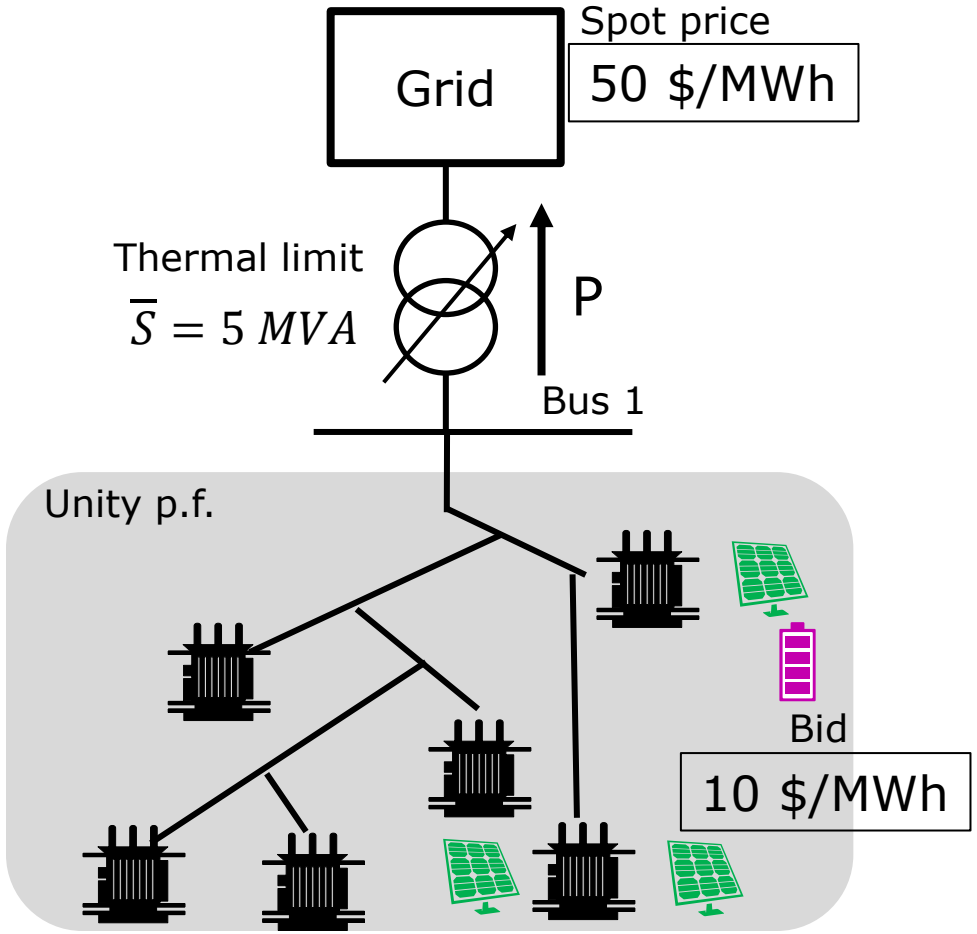


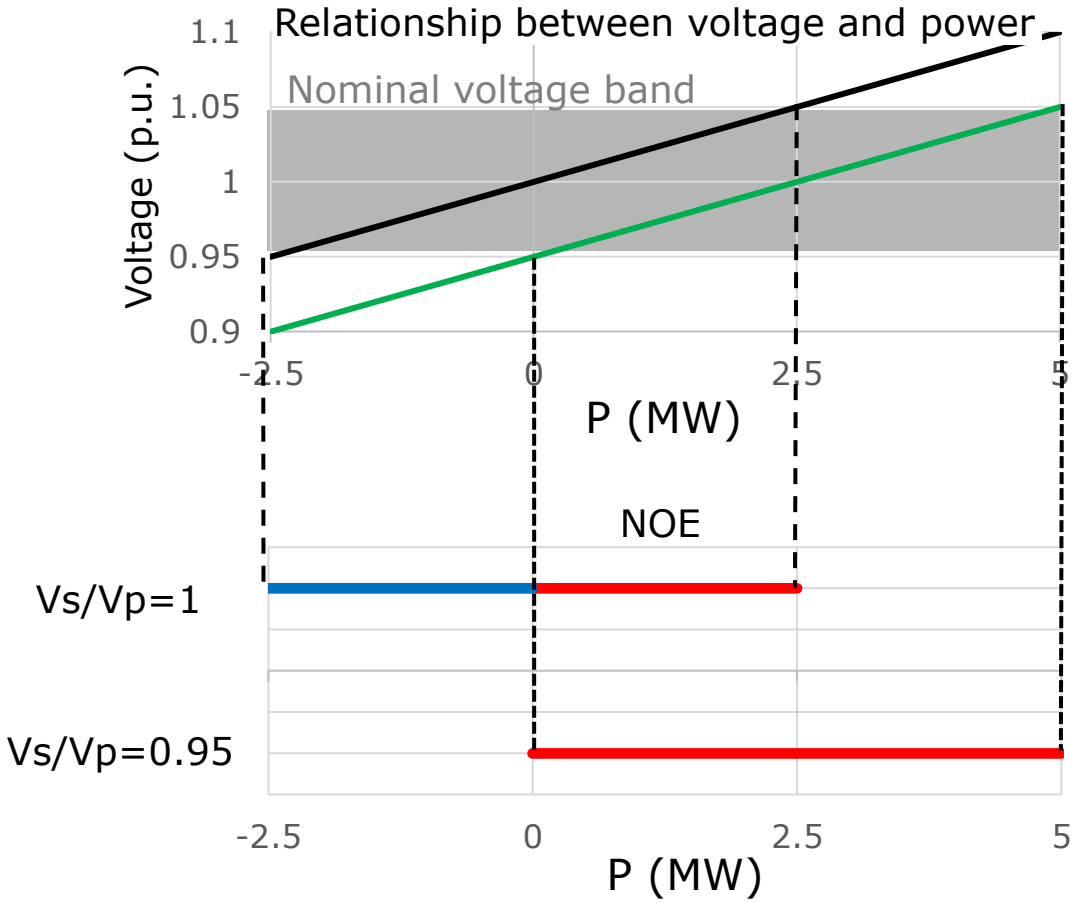




