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Algorithms and Optimization Strategies for Building Energy Management & Demand Response

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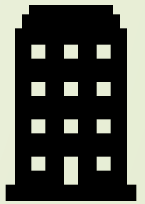
Outline

- Context
- Energy Forecasting
- Energy Optimisation
- Discussions & Conclusion

Context

- **Building Energy Management: building types/ operation characteristics**



  - Commercial (operating only in daytime)
  - Residential (all through the day, peak demand in early evening, low demand in night)
  - Industrial (all through the day, (normal) usage in night)

Context

- **Demand flexibility and demand response**

  - Smart meter data
  - Energy demand profiles/ building types

- **Renewable generation variations and uncertain**

  - Wind energy highly variable and uncertain
  - Solar energy not available in night

Context

- Forecasting algorithms are critical
- Optimization are efficient tools
- Research gaps and directions

Energy forecasting

- **Building physics-based approaches**
  - Physics-based differential equations
  - Building simulation model with details (building simulation software such as Energy Plus)
- **Machine learning based data driven approaches**
  - Supervised learning (classification and regression)
  - Unsupervised learning (clustering)
  - Hybrid methods

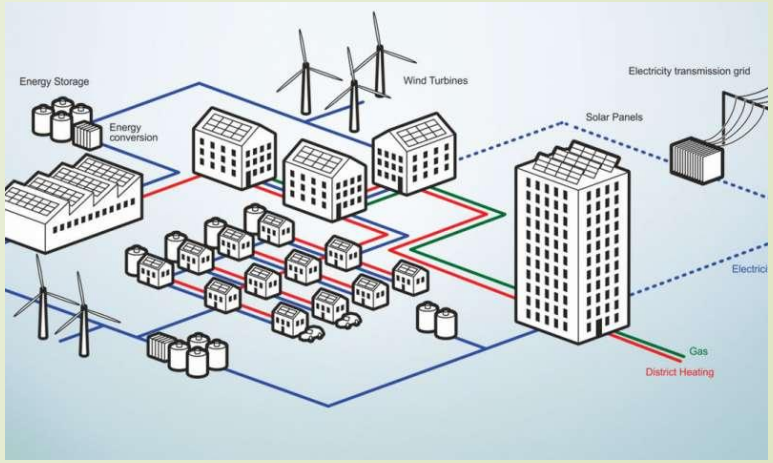
Building physics-based approaches

- **Physics-based differential equations**
  - each thermal appliance
  - Simplified aggregation model
- **Building simulation software**
  - Energy Plus

Data-driven Energy Forecasting

- **Building/home level energy forecasting**
  - Smart homes
  - Building energy management

- **District/grid level energy forecasting**
  - District energy management
  - Smart microgrids



Energy forecasting process

Common Forecasting Algorithms

- **Artificial neural networks (ANNs)**
- **Deep learning: recurrent neural network (RNN)**
- Support vector regression (SVR)
- Support vector machine (SVM)
- Radom forecast
- **Online learning**
- **Hybrid methods: clustering and classification/ regression**

Energy optimisation

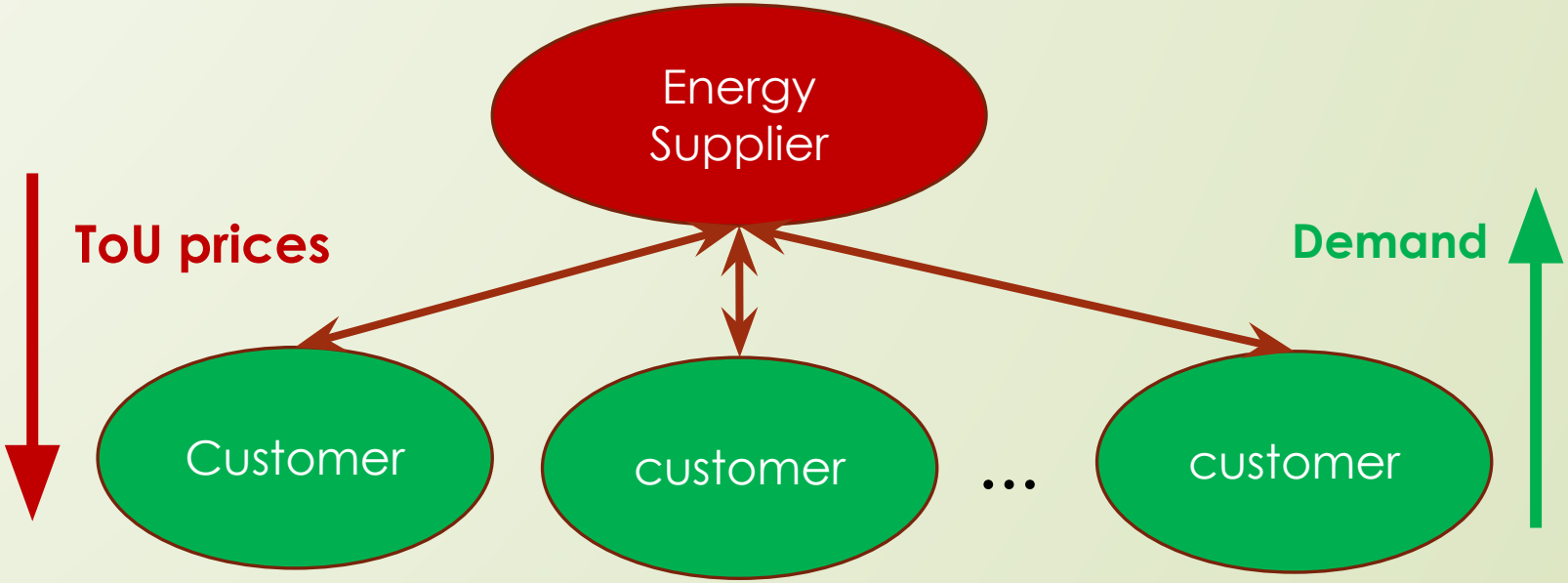
- **Energy forecast models in place!**
- **How to obtain optimal decisions to maximize users' utility**
  - Energy optimisation

