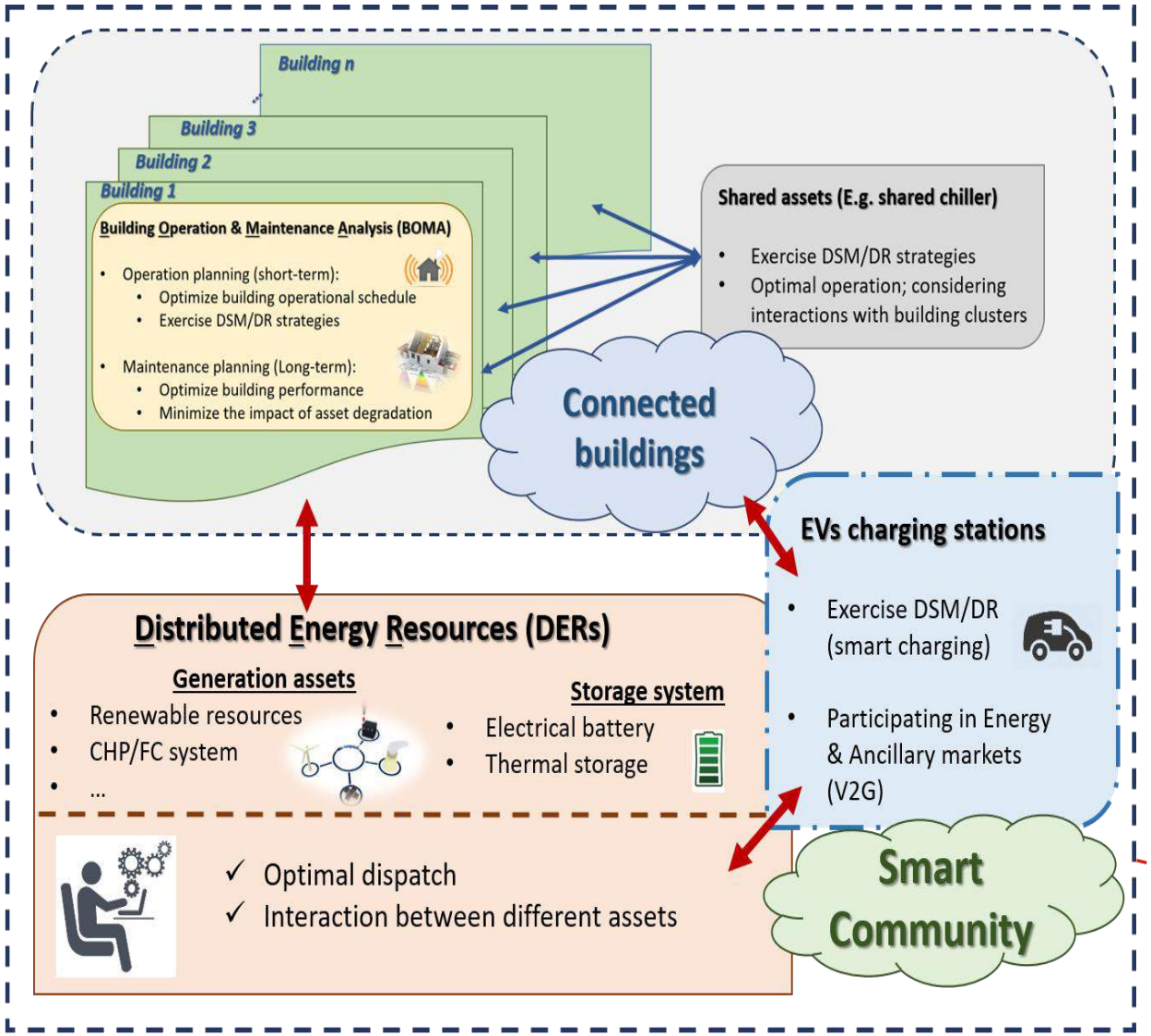
RUTGERS
School of Engineering

RU-LESS

Micro-grid Optimal Design and Planning

LESS Optimization and Control Tool-box

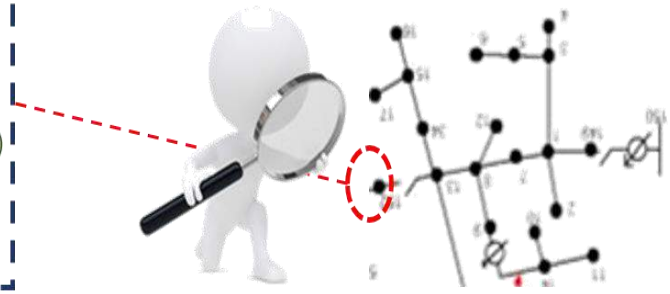


- **Different levels of analytics**

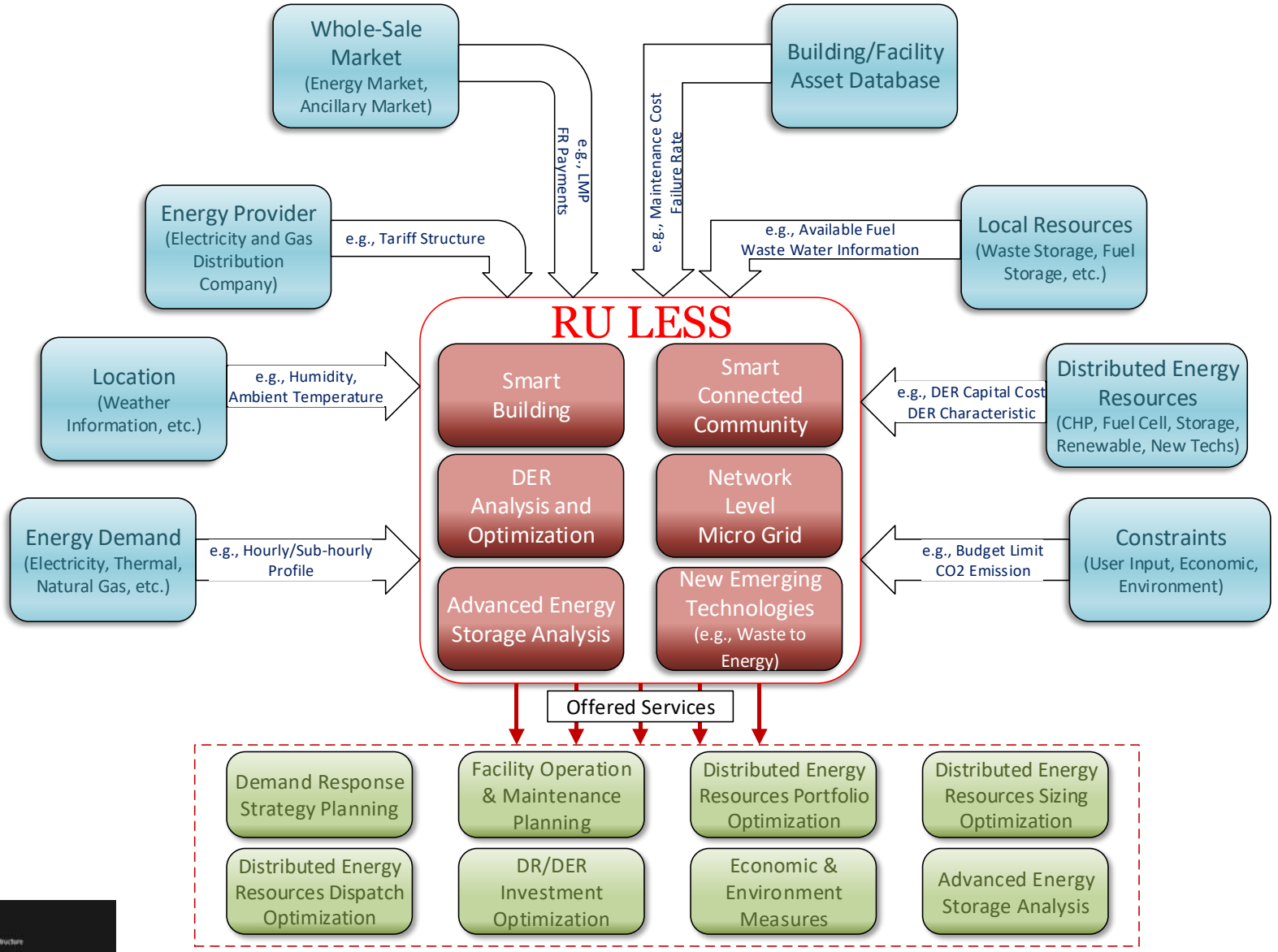
- **Facility level**
- Load forecasting
- Load disaggregation
- Optimal O&M strategies
- DER evaluation

- **Community level**
- Smart planning and control
- DER portfolio optimization
- Optimal dispatch of DERs

- **Network level**
- Network-aware planning and control
- Impact analysis: impact of DERs and DSM strategies on distribution network
- Optimal location of DGs in distribution network



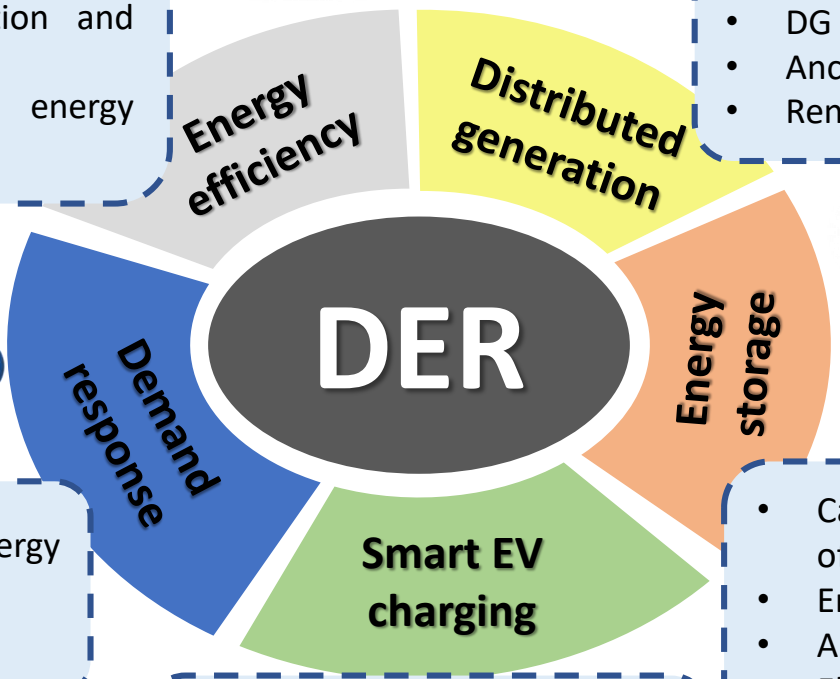
RU-LESS Core Modules



Distributed Energy Resources (DER)

- Building/Community smart control – Demand Side Management
- Building/Community operation and maintenance planning
- HVAC smart control for energy management purpose

- DG portfolio optimization
- DG optimal dispatch
- Ancillary service participation
- Renewable resources & CHP/FC



- HVAC smart control for energy management purpose
- Demand side management

- Capacity planning for the network of energy storage
- Energy storage optimal dispatch
- Ancillary service participation
- Electric and thermal storage

- EV charging smart control
- Energy market / ancillary service participation (V2G)

What does RU-LESS offer?