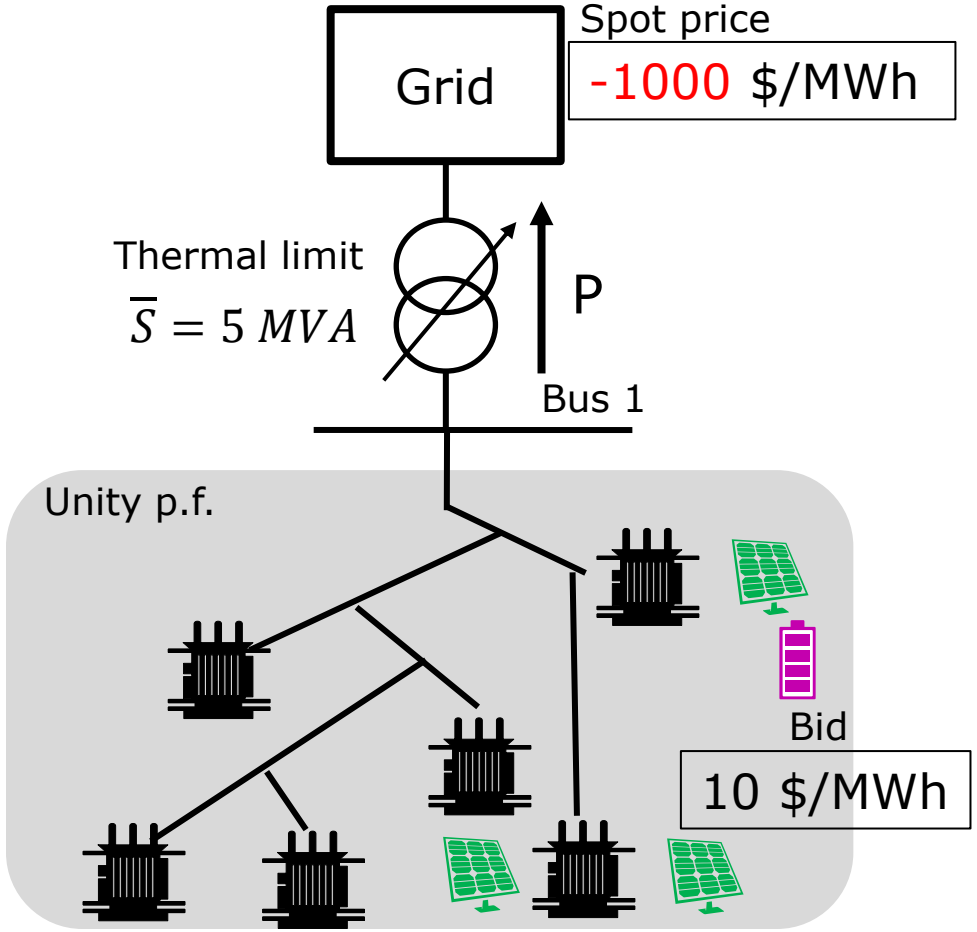


