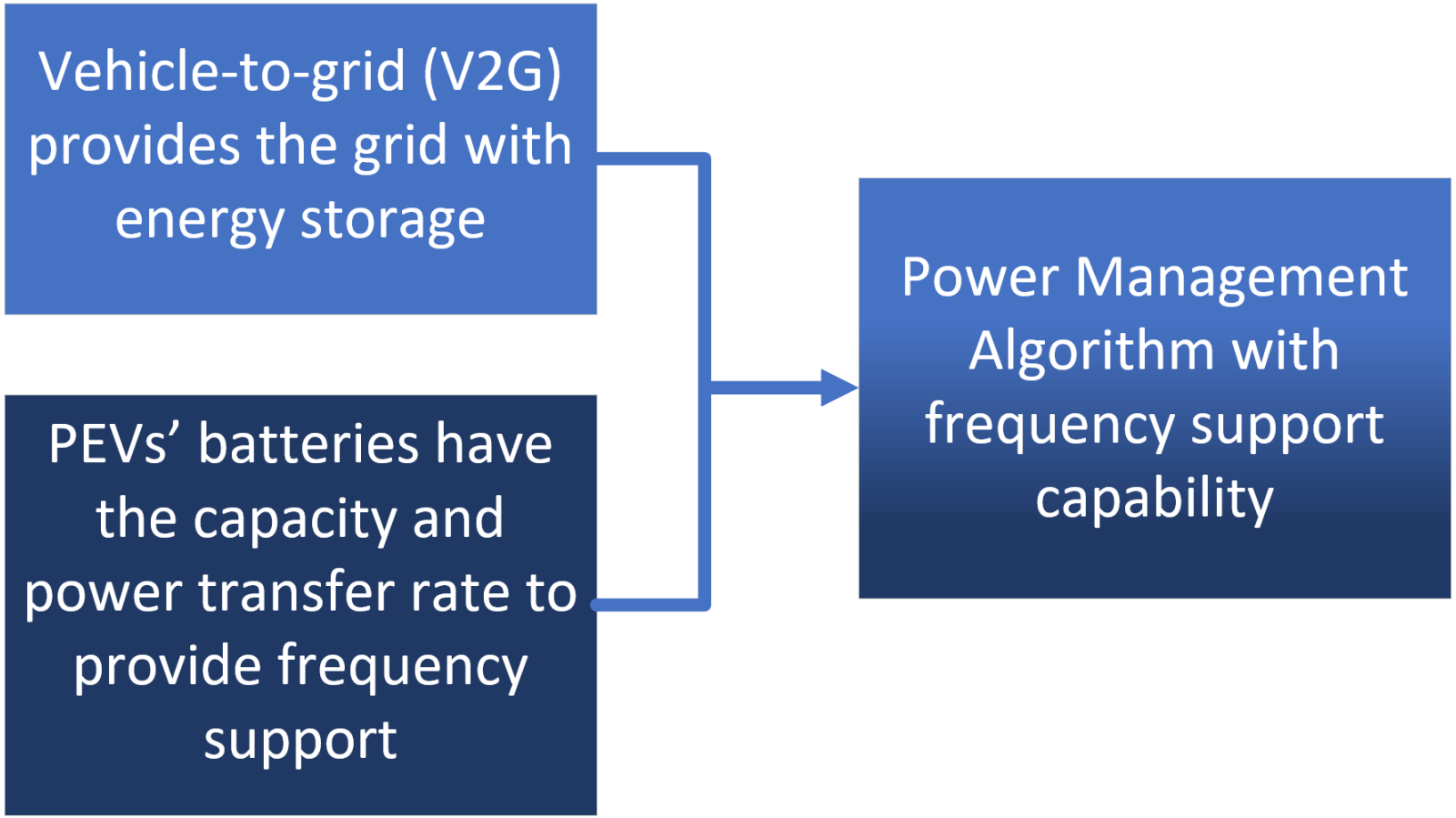
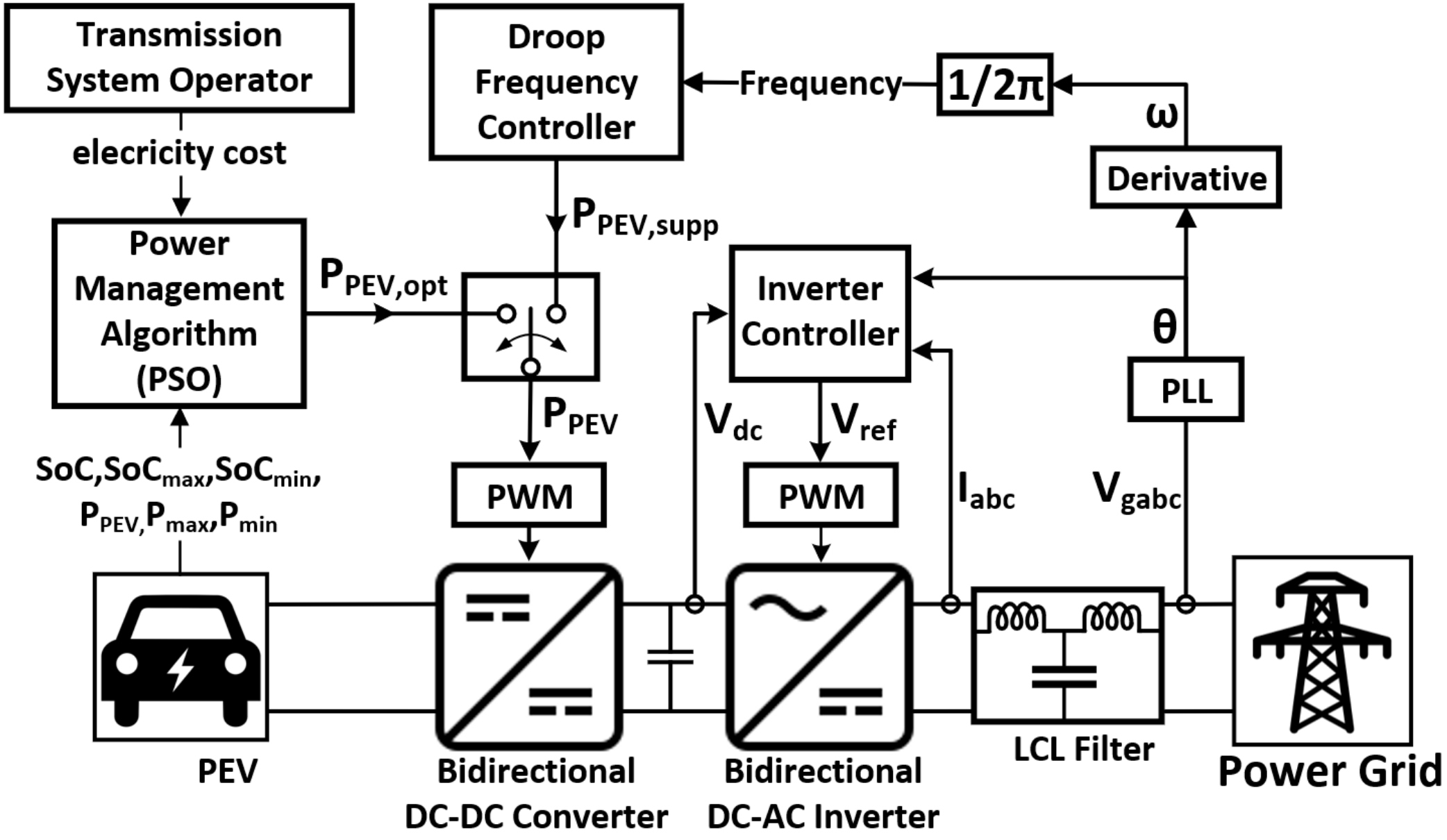
Optimal Power Management for Residential PEV Chargers with Frequency Support Capability