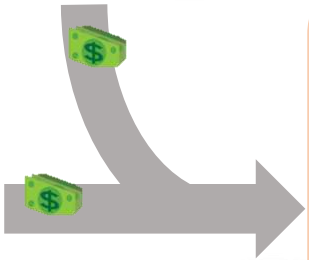
Demand side management

- **Building smart control**
  - Demand forecast
  - HVAC smart control
  - Lighting smart control
  - EV smart charging
  - Heating / cooling / mobility demand coordination for peak shaving and load balancing purpose
  - Smart material – smart control integration
  - Demand response planning for energy cost reduction

- **Community smart control**
  - Demand coordination among buildings
  - Community operation and maintenance planning for energy efficiency and reliability purpose

Distributed generation management

- DG portfolio optimization / capacity planning / optimal dispatch
- Energy storage allocation / capacity planning / optimal dispatch
- EV Optimal charge and discharge in the presence of V2G
- Network level power flow analysis
- Emission reduction analysis



DER revenue sources

- Energy cost reduction
- Demand charge reduction
- Ancillary market credit
  - Frequency regulation
  - Net-metering
- Resiliency improvement
- Advanced cost & benefit analysis

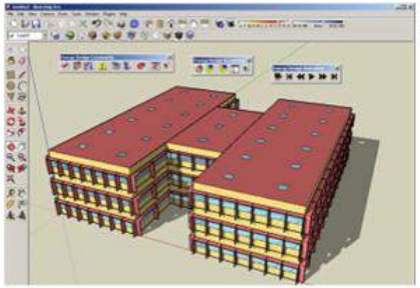
RU-LESS
sample research projects

Load forecasting toolbox– A hybrid (physics + statistics) approach

Forecasting

12 zones selected

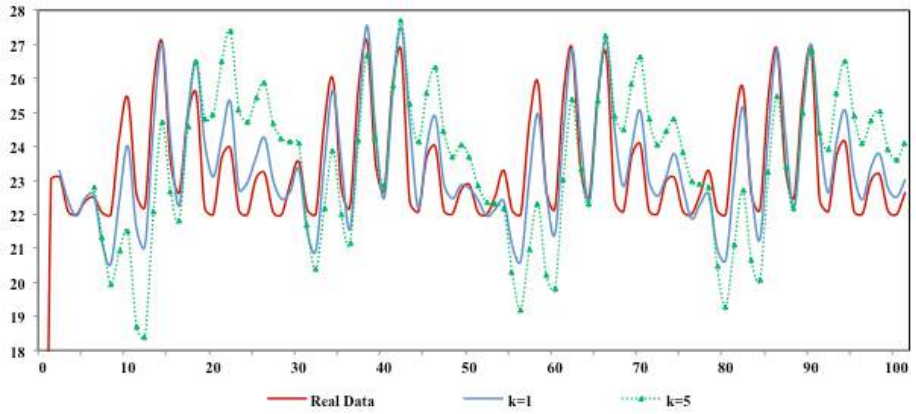
Phoenix Az
Offline: July 2009
Online: August 2009



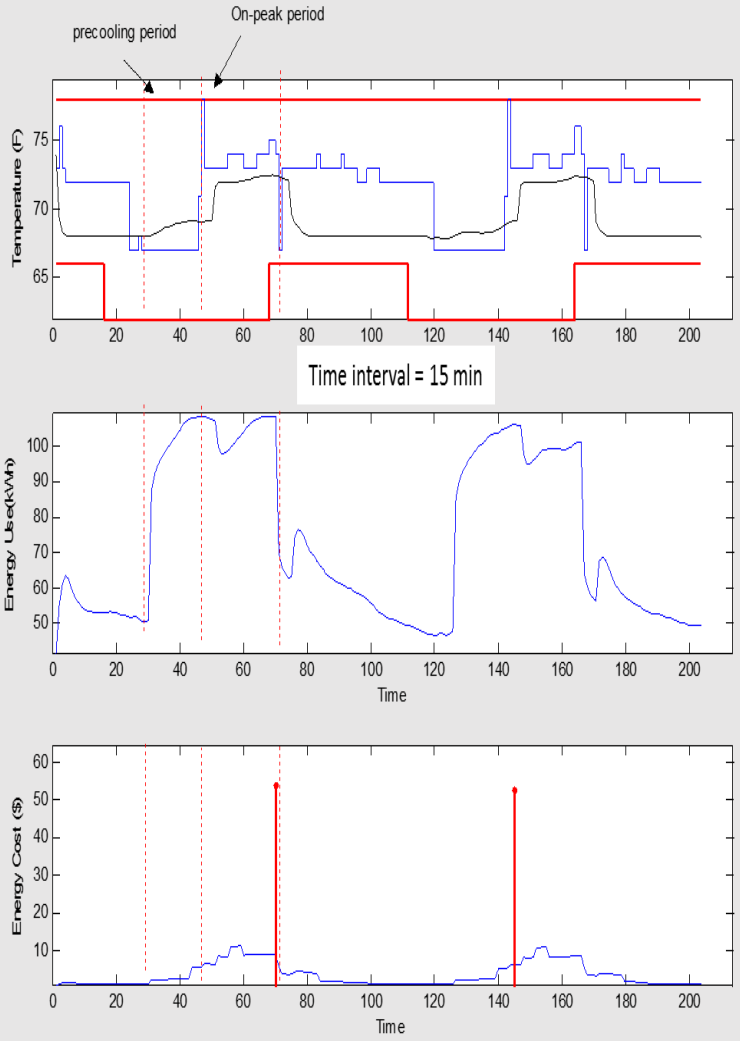
The Medium Office Example by USDOE

Standard Model used in many researches

$$\hat{T}_{in}^{t+k}(i) = \hat{T}_{in}^{t+k-1}(i) + \hat{\alpha}_i^k R^{t+k-1}(i) + \hat{\varphi}_i^k \left(\hat{T}_{in}^{t+k-1}(i) - \hat{T}_{ext}^{t+k-1}(i)\right)$$

