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Analysis of the potential to leverage price volatility through flexibility options in a local energy system

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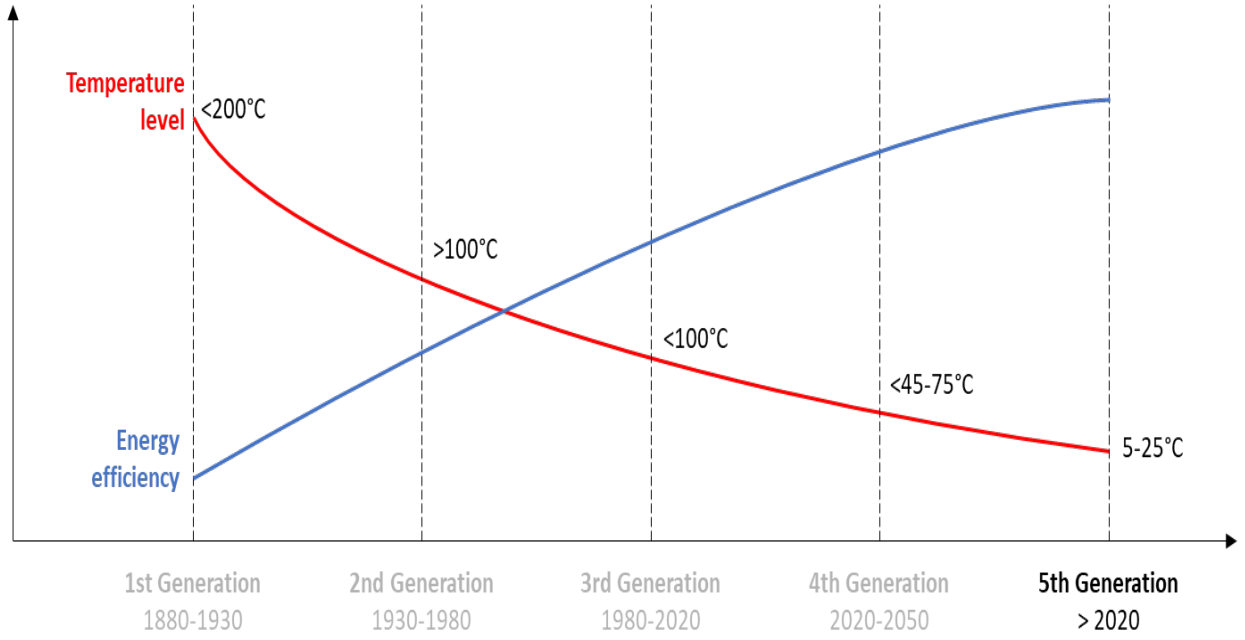
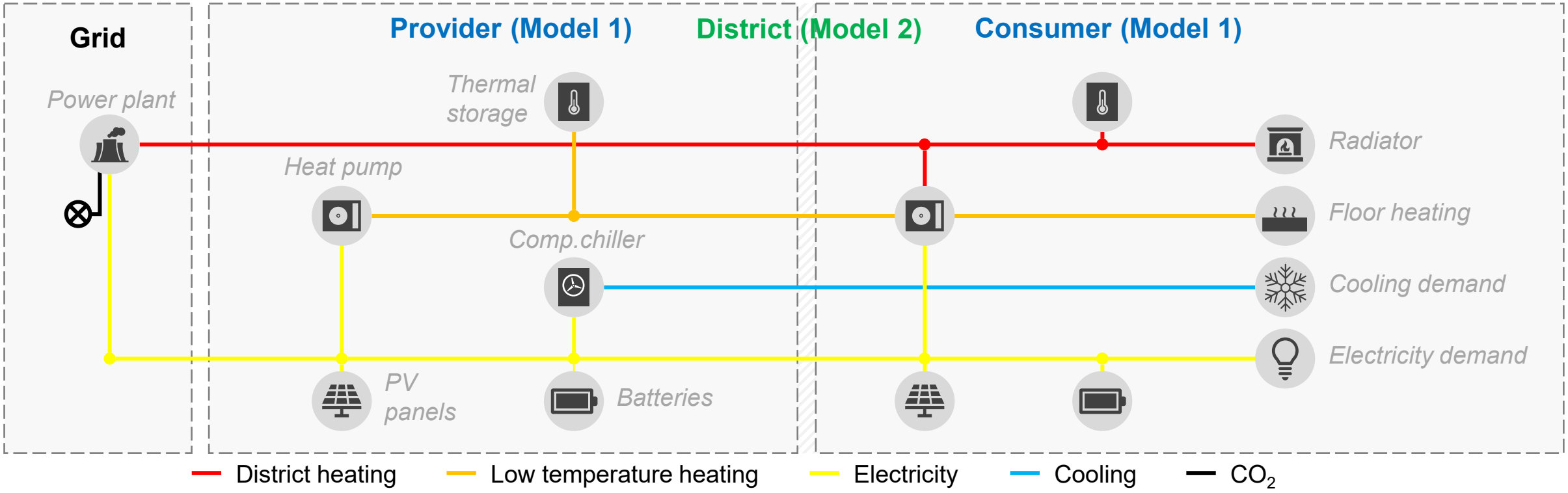
Effects of flexibilities in energy systems of a district is today's focus