Iason Kalaitzakis
Michail Dakanalis
Fotios D. Kanellos

TECHNICAL UNIVERSITY OF CRETE

Introduction




Transmission System Operator
elecricity cost
Power Management Algorithm (PSO)
SoC,SoCmax,SoCmin,
PPEV,Pmax,Pmin
PPEV,opt
Droop Frequency Controller
Frequency
1/2π
ω
Derivative
PPEV,supp
PPEV
PWM
Inverter Controller
Vdc
Vref
PWM
Iabc
θ
PLL
Vgabc
PEV
Bidirectional DC-DC Converter
Bidirectional DC-AC Inverter
LCL Filter
Power Grid

Particle Swarm Optimization

Main cost equation

$$\min \left(\sum_{t} \left(P_{PEV}(t) \cdot cost(t) \right) dt + penalties \right)$$

Restrictions applied through penalties

$$P_{PEV} \leq P_{max} \quad \forall t$$

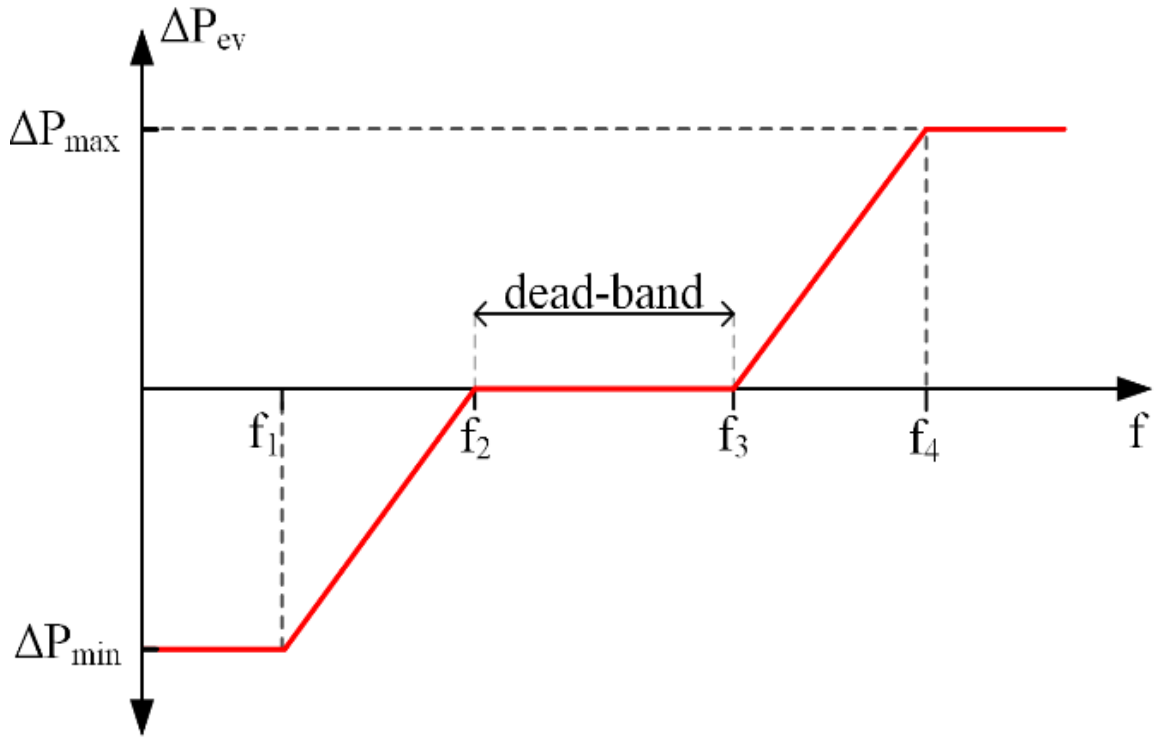
$$P_{PEV} \geq P_{min} \quad \forall t$$

$$SoC(0) + \sum_{t=0:dt:T} P_{PEV}(t) \cdot dt \leq SoC_{max}$$

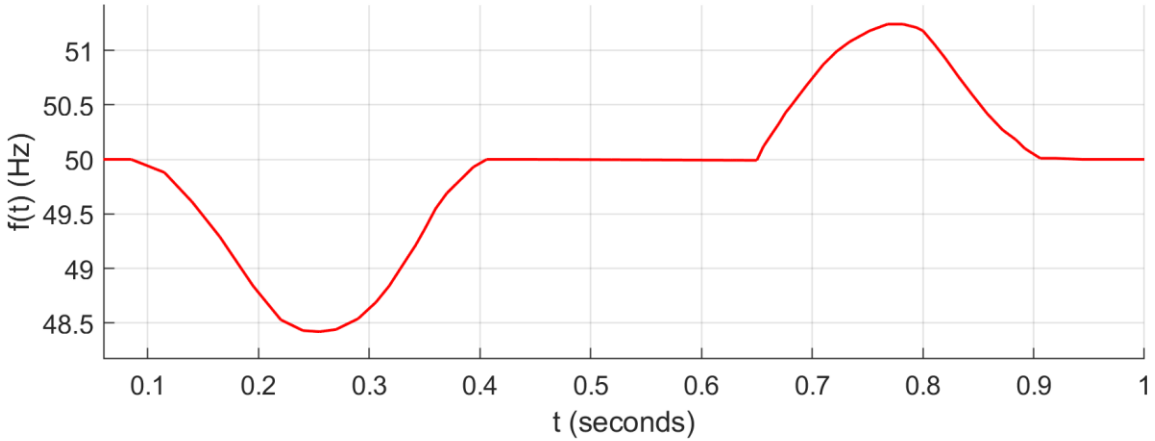
$$SoC(0) + \sum_{t=0:dt:T} P_{PEV}(t) \cdot dt \geq SoC_{min}$$