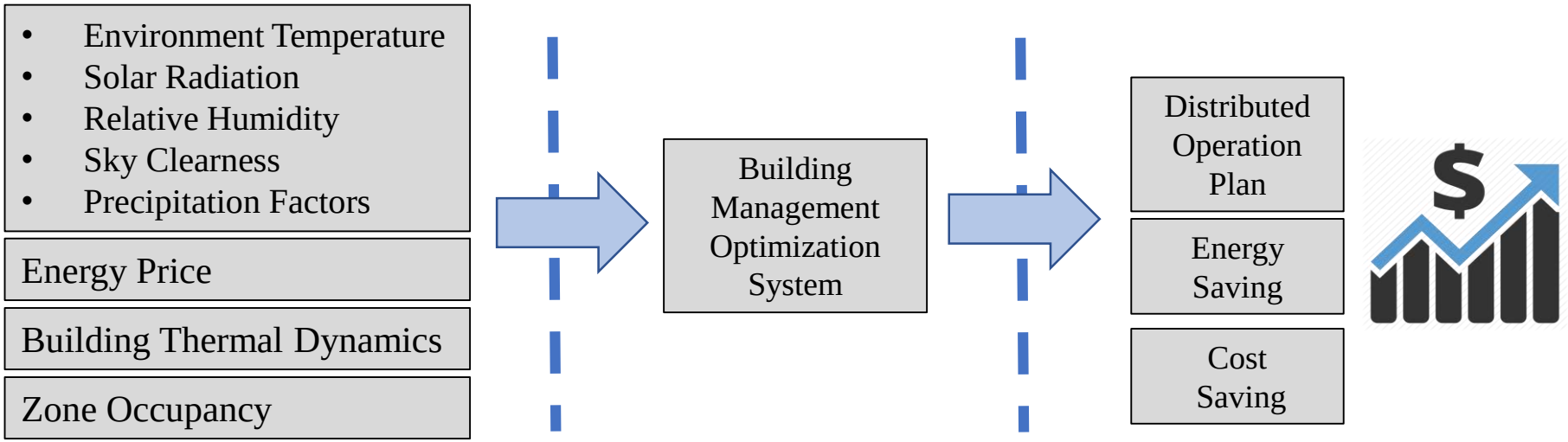


Optimization & MPC



Smart Building

- Building HVAC operation planning based on:
  - Human behavior
  - Building thermal capacity
  - Building thermal response
  - Weather patterns and asset condition
  - Human productivity and comfort level
  - High level control signals (utility/Community operator) for demand side management
- Data driven methods capture human preference/behavior and building thermal attributes
- Combined algorithms for building zone-level distributed control
  - Guaranties comfort/productivity levels for individual zones
  - Effective response to external signals
  - Avoiding from unnecessary HVAC/Lighting consumption

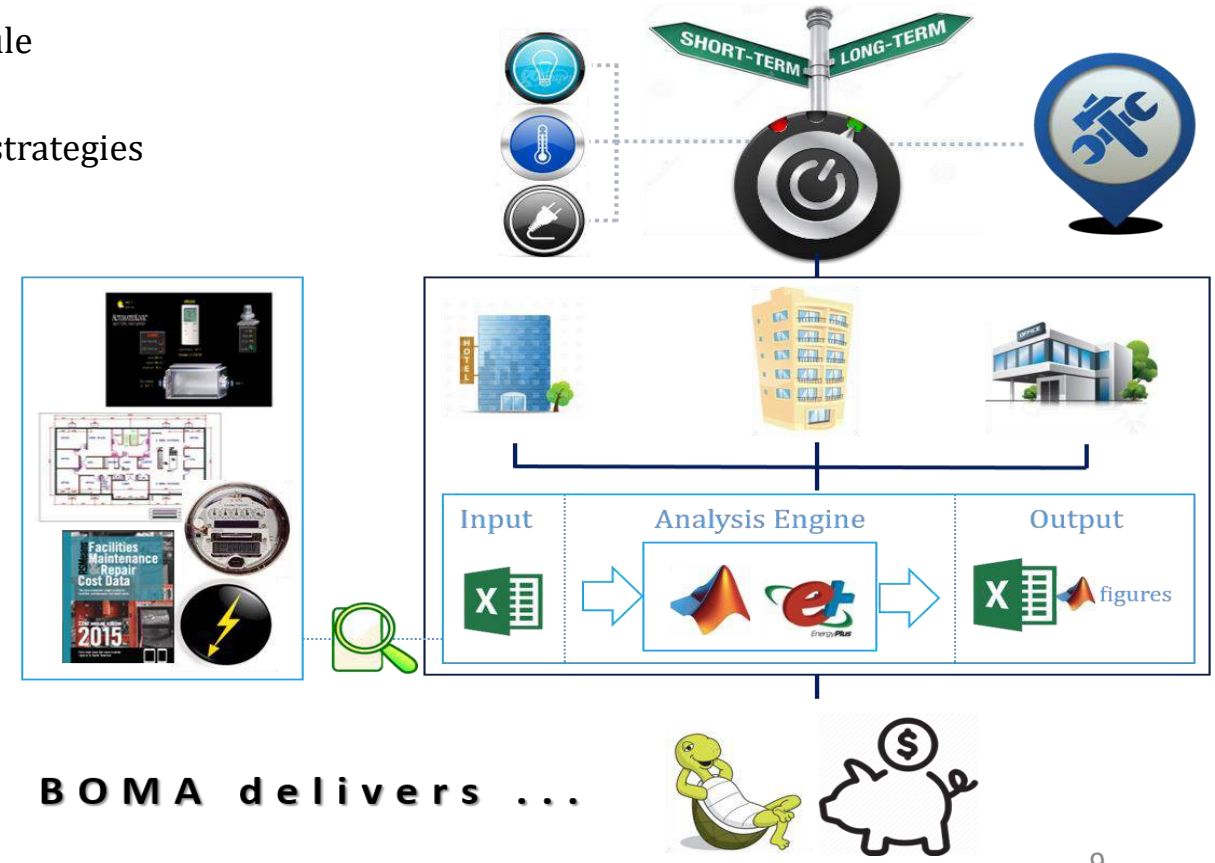


Smart Connected Community

- **Operational planning**
  - Estimation of hourly HVAC consumption
  - Hourly HVAC set point schedule
  - Lighting and equipment schedule
  - Load shifting capability
  - Evaluation of different control strategies
- **Maintenance planning**
  - Minimizing the impact of asset degradation
  - Maximizing building performance
  - Minimizing the impact of asset failure

