Energy Management Systems

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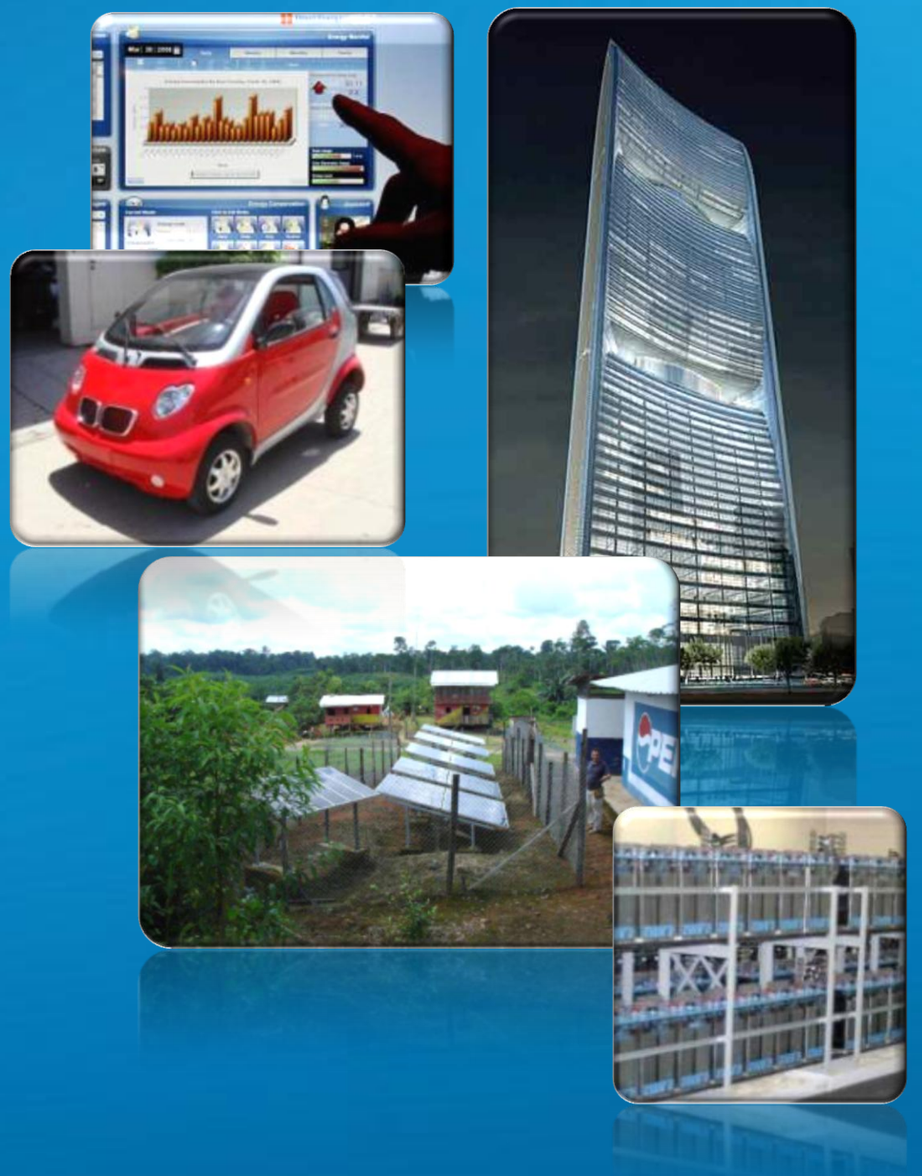
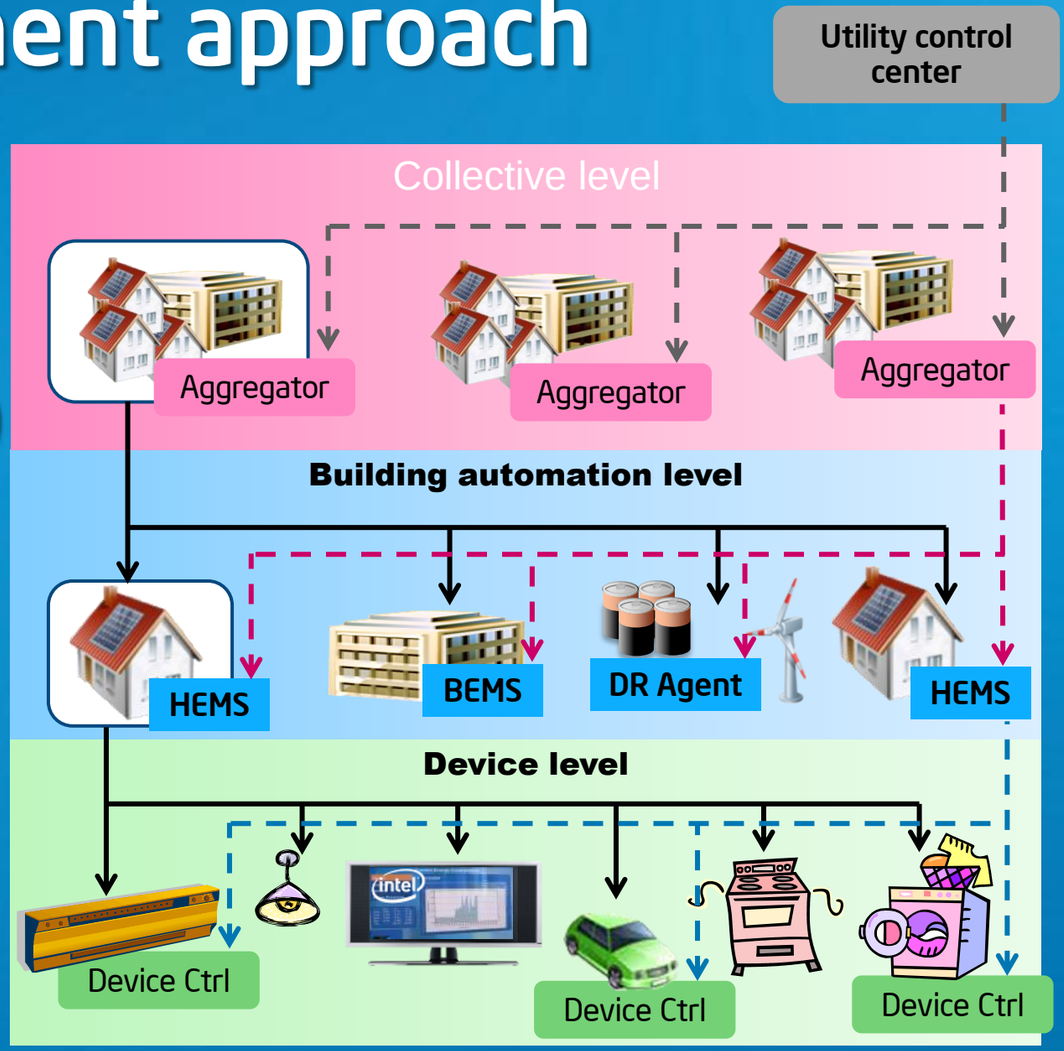
Project goal

