A Multi–Scale Energy Demand Model suggests sharing Market Risks with Intelligent Energy Cooperatives

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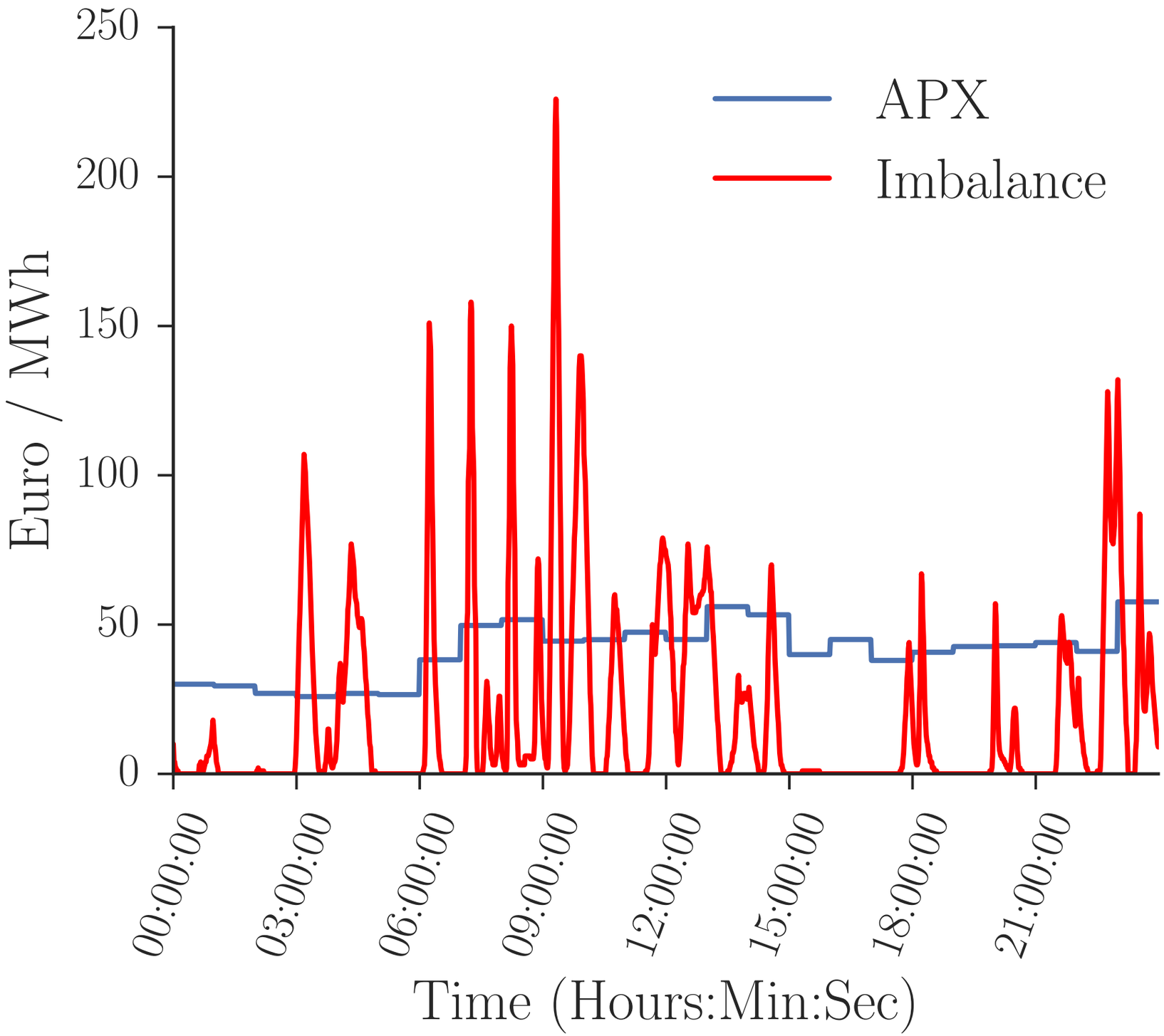
Sharing Market Risk



Sharing Market Risk

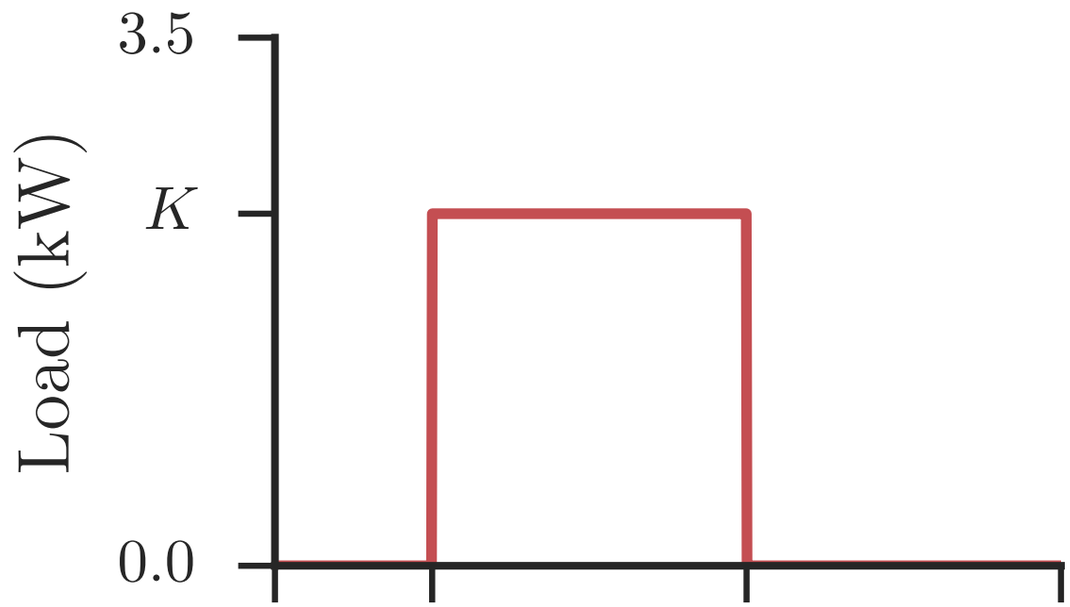
- Innovative tariff
- Low price ~ day-ahead price
- High penalties for positive imbalances
- x10 day-ahead price
- Size?