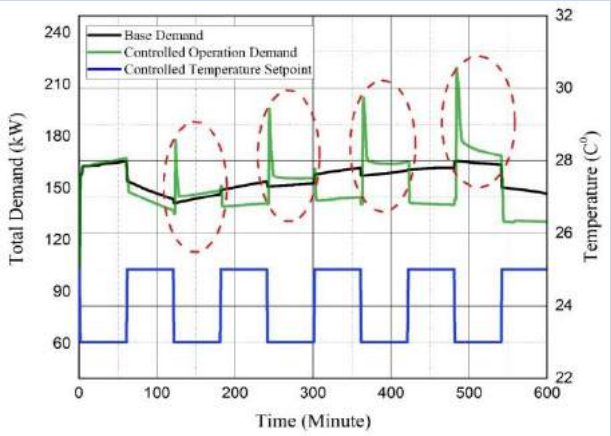
BOMA

(**B**uilding **O**peration & **M**aintenance **A**nalyzer)

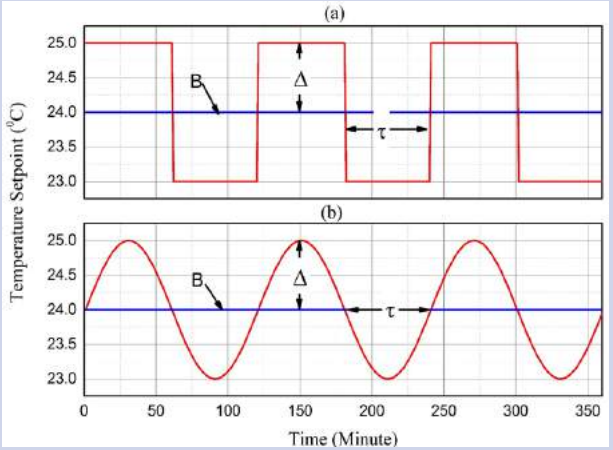


HVAC Cooperative Operation in Connected Buildings

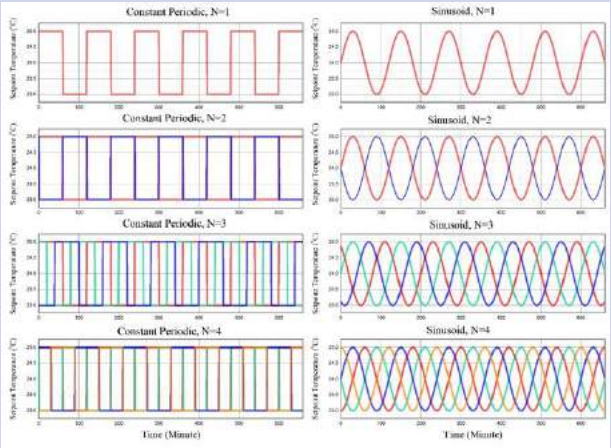
Using building thermal capacitance



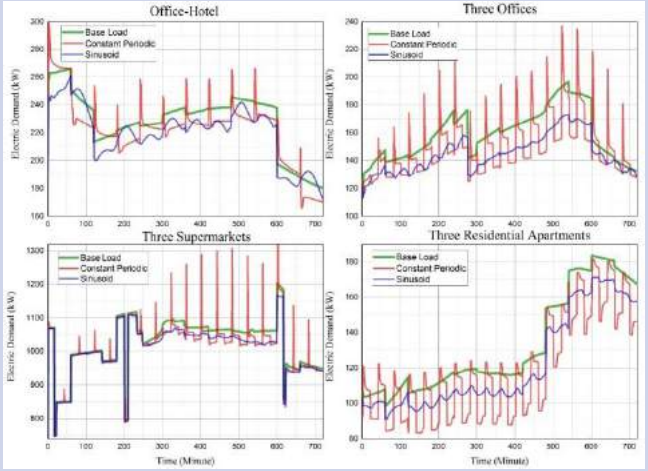
Periodic Setpoint Scheduling



Synchronized Operation for Building Clusters



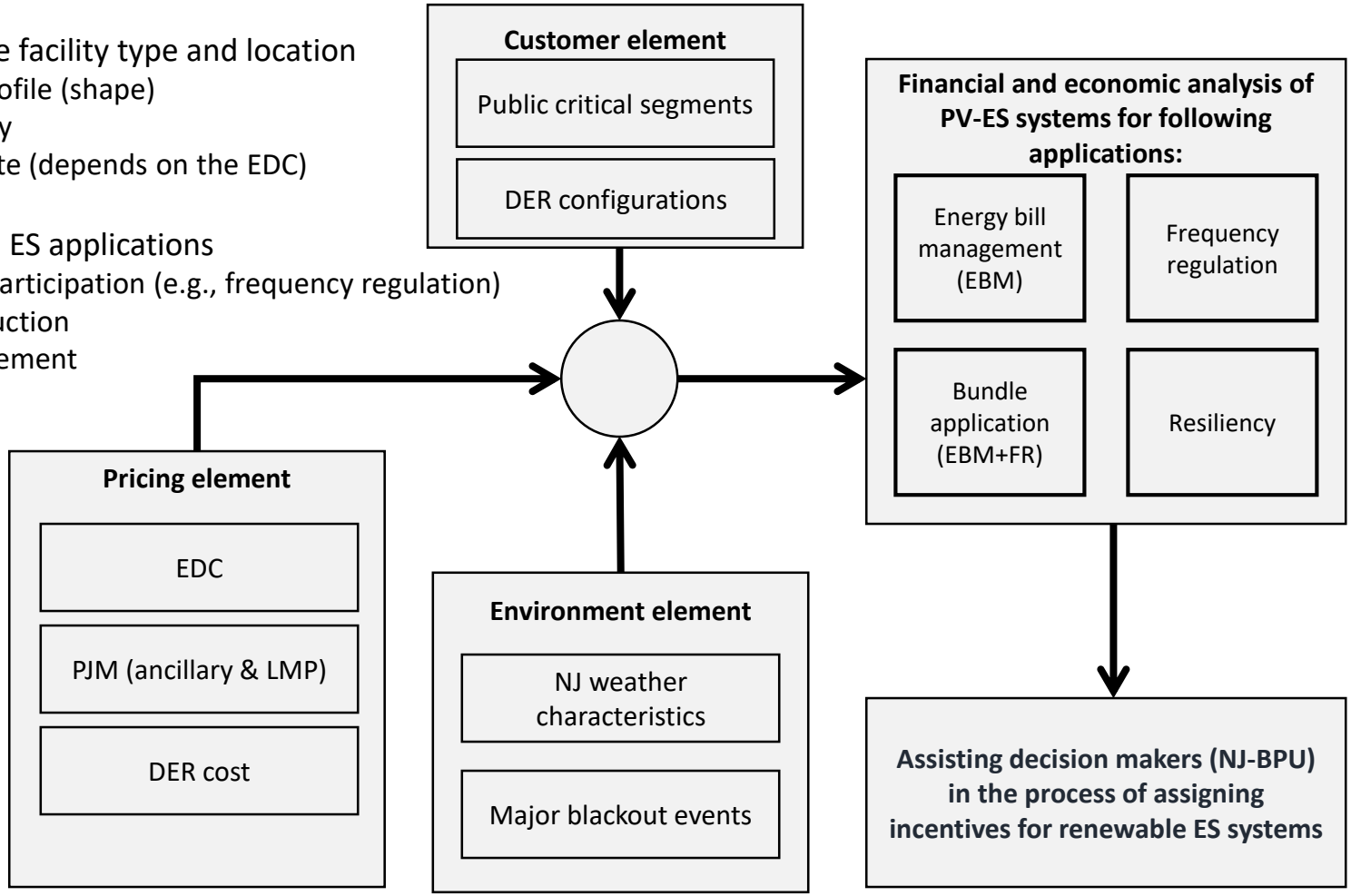
Saving Opportunities in Connected Buildings