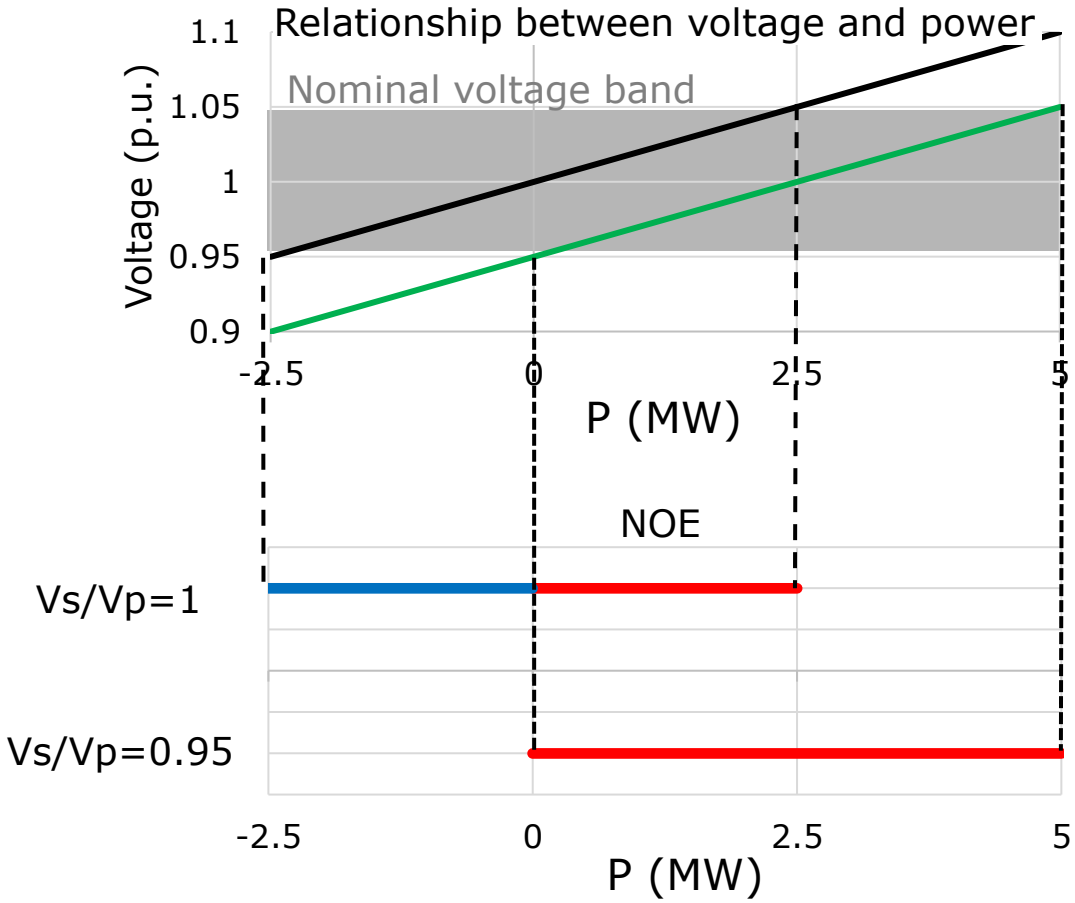
Impact of OLTC operation on export and import