Standard Load Profile

Standard Load Profile

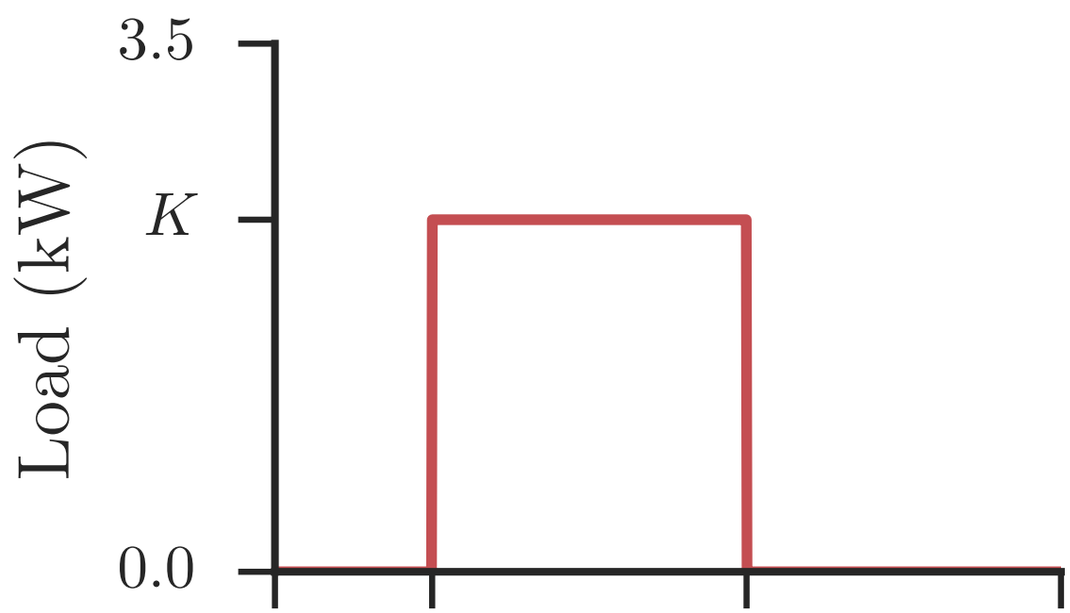
- Limited data
- Various scales
- Case specific

Process



$$f(t, t_0, \delta, k) = \begin{cases} k, & t \in [t_0, t_0 + \delta) \\ 0, & \text{otherwise} \end{cases}$$