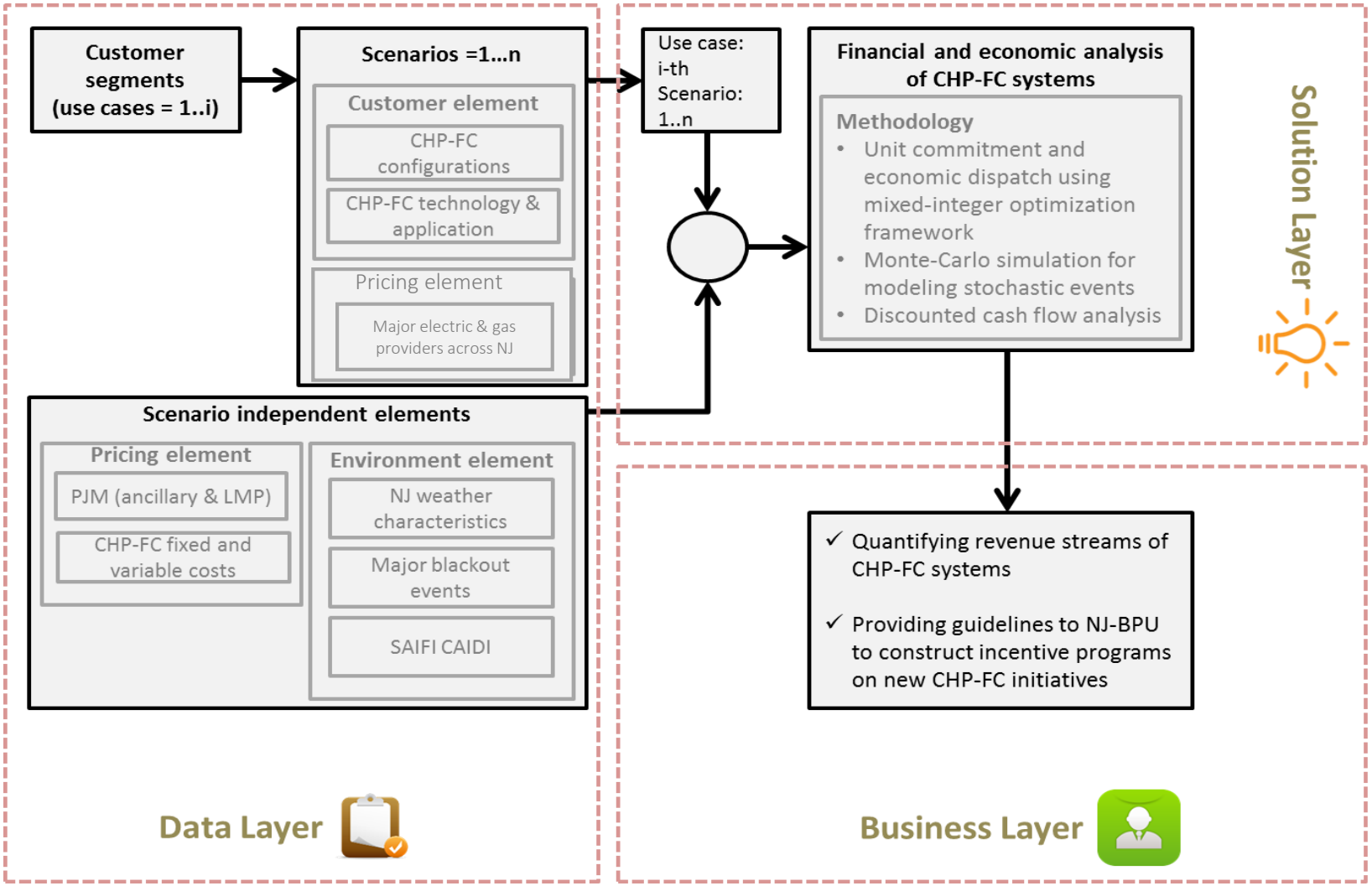
DER evaluation tool; Energy Storage evaluation for different facilities

- Evaluation based on the facility type and location
  - Electricity Load profile (shape)
  - Criticality of facility
  - Electricity tariff rate (depends on the EDC)
- Evaluation according to ES applications
  - Ancillary market participation (e.g., frequency regulation)
  - Electricity bill reduction
  - Resiliency Enhancement