Market design – System integration of flexibilities: Variable electricity tariffs, grid-oriented load control



What is the impact of **time-variable electricity prices** and **shut-off periods for heat pumps** on the **behavior of actors** with regard to the **energy system of a district**?

District is viewed and optimized from two perspectives



Model 1: Consumer / provider model

Bi-level optimization:

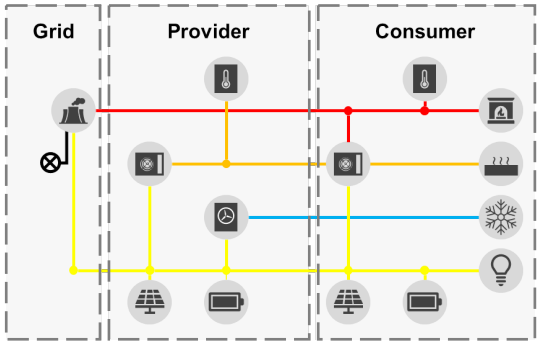
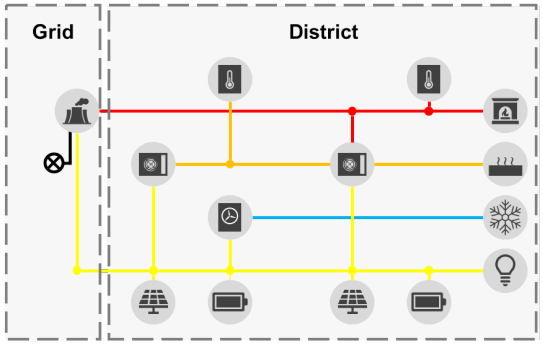
1. Provider: Offering of energy prices
2. Consumer: Optimize costs of energy consumption
3. Provider: Optimize energy supply

Model 2: District model (Macro)

Optimization:

- District: Optimization of the annualized costs of the energy consumption for the district

In the case of variable electricity prices, the price is divided into three daily periods

Model	Electricity supply	Constant electricity price [ct/kWh]	Variable electricity price [ct/kWh]
Model 1: Consumer / provider model 	Grid → Provider Provider → Consumer	31.75 0 h – 24 h	29 (0 h – 6), 34 (6 – 15), 33 (15 – 19), 29 (19 – 24 h)
	Grid ← Provider Provider ← Consumer	6 0 h – 24 h	5 (0 h – 6), 7 (6 – 15), 6 (15 – 19), 5 (19 – 24 h)
Model 2: District model (Macro) 	Grid → District	31.75 0 h – 24 h	29 (0 h – 6), 34 (6 – 15), 33 (15 – 19), 29 (19 – 24 h)
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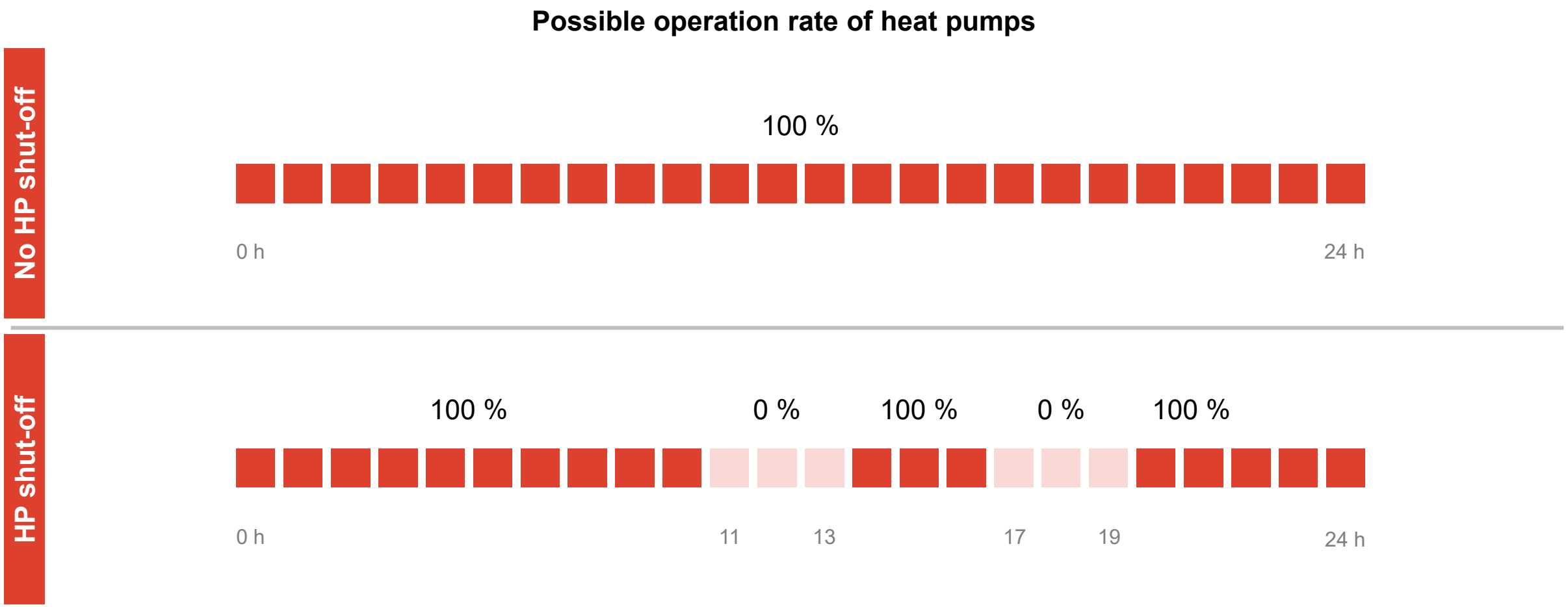
During the shut-off periods, heat pumps must not be operated