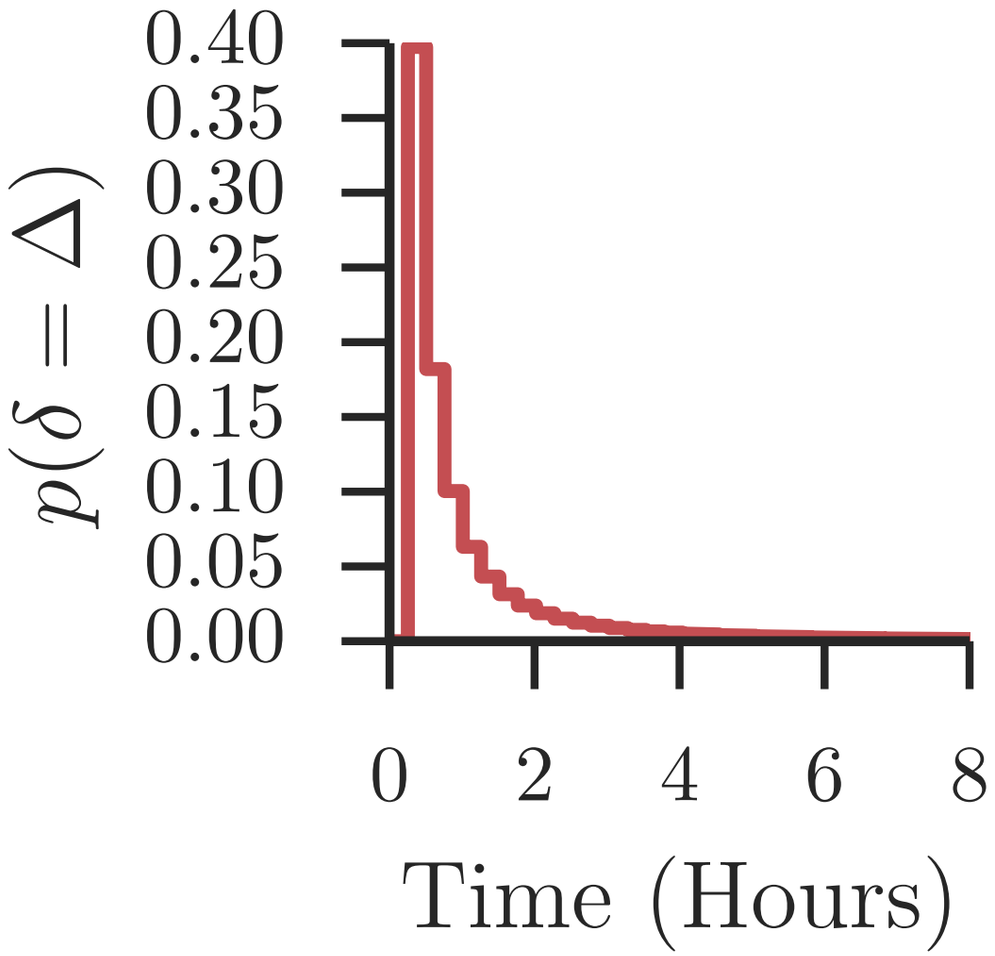
Process

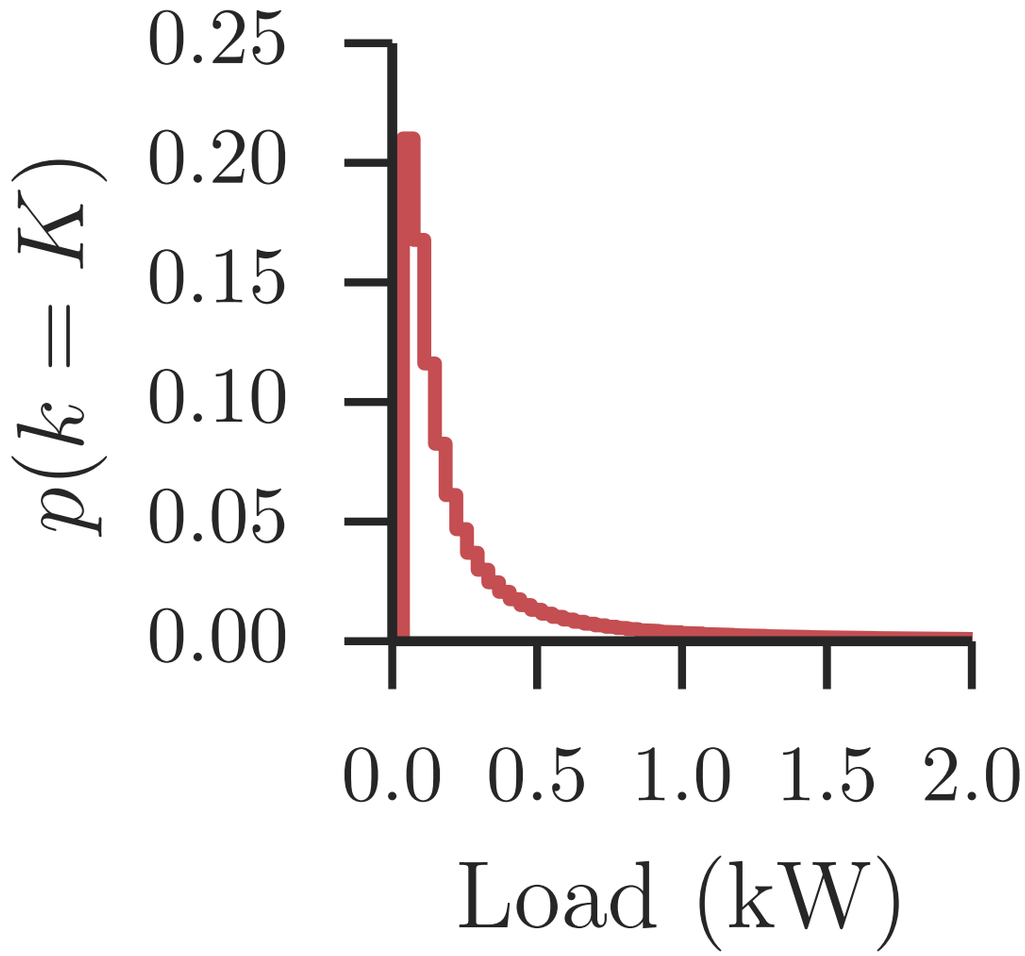


$$q_N(t, p_{t_0}, p_\delta, p_k) = \sum_{i=1}^{N} f(t, t_0^i, \delta^i, k^i)$$

Duration & Load

$$q_N(t, p_{t_0}, p_\delta, p_k) = \sum_{i=1}^{N} f(t, t_0^i, \delta^i, k^i)$$





Multiple Processes

$$\mathbb{E}\left[q_N(t, p_{t_0}, p_\delta, p_k)\right] = N\ \mathbb{E}[k]\ \sum_T p_{t_0}(T)\bar{P}_\delta(t-T)$$

Assuming wrapping around along the time-axis:

$$\hat{q}'(t) = \sum_T p_{t_0}(T)\bar{P}_\delta(s), s = \begin{cases} t-T & ,\forall T \in [0,t] \\ n-|t-T| & ,\forall T \in (t,n] \end{cases}$$

Decomposition

$$\hat{q}'(t) = \sum_T p_{t_0}(T)\bar{P}_\delta(s), s = \begin{cases} t - T & ,\forall T \in [0, t] \\ n - |t - T| & ,\forall T \in (t, n] \end{cases}$$

$$\begin{bmatrix} \bar{P}_\delta(0) & \bar{P}_\delta(n) & \dots & \bar{P}_\delta(1) \\ \bar{P}_\delta(1) & \bar{P}_\delta(0) & \dots & \bar{P}_\delta(2) \\ \vdots & \vdots & \ddots & \vdots \\ \bar{P}_\delta(n) & \bar{P}_\delta(n-1) & \dots & \bar{P}_\delta(0) \end{bmatrix} \times \begin{bmatrix} p_{t_0}(0) \\ p_{t_0}(1) \\ \vdots \\ p_{t_0}(n) \end{bmatrix} = \begin{bmatrix} \hat{q}'(0) \\ \hat{q}'(1) \\ \vdots \\ \hat{q}'(n) \end{bmatrix}$$