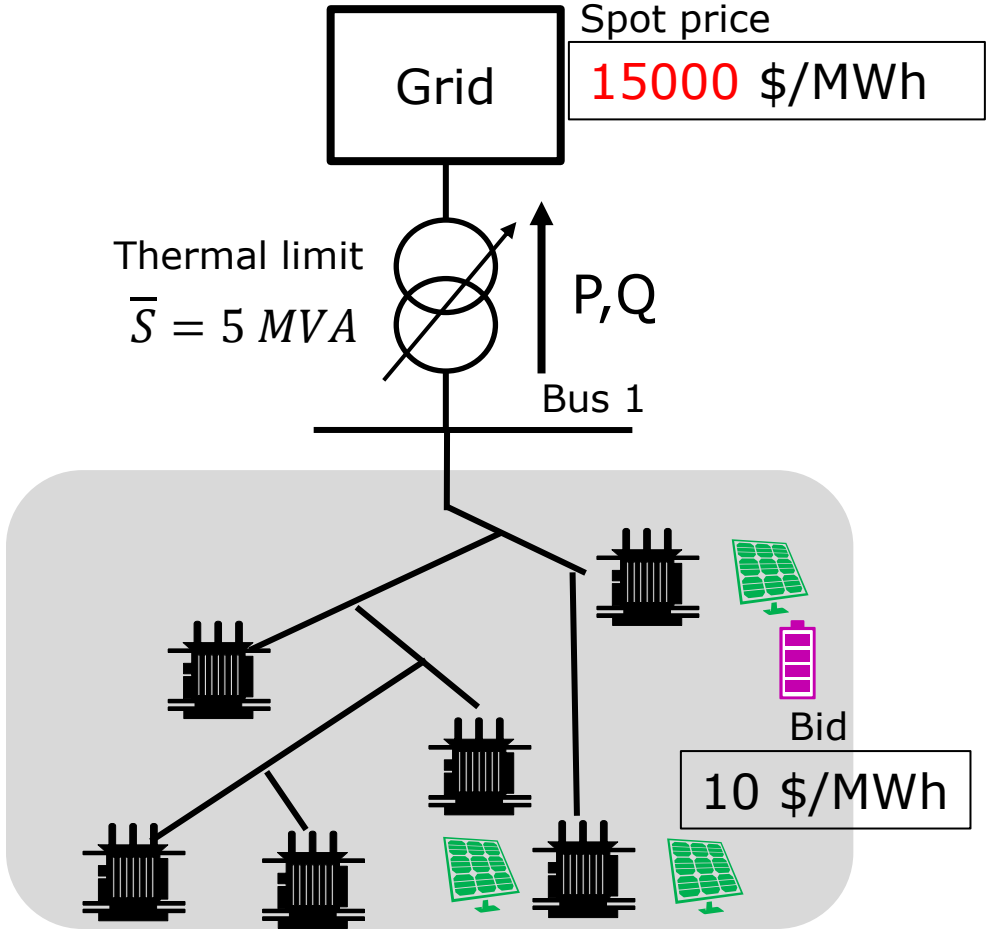


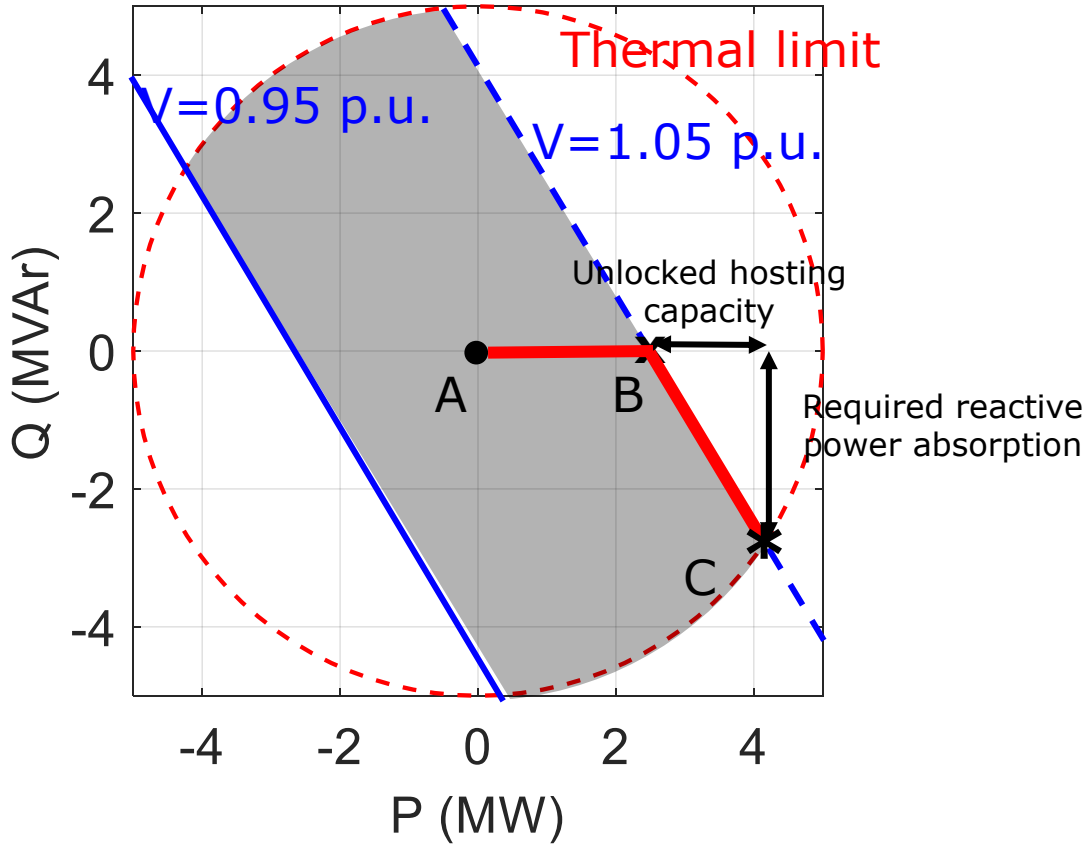
Need to actively co-optimise OLTC and wholesale market services