Introducing the measures leads to four cases

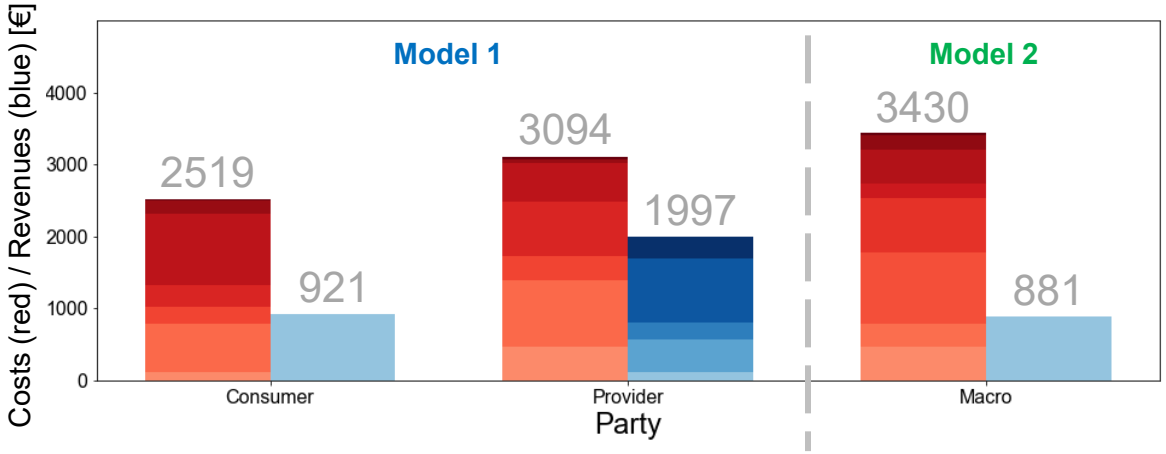
	Constant electricity price	Time-variable electricity price
No HP shut-off	1 Constant electricity price No HP shut-off	2 Time variable electricity price No HP shut-off
HP shut-off	3 Constant electricity price With HP shut-off	4 Time variable electricity price With HP shut-off