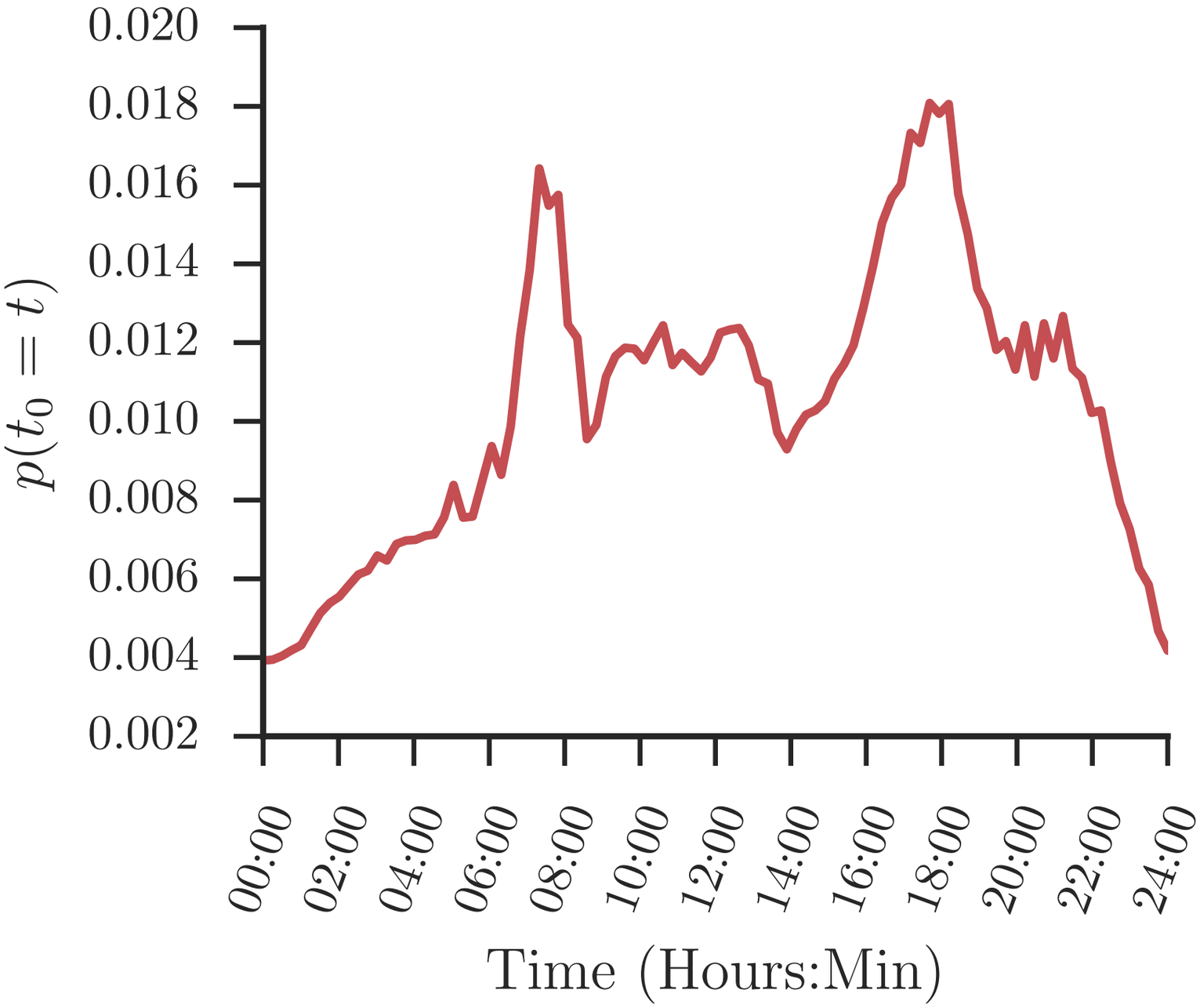
Decomposition

$$\hat{q}'(t) = \sum_T p_{t_0}(T)\bar{P}_\delta(s), s = \begin{cases} t - T & ,\forall T \in [0, t] \\ n - |t - T|, & \forall T \in (t, n] \end{cases}$$