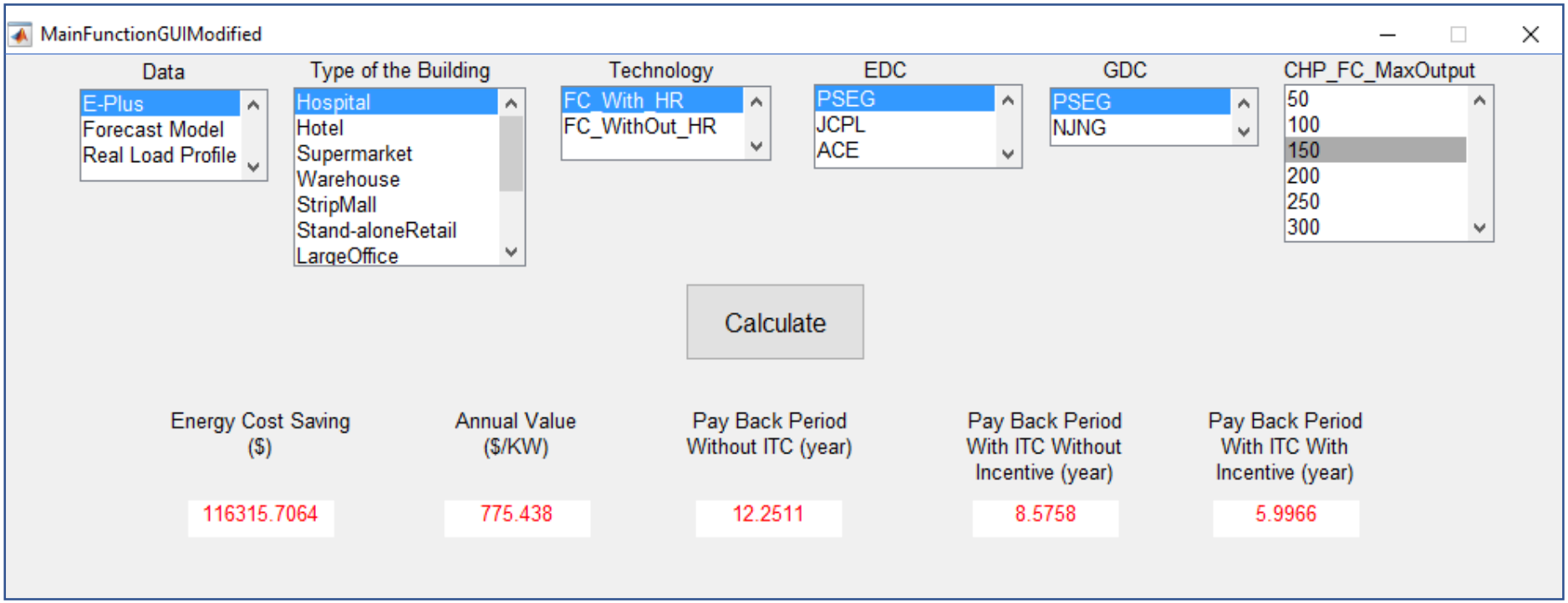
Methodology;
- Mixed-integer optimization framework for daily economic dispatch
- Monte-Carlo simulation for blackout events
- Discounted cash flow analysis



DER evaluation tool; CHP/FC evaluation for different facilities



CHP/FC evaluation tool (User Interface Screen-shot)



DER portfolio optimization & management

- Advance investment planning using real-option approach
- Portfolio optimization considering different sources of uncertainty
  - Energy price
  - Technology cost
  - Future demand, etc.

- Portfolio
- Gas-fired, PV, Wind Turbine, Energy storage, …

- Uncertainty in Investment
  - Gas price
  - PV and Storage capital cost

- Gas Price
- Electricity Price
- Electricity Demand
- Weather Data
- Micro-grid's Configuration