Less Measures More

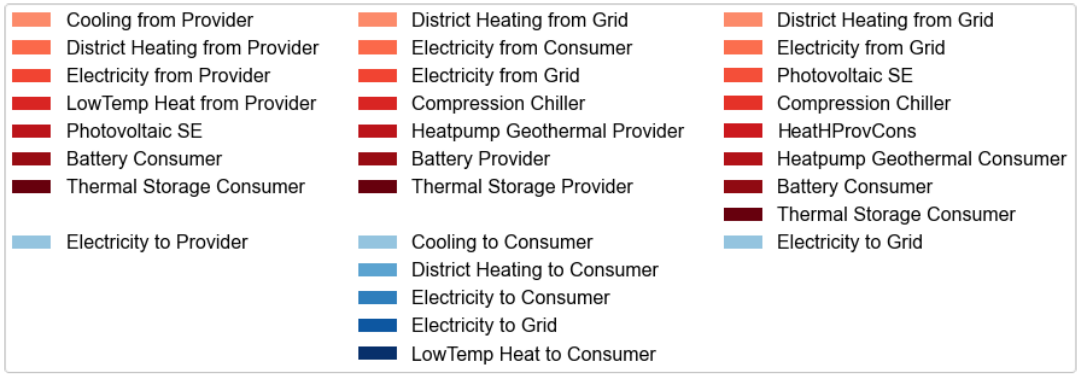
Less Measures More

Consumer welfare increases while welfare on producer's side decreases

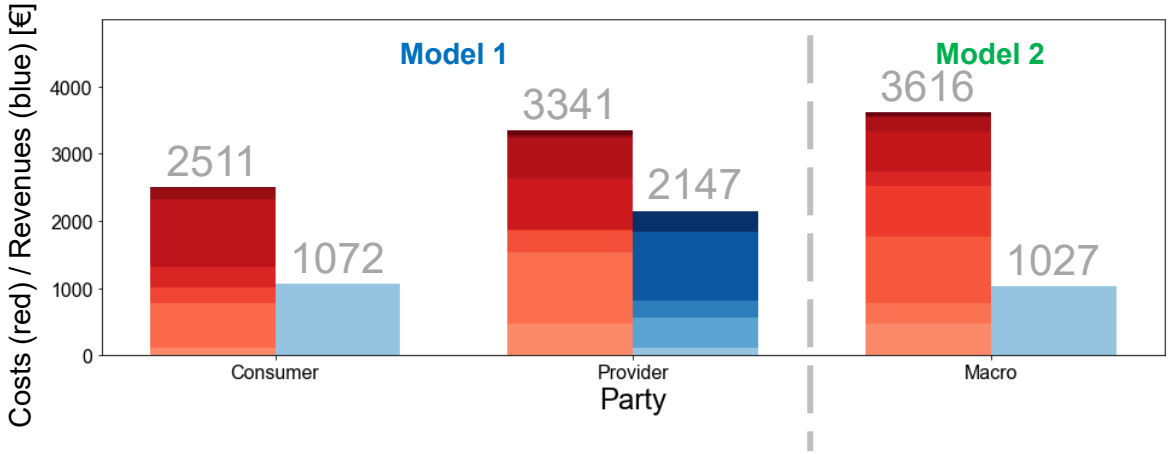
1. Constant electricity price / No HP shut-off



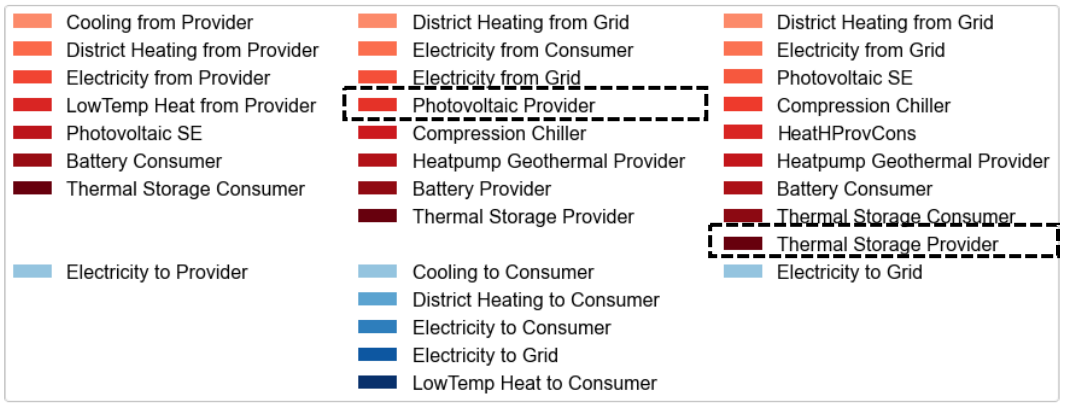
Welfare: -1598-1097 = **-2695** < **-2549**



4. Time-variable electricity price / HP shut-off



Welfare: -1439-1194 = **-2633** < **-2589**



Measures lead to higher revenues, intensive battery use, larger heat pumps and storages

Variable electricity price

- Installation of **PV panels** *(Producer)*
- **Higher revenues** from electricity marketing *(17 % Producer, 16 % Consumer)*
- **More intensive use** of the battery *(33 % Producer, 18 % Consumer)*

→ **Utilization of higher feed-in prices**

HP shut-off

- **Larger heat pump** *(27 % Producer)*
- **Larger thermal storage** *(86 % Producer)*

→ **Bridging the time of heat pump shut-off periods**

As a next step, we will investigate effects of further price signals and measures to control load

Variable electricity prices

Grid-oriented load control

What influence on the behavior of the actors with regard to the energy system of a district …

…does **spot market-oriented electricity prices** have?

…does the **load-oriented control of heat pumps** have?

… have **procurement strategies of energy suppliers**?

… does the **load-oriented control of wall boxes** for battery electrical vehicles have?

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