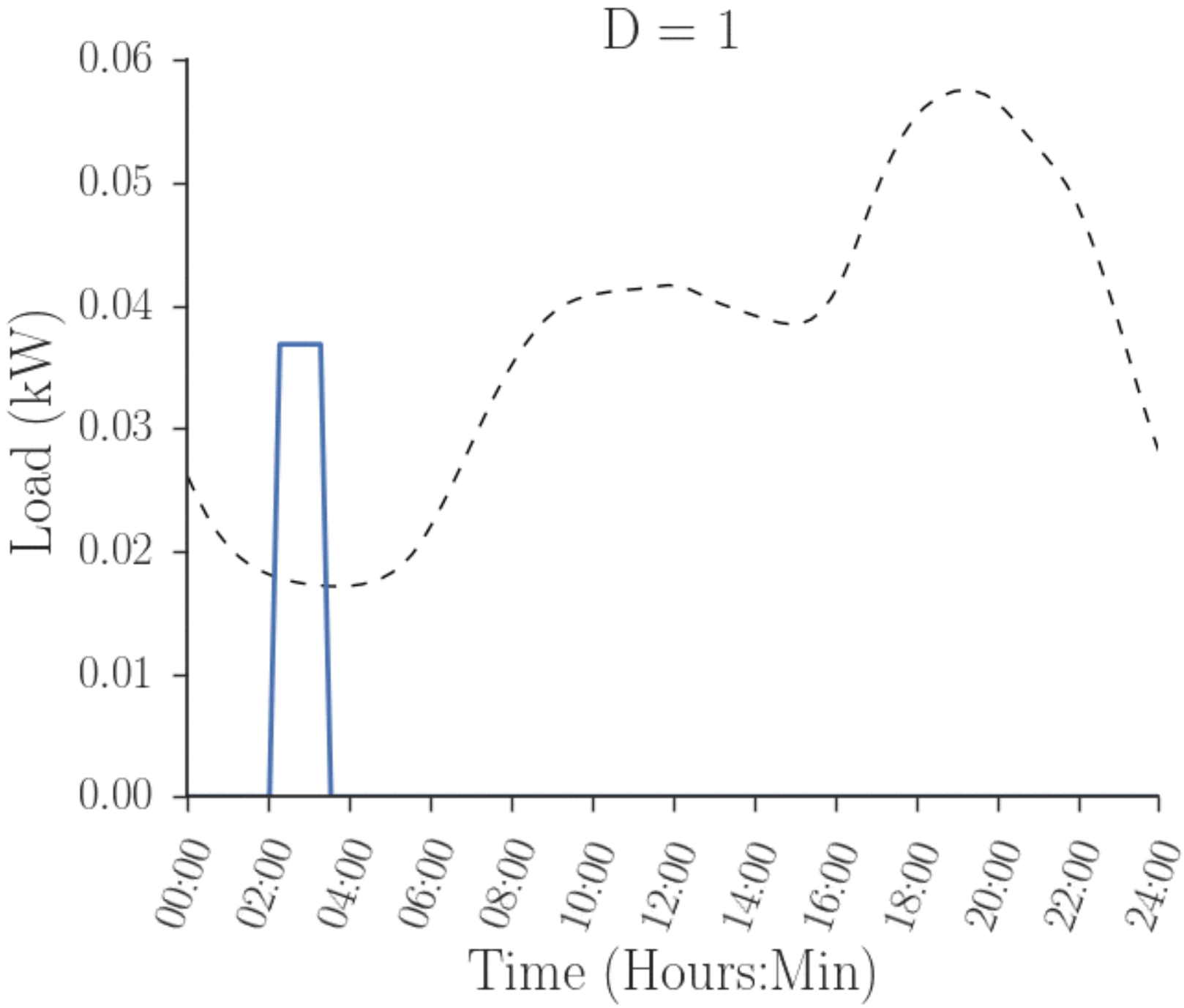
$$\mathrm{Ax} = \mathrm{b}$$

$$\begin{bmatrix} \bar{P}_\delta(0) & \bar{P}_\delta(n) & \dots & \bar{P}_\delta(1) \\ \bar{P}_\delta(1) & \bar{P}_\delta(0) & \dots & \bar{P}_\delta(2) \\ \vdots & \vdots & \ddots & \vdots \\ \bar{P}_\delta(n) & \bar{P}_\delta(n-1) & \dots & \bar{P}_\delta(0) \end{bmatrix} \times \begin{bmatrix} p_{t_0}(0) \\ p_{t_0}(1) \\ \vdots \\ p_{t_0}(n) \end{bmatrix} = \begin{bmatrix} \hat{q}'(0) \\ \hat{q}'(1) \\ \vdots \\ \hat{q}'(n) \end{bmatrix}$$

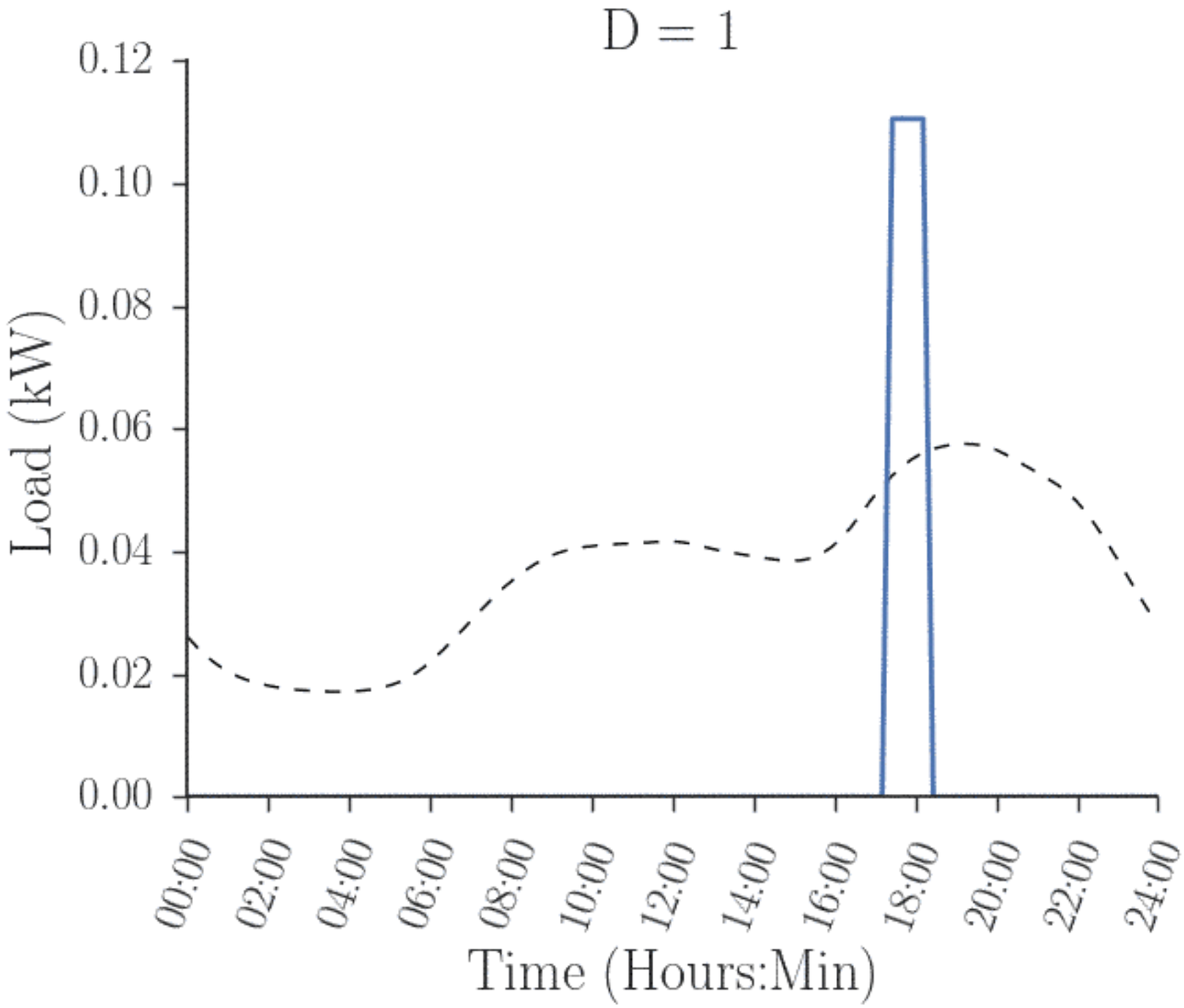
When processes start?