DER and reactive power management to increase export capacity





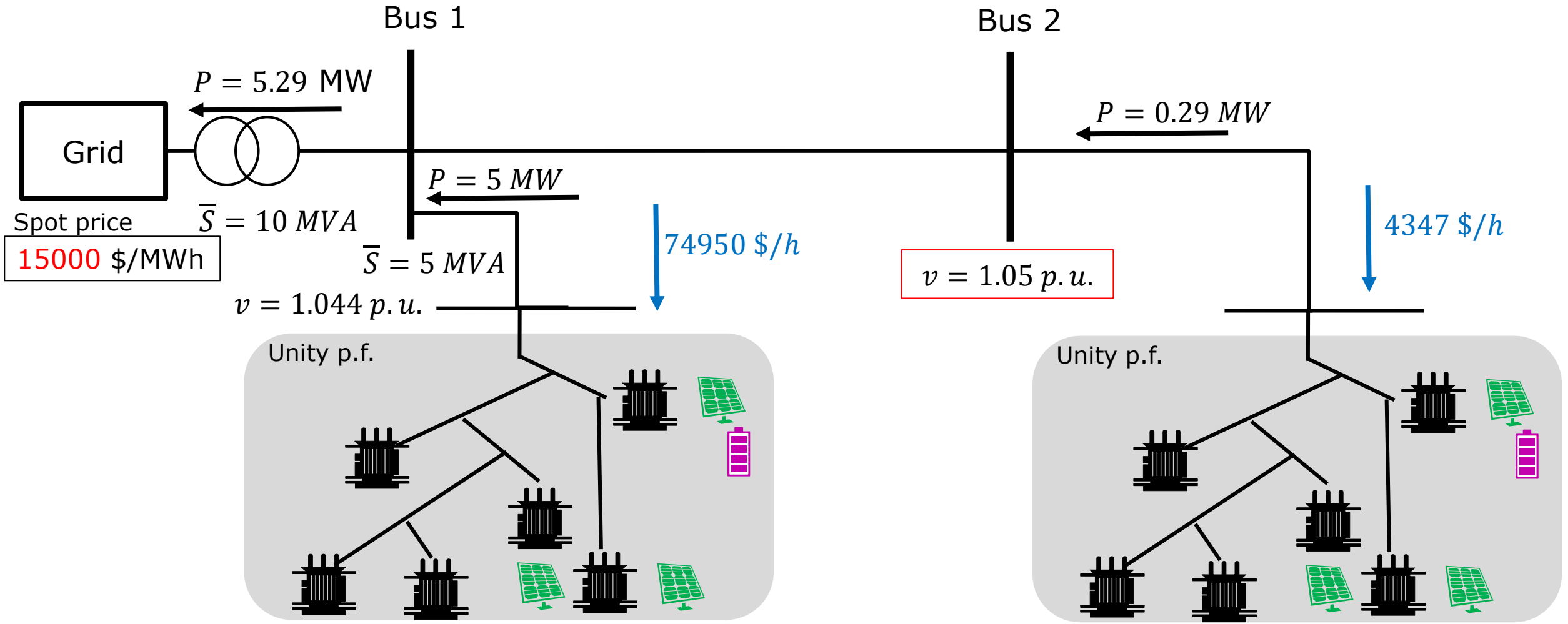
Unlocked active power capacity = 1.7 MW

Required reactive power = 2.7 MVAr

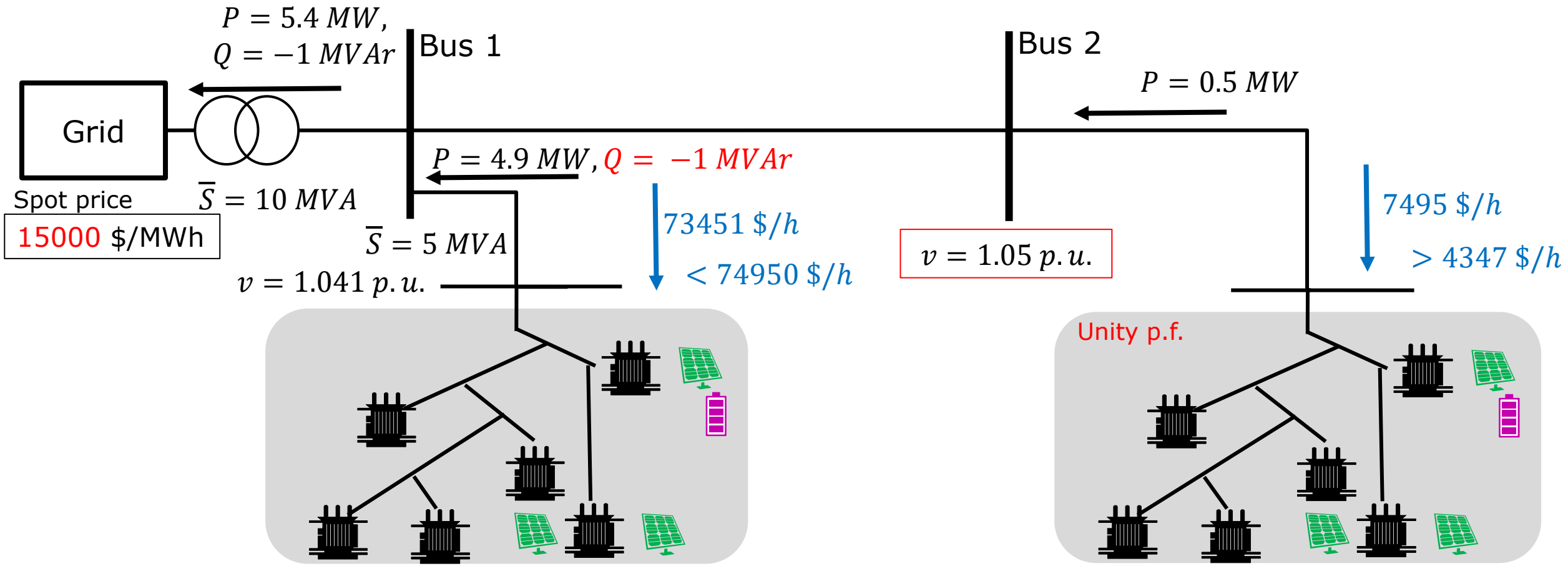
Value of unlocked capacity = 1.7x14990 = **25483 $/h**