Energy optimisation

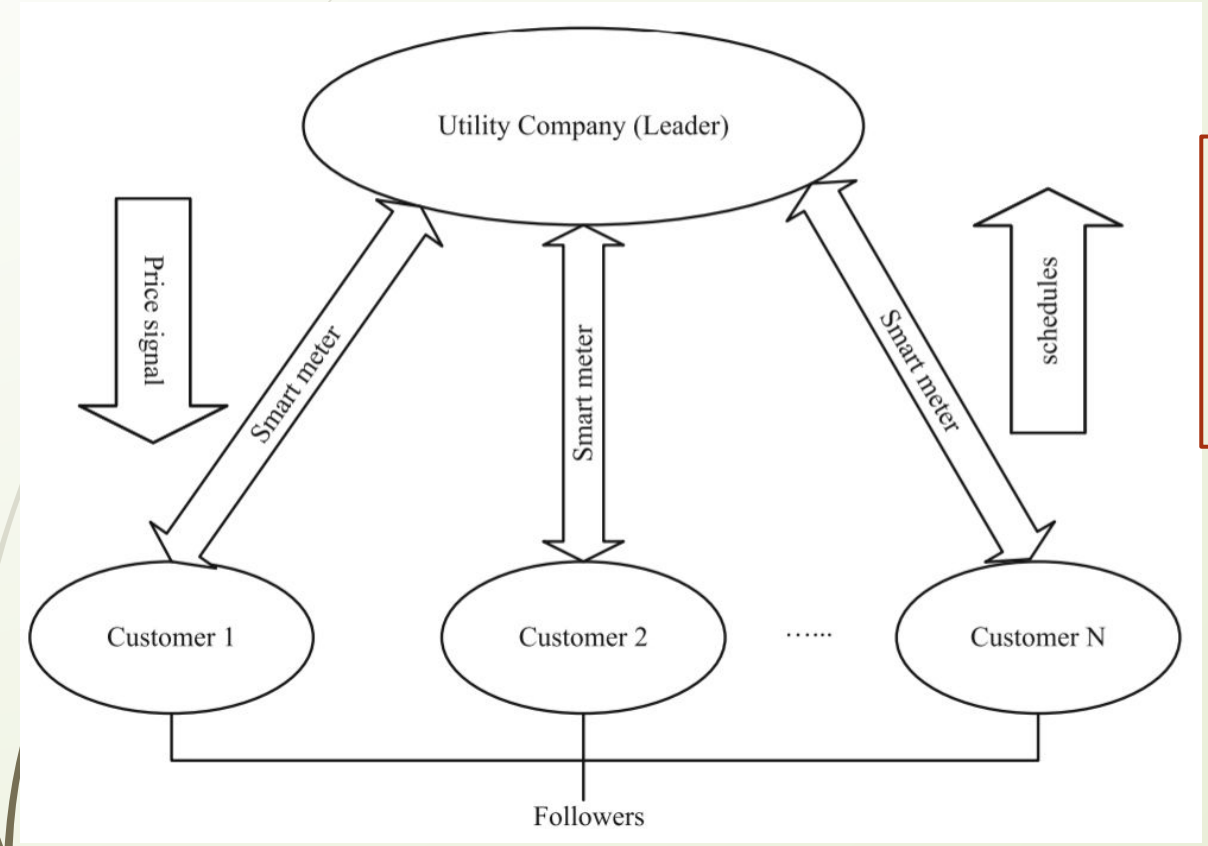
- **Multi-objective optimization vs single objective optimization**
  - ➢ Multi-party interactive decision making in a centralised way -> multi-objective optimization
- **Hierarchical (multi-level optimization) vs single level optimization**
  - ➢ Sequential decision making with multi-parties -> multi-level optimisation
- **Deterministic optimization vs stochastic optimization**
  - ➢ Model parameters and control variables are deterministic
  - ➢ Model parameters or control variables are stochastic