Our research aims to develop Energy Management Systems which shape the power demand of devices, buildings and collections of buildings in order to benefit individual consumers by minimizing their energy cost, and society at large by enabling efficient, reliable Smart Grids with significant renewable generation.



Multi-level management approach

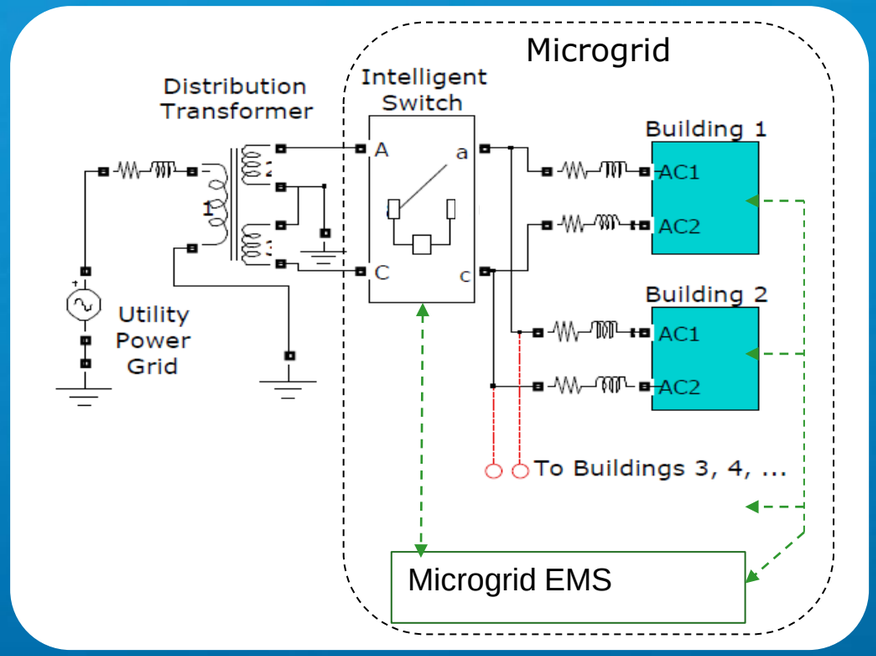
- Device level (Device controller)
  - Only in smart loads/DR, e.g. EV
  - Single device optimization (quadratic)
- Building level (HEMS/BEMS)
  - Optimization of several devices
  - Multi-objective (search)
- Collective level (Aggregator)
  - Optimization across collection of buildings & shared resources
  - Linear opt/multi-agent system?

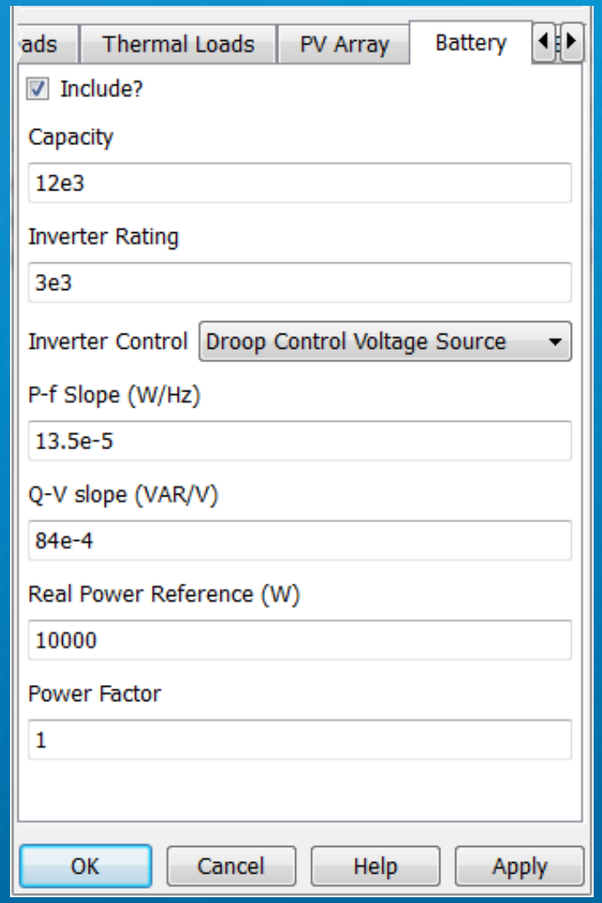


*DR = Distributed Resource

Multi-level modeling tools

- Simulation platform in Matlab and Simulink being developed in collaboration with the University of Colorado
  - Short (sec/min) and long (hr/day) time scales
  - Microgrid can operate off-grid (islanded) and grid-tied
    - ensure seamless disconnection & re-connection