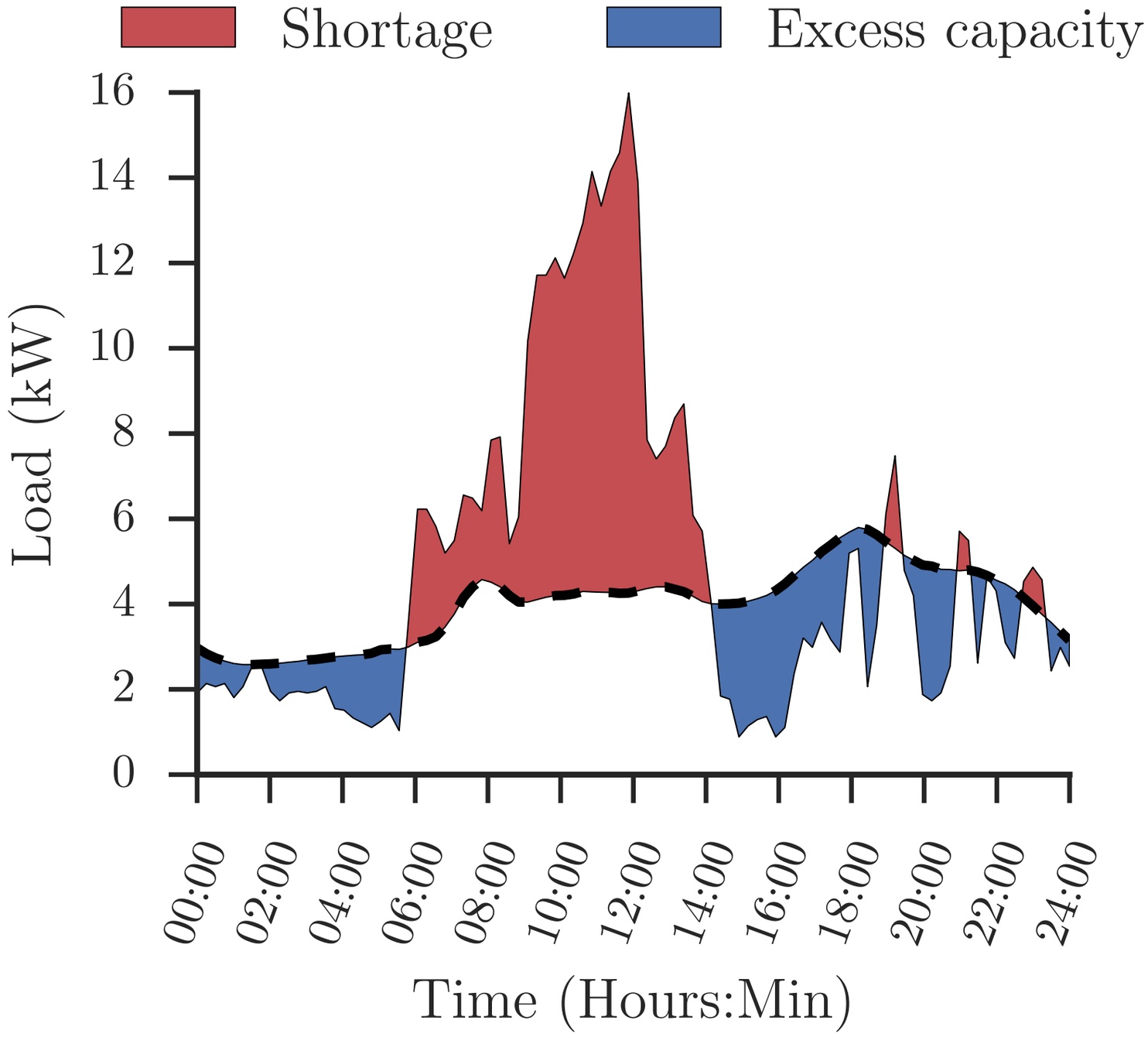
Household Load Profile



Synthetic Load Profiles



1. Virtual Storage



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