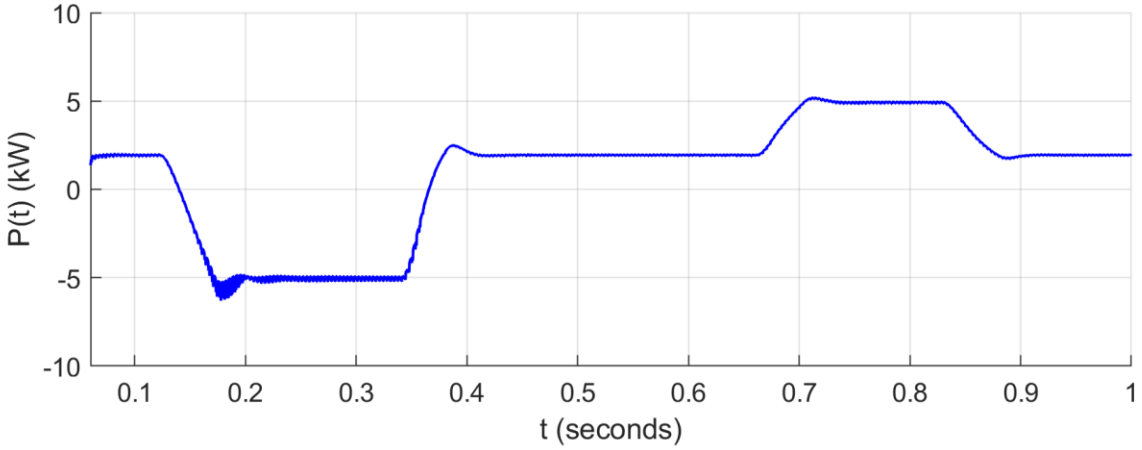
Droop Frequency Control

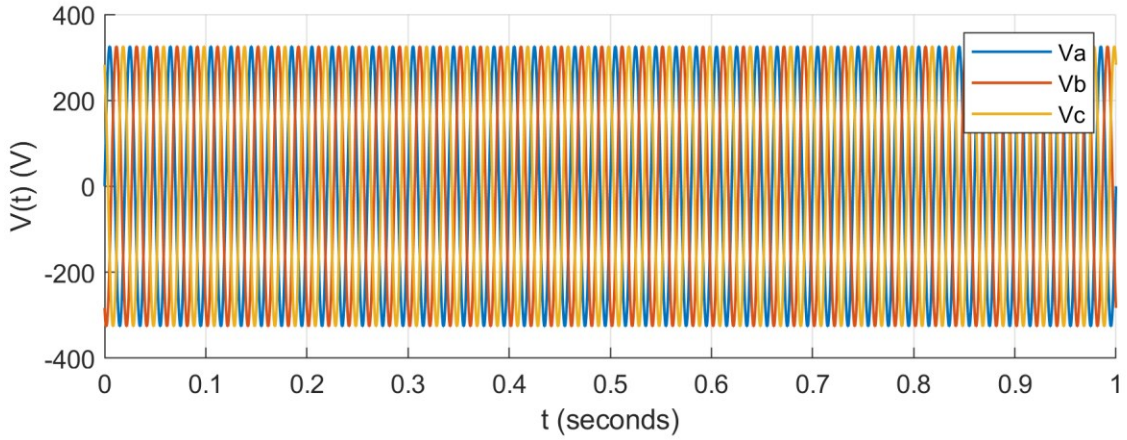
$$\Delta P_{PEV} = \begin{cases} \Delta P_{min} & f < f_1 \\ \Delta P_{min} - \dfrac{\Delta P_{min}}{f_2 - f_1}(f - f_1) & f_1 \le f \le f_2 \\ 0 & f_2 \le f \le f_3 \\ \dfrac{\Delta P_{max}}{f_4 - f_3}(f - f_3) & f_3 \le f \le f_4 \\ \Delta P_{max} & f > f_4 \end{cases}$$