Multi-level examples and results

- Device-level : plug-in electric vehicles (PEVs)
  - significant and potentially intelligent loads
- Building-level : Home Energy Management System
  - targeting next generation HEMS products
- Collective level : EV charging aggregator
  - at early stages, with preliminary results

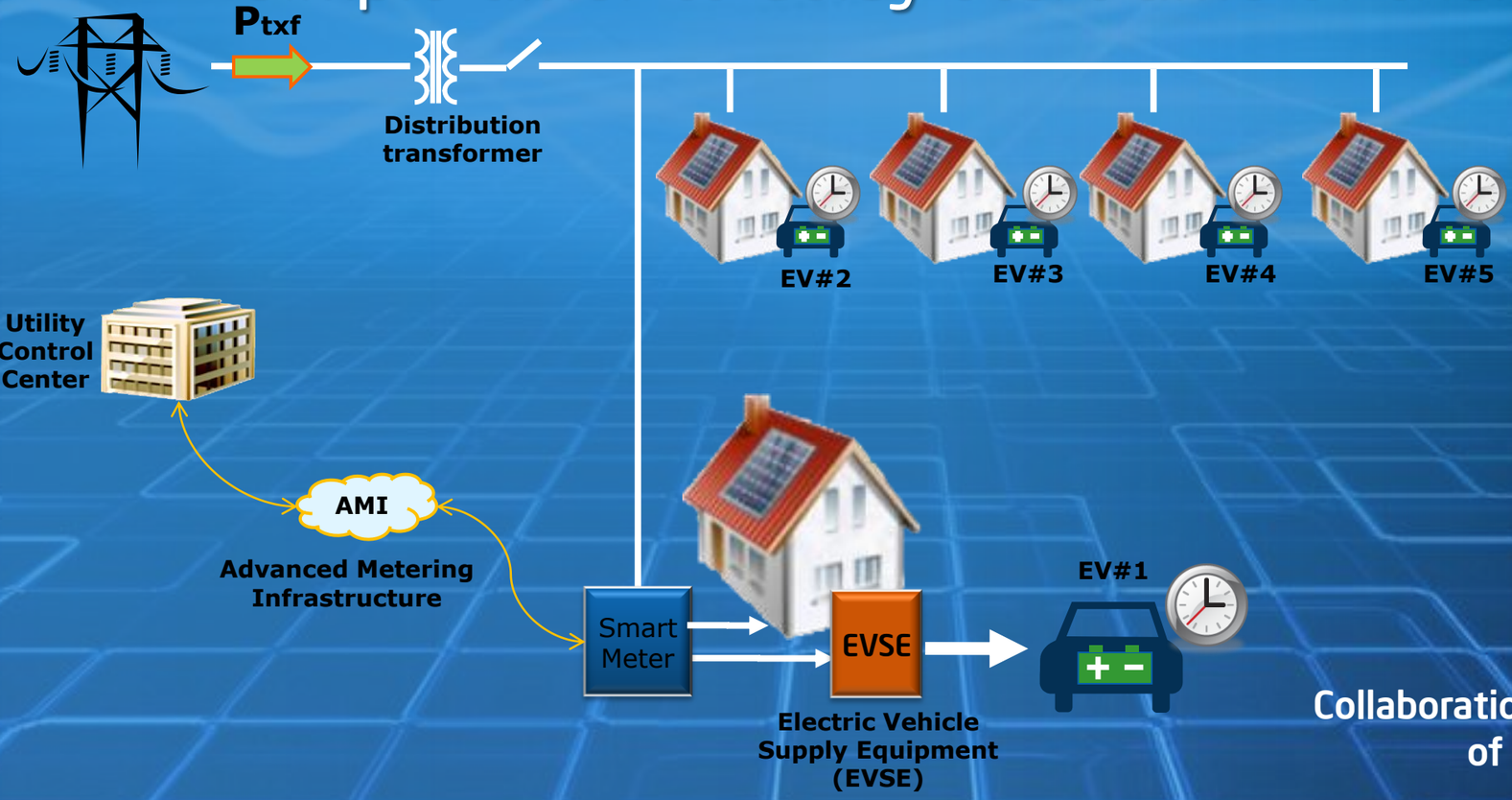
Demo at http://www.intel.com/embedded/energy/homeenergy/demo/index.html