Hierarchical optimization: examples

- Hierarchical decision making



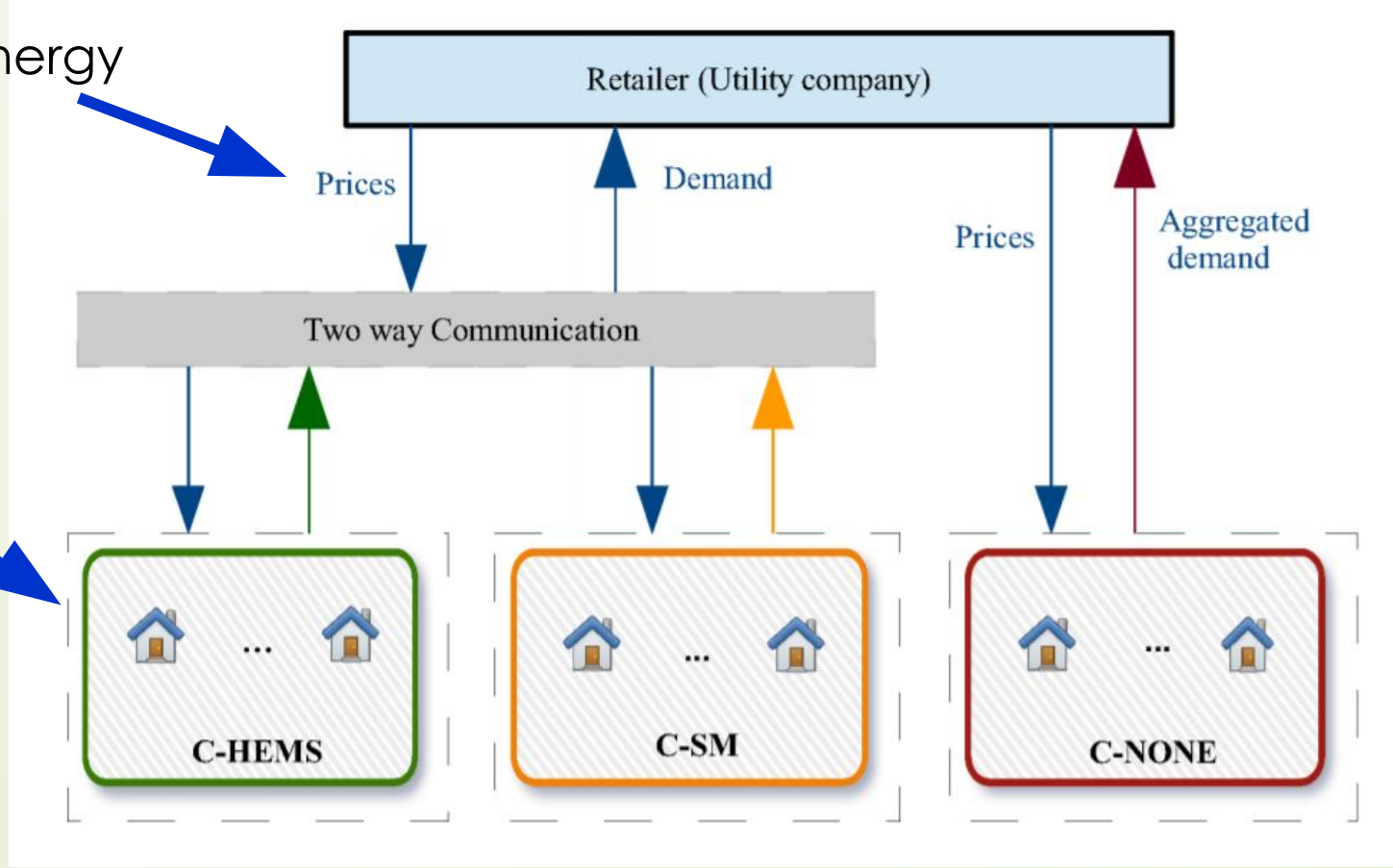
Case 1



- Optimize **energy prices** for energy supplier to maximize its profit.
- Optimize **energy usage** for customers to maximize their benefits.

Case 2

- Optimize **energy prices** for energy supplier to maximize its profit.
- Consider **customer segments** with different behaviours



Summary (1)

- **Energy forecast**
  - Home/building level forecast
  - District/grid level forecast
  - Building physic based model
  - Data-driven based models

- **Energy optimization**
  - Multi-level optimization vs single level
  - Multi-objective optimization vs single objective
  - Stochastic optimization vs deterministic

Summary (2)

- **Forecast algorithms selection**
  - ANN
  - Deep learning: RNN
  - Hybrid methods
  - Online learning
  - Problem dependant

- **Energy optimisation**
  - Trade-off between tractability and optimisation performance

Thank you!