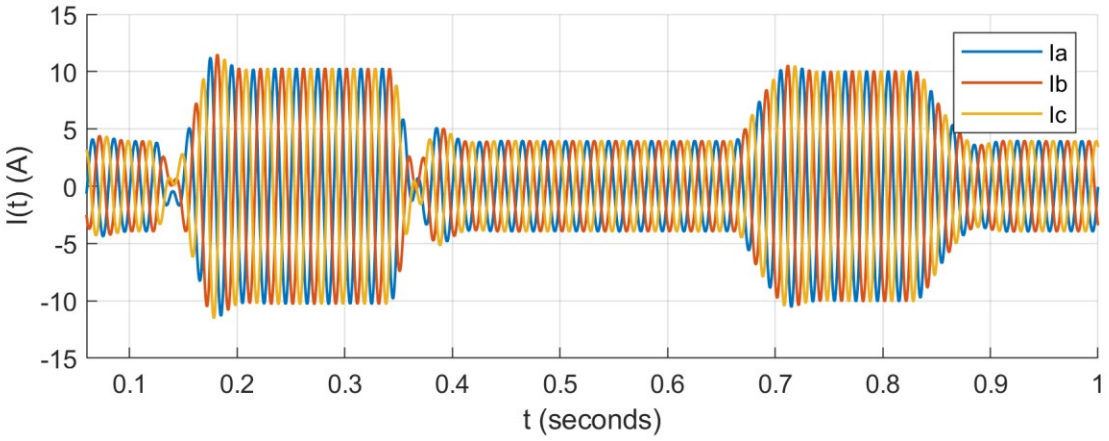


Frequency Controller Operation





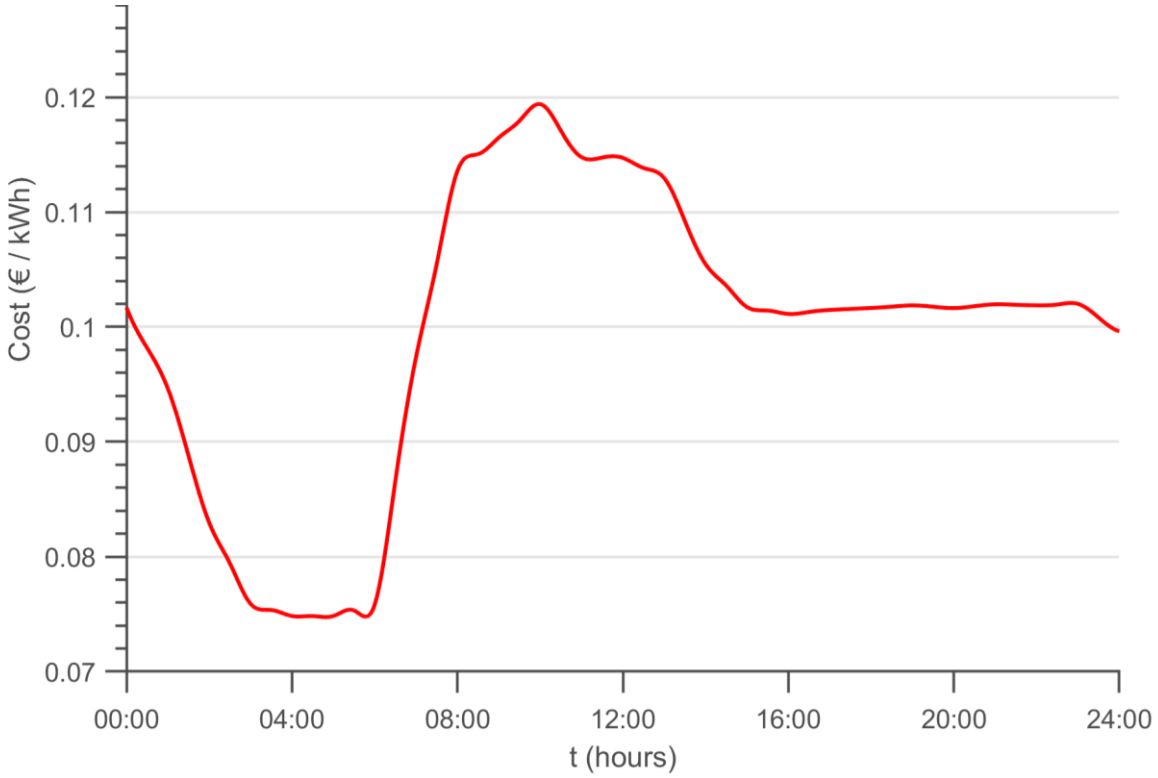