Value of reactive power= 25483/2.7 = **9438 $/MVArh**

Impact of (active power) dynamic operating envelopes on aggregators' cash flows



Locational value of reactive power: cooperation between aggregators



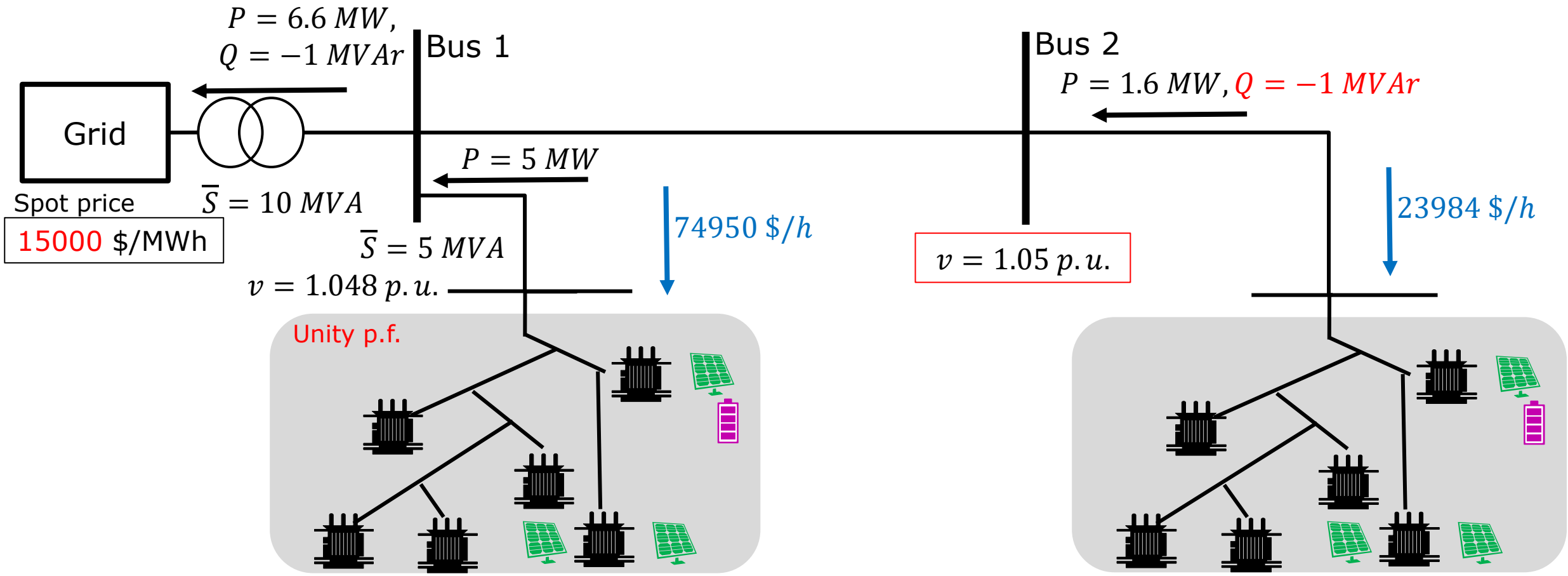
Unlocked active power capacity = 0.11 MW