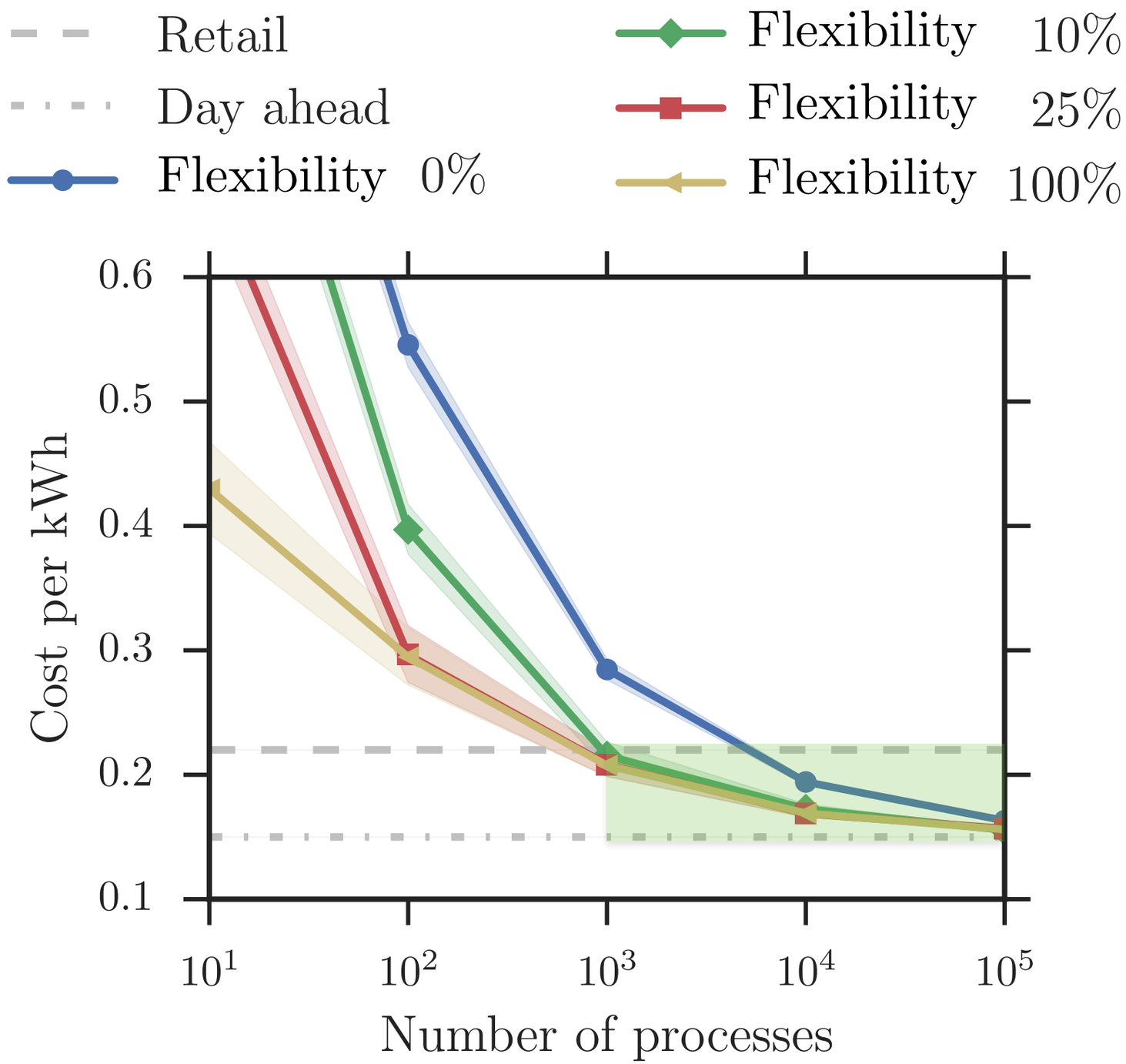
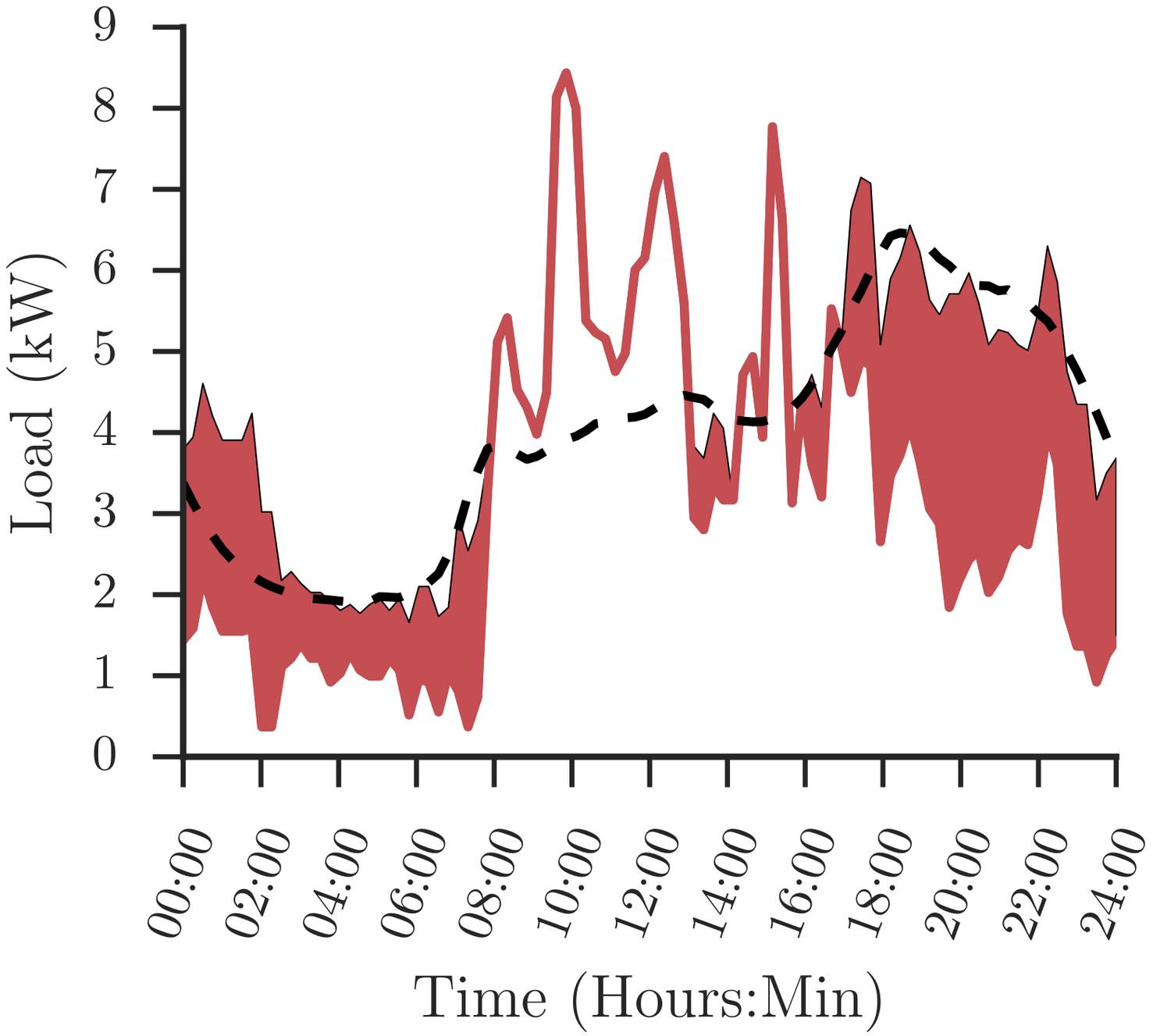
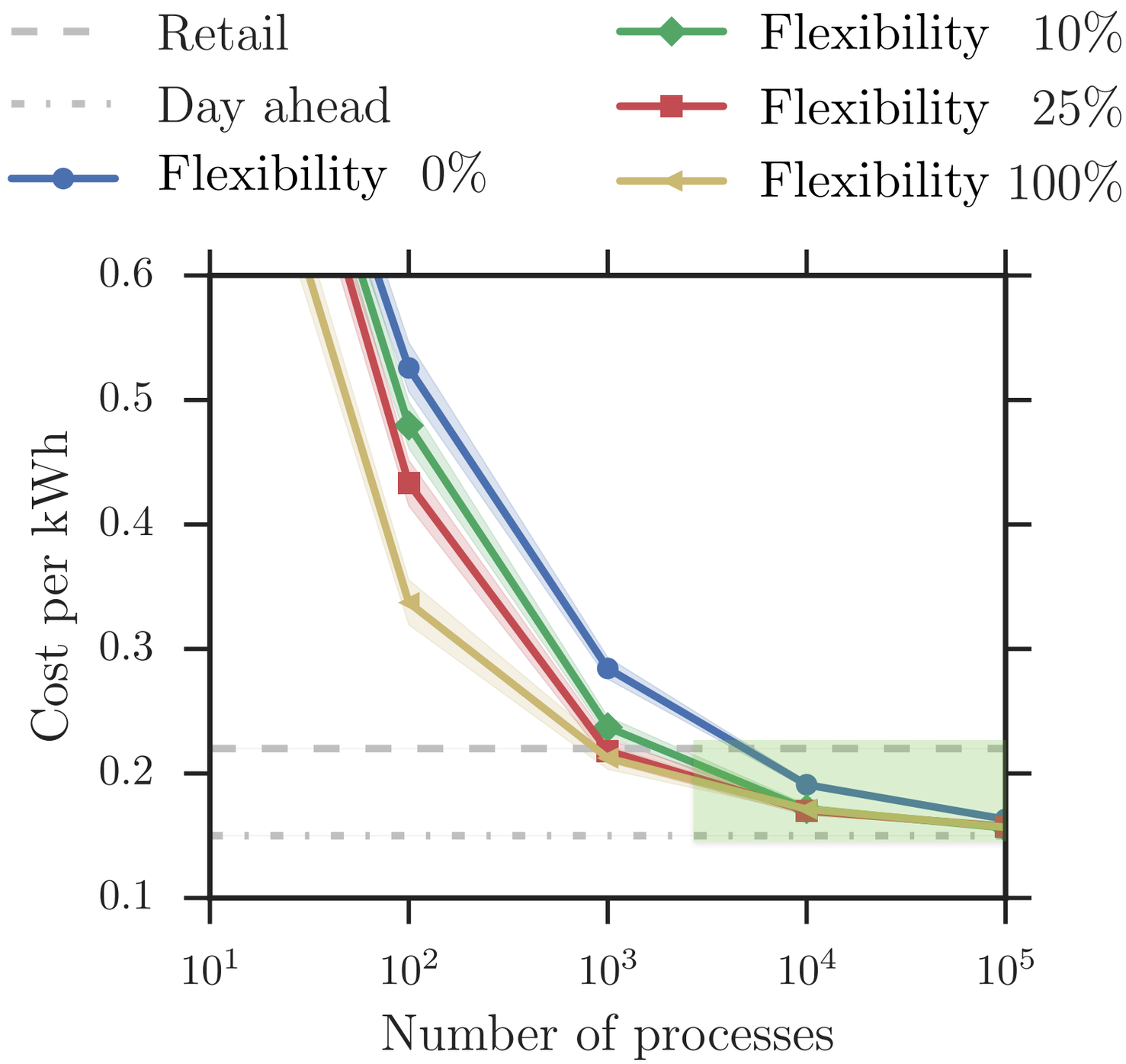