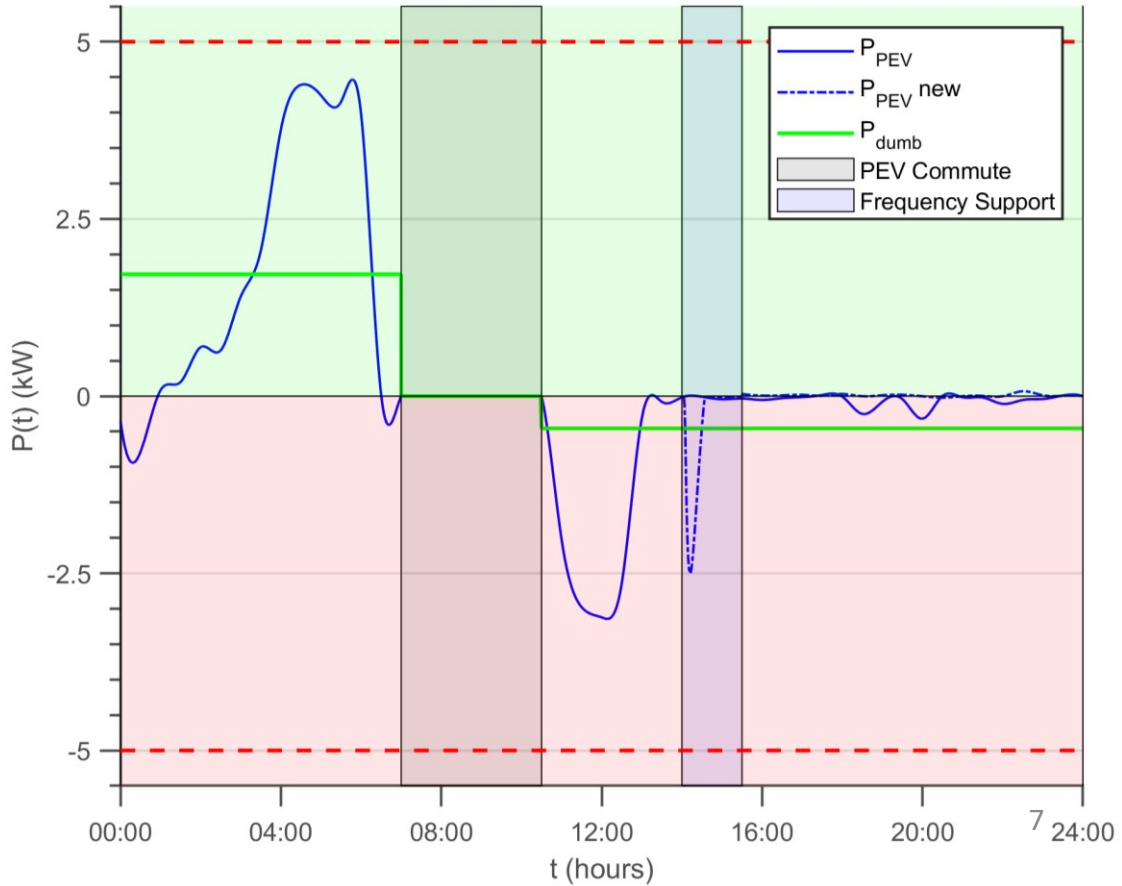


Case study

Power management algorithm:

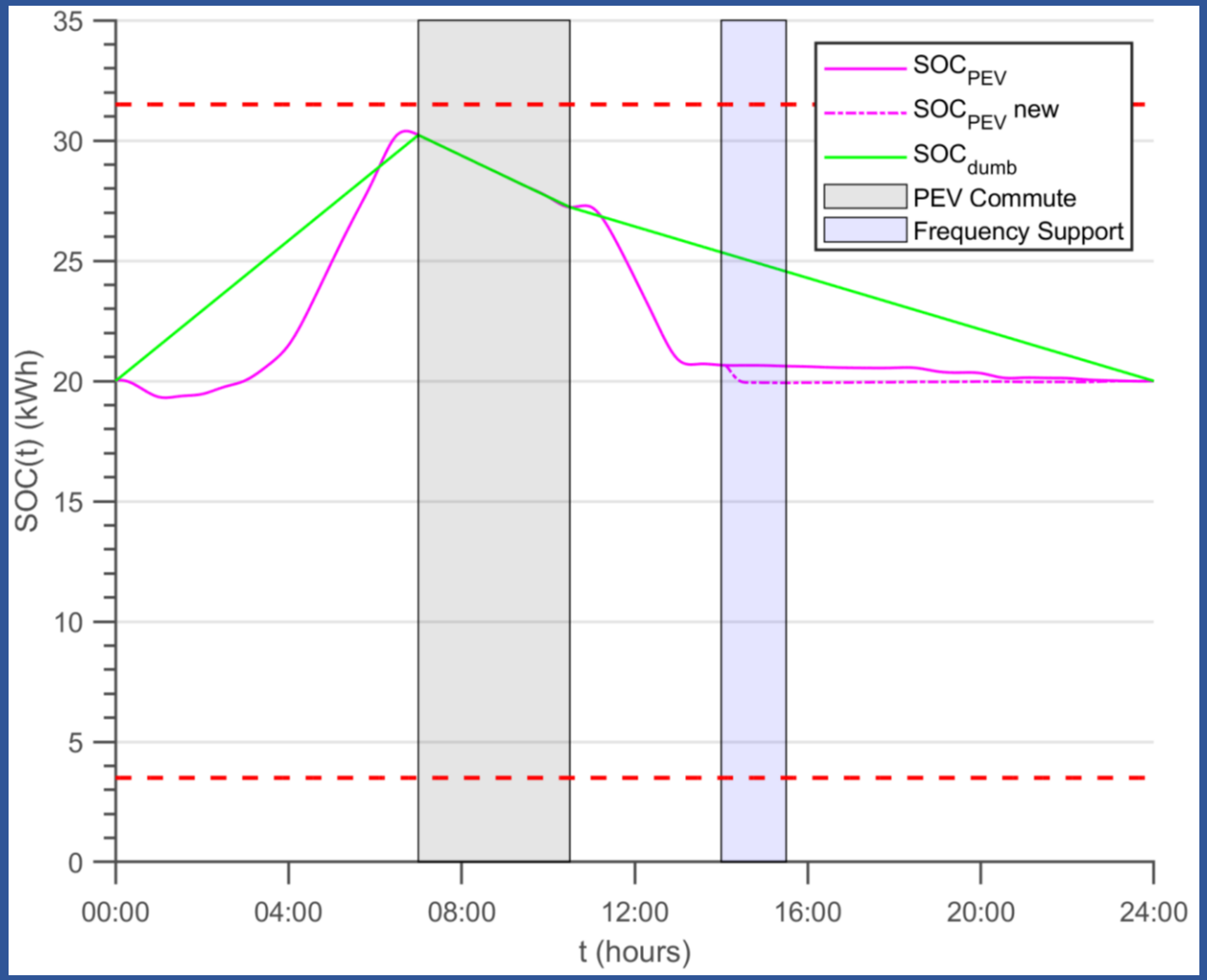
- Sells power during peak cost (peak grid demand)
- Buys power during low cost (low grid demand)
- Supports a commute during which the PEV is unavailable





State of Charge of the PEV's battery

- Additional energy loss of the battery in case of frequency support
- Dumb charging also features V2G for fair comparison



Results

	Type of Operation		
	PSO without grid support	**PSO with grid support**	**Dumb Charging**
Daily Cost (€)	0.21	0.27	0.35

Acknowledgement

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Thank you for your attention!