Required reactive power = 1 MVAr

Value of unlocked capacity = 1649 $/h

Value of reactive power from Bus 1= **1649 $/MVArh**

Locational value of reactive power: aggregator 2 "self-help"



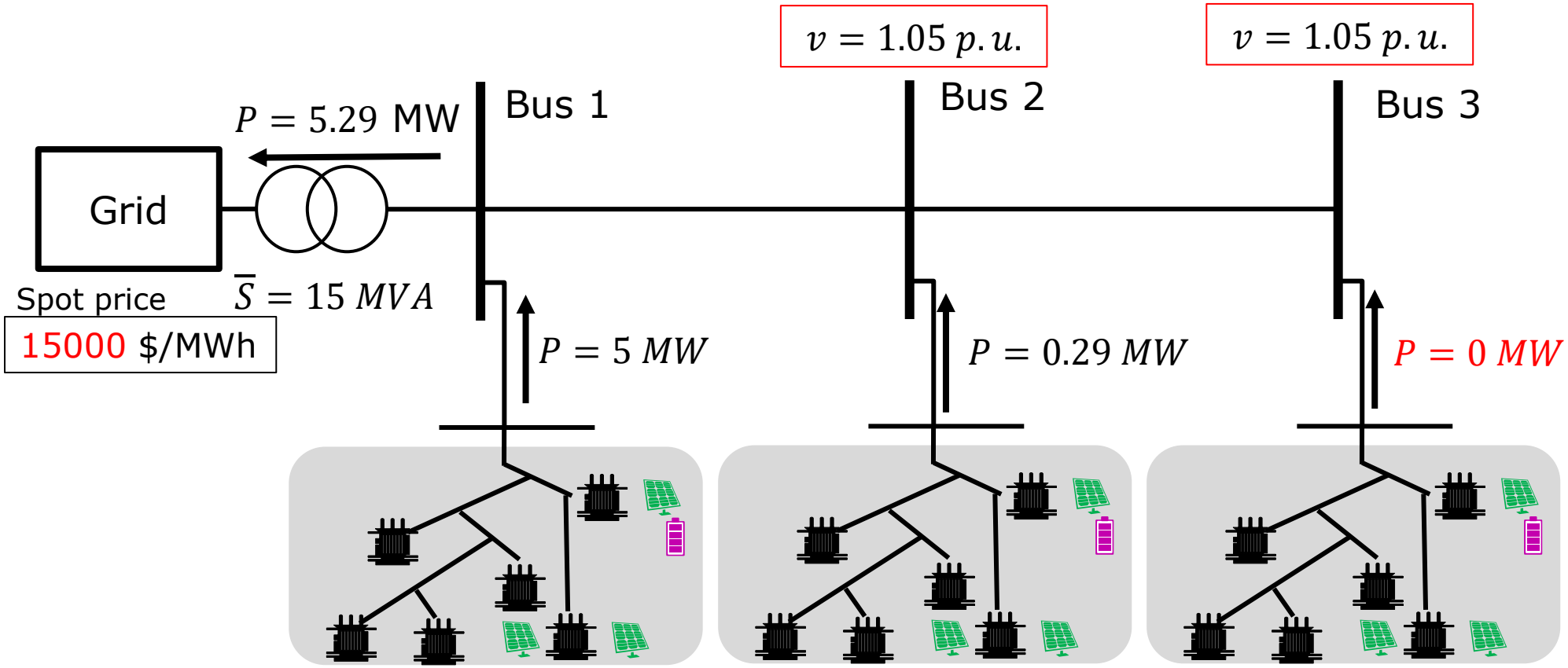
Unlocked active power capacity = 1.6 MW

Required reactive power = 1 MVAr

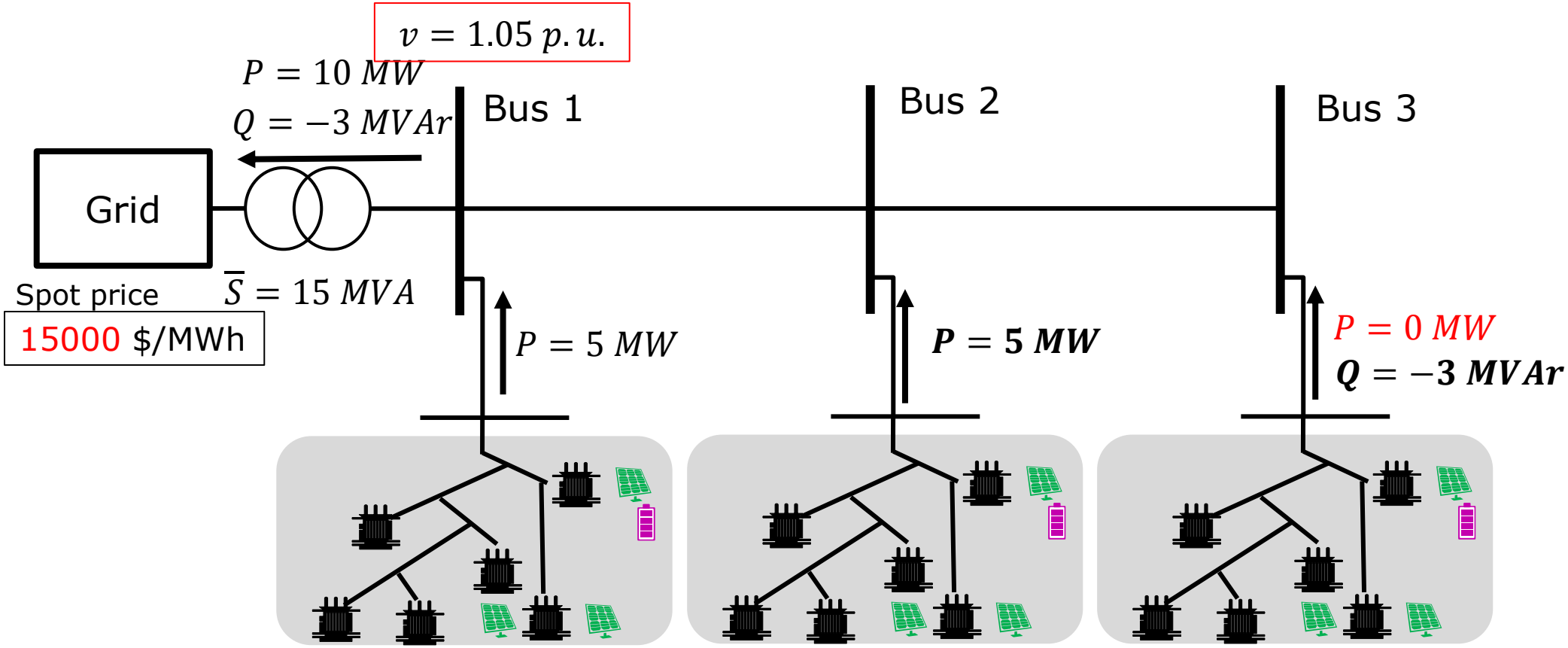
Value of unlocked capacity = 23984 $/h

Value of reactive power from Bus2= **23984 $/MVArh**

More on cooperation among aggregators and the locational value of reactive power



More on cooperation among aggregators and the locational value of reactive power



Unlocked active power capacity = 4.71 MW

Required reactive power = 3 MVAr

Value of unlocked capacity = 70602 $/h

Value of reactive power from Bus3= **23,534 $/MVArh**

Key remarks

- To unlock the true value of DER and two-sided markets, wholesale market and local network services should be co-optimized

- Our proposed extension of LMP theory provides a suitable, fundamental techno-economic framework to value active and reactive power services
  - Local voltage and reactive power management increases distribution network flexibility and unlocks active power export capacity

Next

- Next: the LMP-based methodology under development will be used to inform commercial valuation of DNSP/DSO services, e.g.
  - Operation and investment in network asset (e.g., OLTC)
  - DER contracts for high-firmness services (e.g., N-0 capacity services)
  - DER price signals for low-firmness services (e.g., reactive power for intact network)
- Fundamental questions for the **integrated energy-network market design**:
  - How should value be allocated across multiple markets/actors?
  - What is the most suitable commercial framework to do it?

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Impact of OLTC operation in P-Q Space