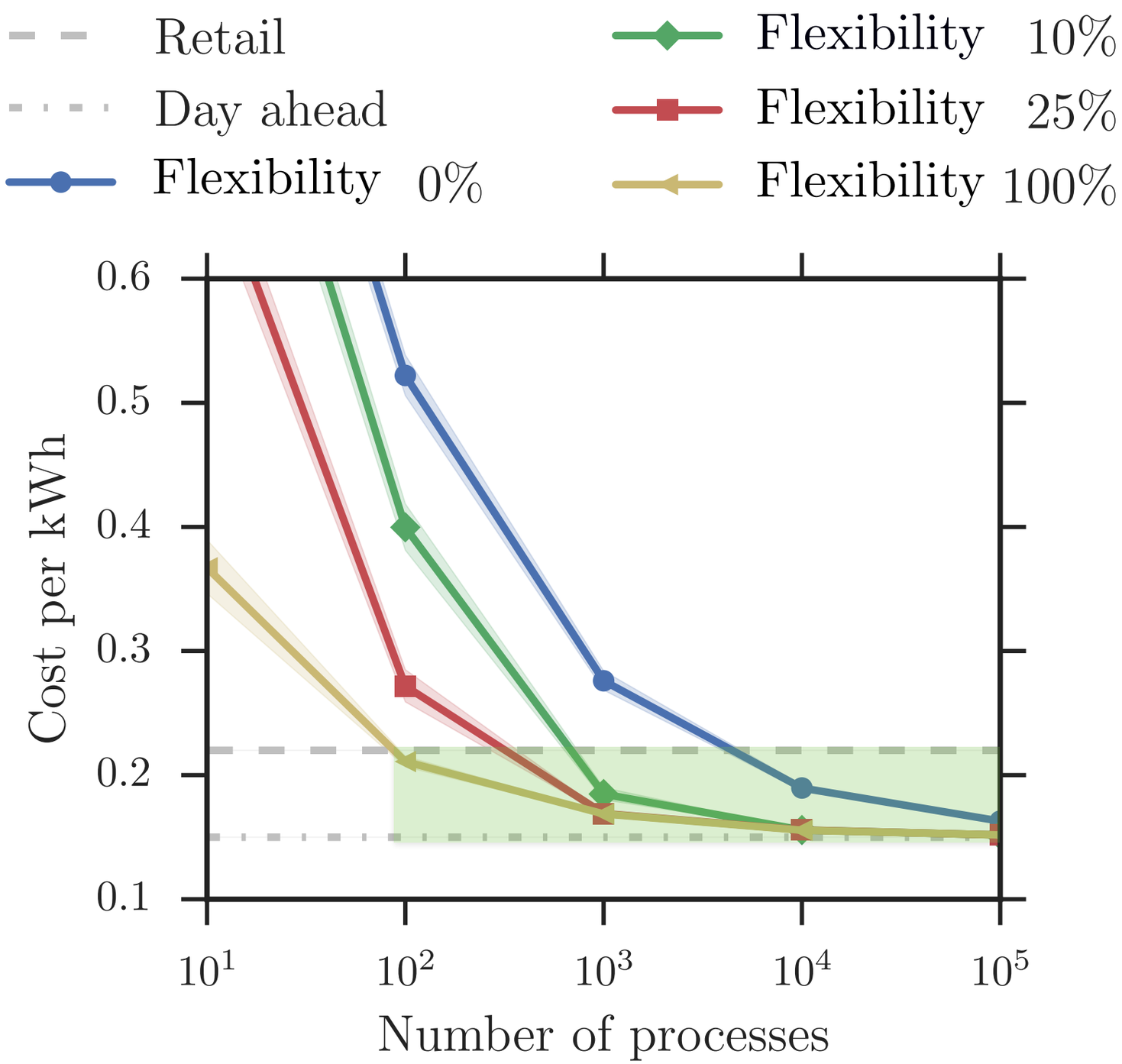
2. Intelligent Demand-Response



2. Intelligent Demand-Response



3. Between-Day Storage



Conclusion

- Multi-scale electricity demand model
- Minimum size of energy-cooperatives to participate under an innovative tariff
- Storage or intelligent demand-response methods

Conclusion

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Extensions

- Joint distributions for duration - load
- Continuous time model
- Varying process characteristics

A Multi–Scale Energy Demand Model suggests sharing Market Risks with Intelligent Energy Cooperatives

Thank you!

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