Planning/Operation Model

Micro-grid's Cost/Revenue

- Investment Model

- Investment cost
- Financing

Economical dispatch; considering operation uncertainties

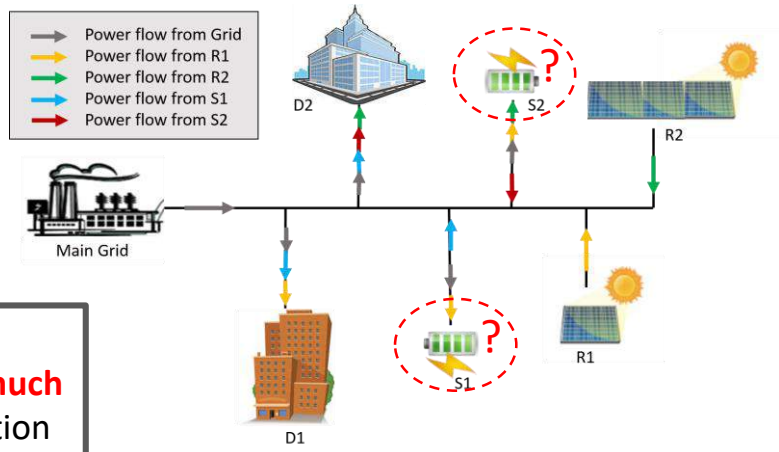
DER Optimal dispatch tool

RUTGERS Center for Advanced Infrastructure and Transportation

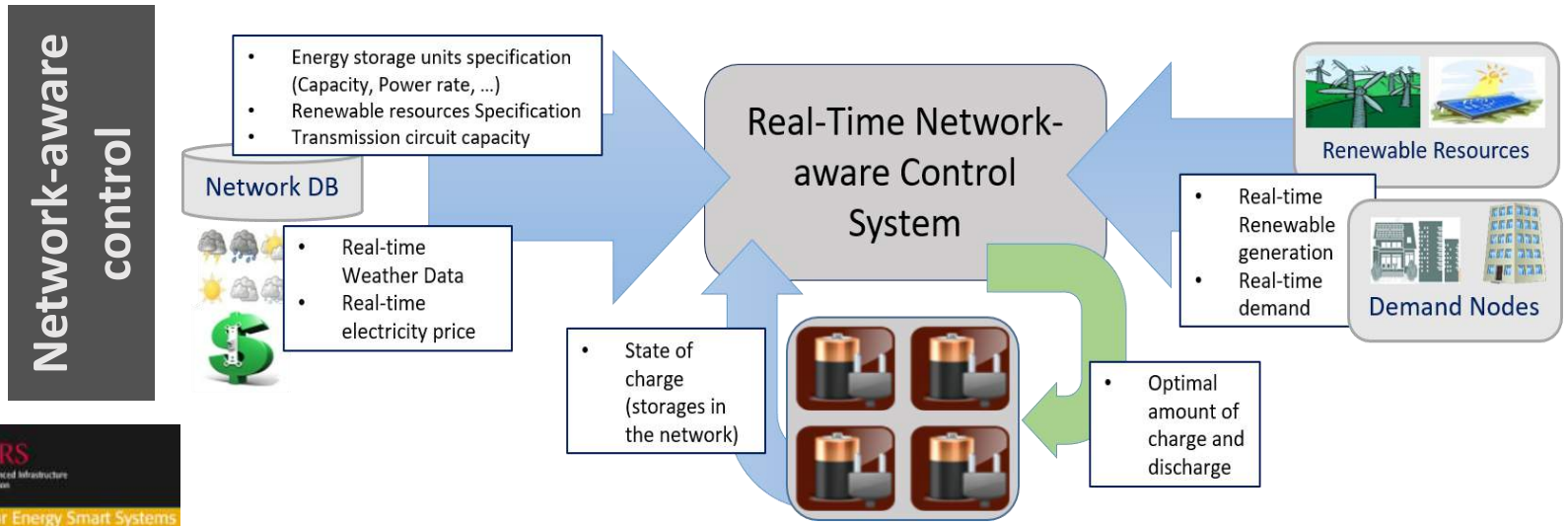
Laboratory for Energy Smart Systems

Energy storage Network-aware planning and control

- Multiple demand nodes
- Multiple renewable energy resources
- Multiple candidate nodes for storage installation

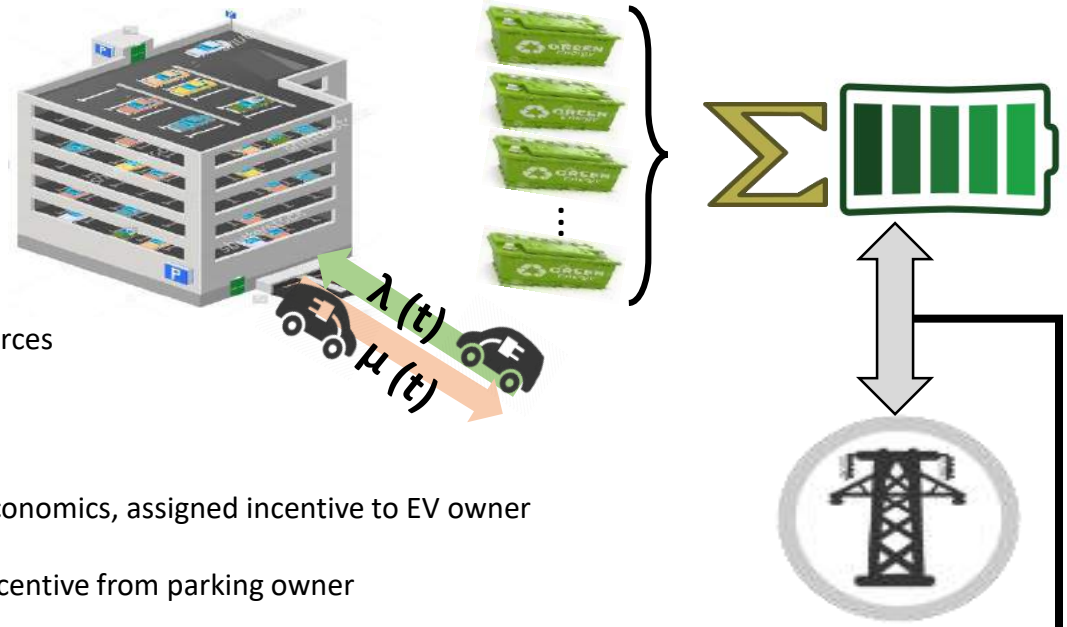


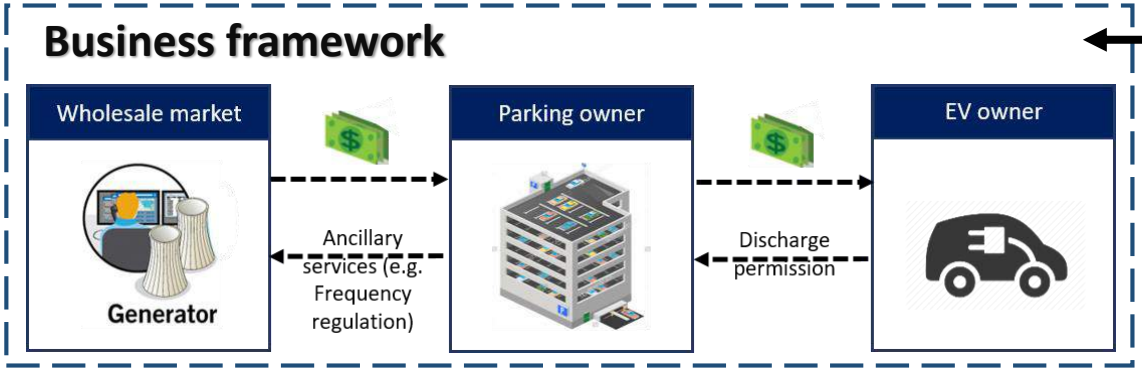
- Capacity planning: **Where to locate** storage systems and **how much capacity to allocate** to each node for optimal sizing and operation



New Emerging Technologies; Dynamic Storage Analysis (EV Parking Lot)

- Aggregated EVs could be utilized as an electricity resource
- Growth in electrical vehicle (EV) adoption
  - Smart charging infrastructure; DSM opportunity
  - Vehicle-to-grid (V2G) connectivity; electricity resources
- Cost and benefit analysis (CBA)
  - Parking owner perspective: market participation economics, assigned incentive to EV owner
  - EV owner perspective: battery degradation cost, incentive from parking owner





- Participating in different markets:
  - Energy market
  - Ancillary services (e.g. frequency regulation)

Thank you