Collective
Building
Device

Five residences charging EVs

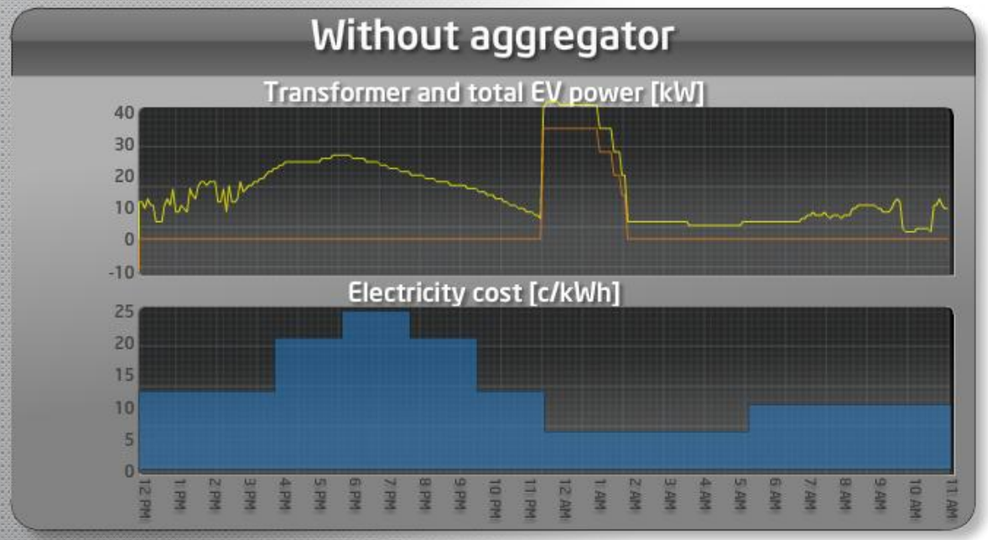
Consumers billed based on time of use electricity pricing

Simple timer to delay start time of charging



Collaboration with University of Colorado, Boulder

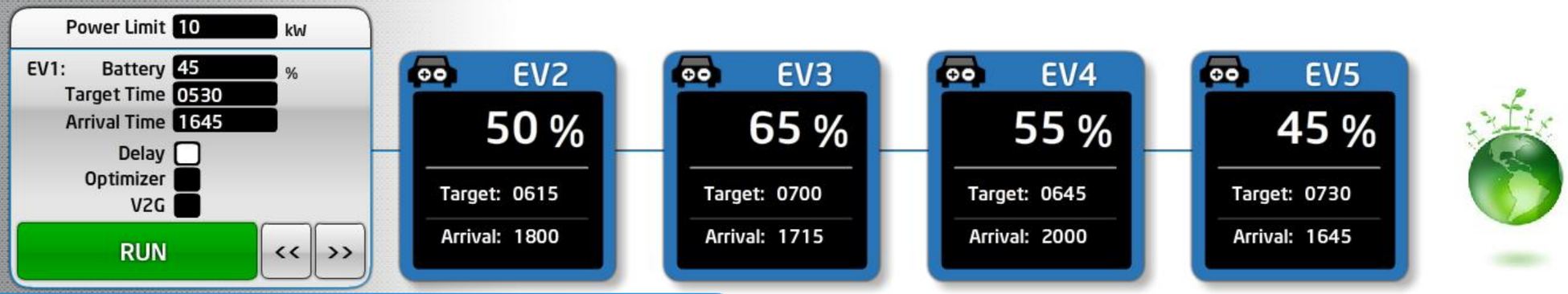
Intelligent Energy Management for Electric Vehicles



Total power through transformer (Ptxf)

Contribution of PEVs to Ptxf

Note time scale : time plotted from noon on Day 1 through noon on Day 2



Simple time delay

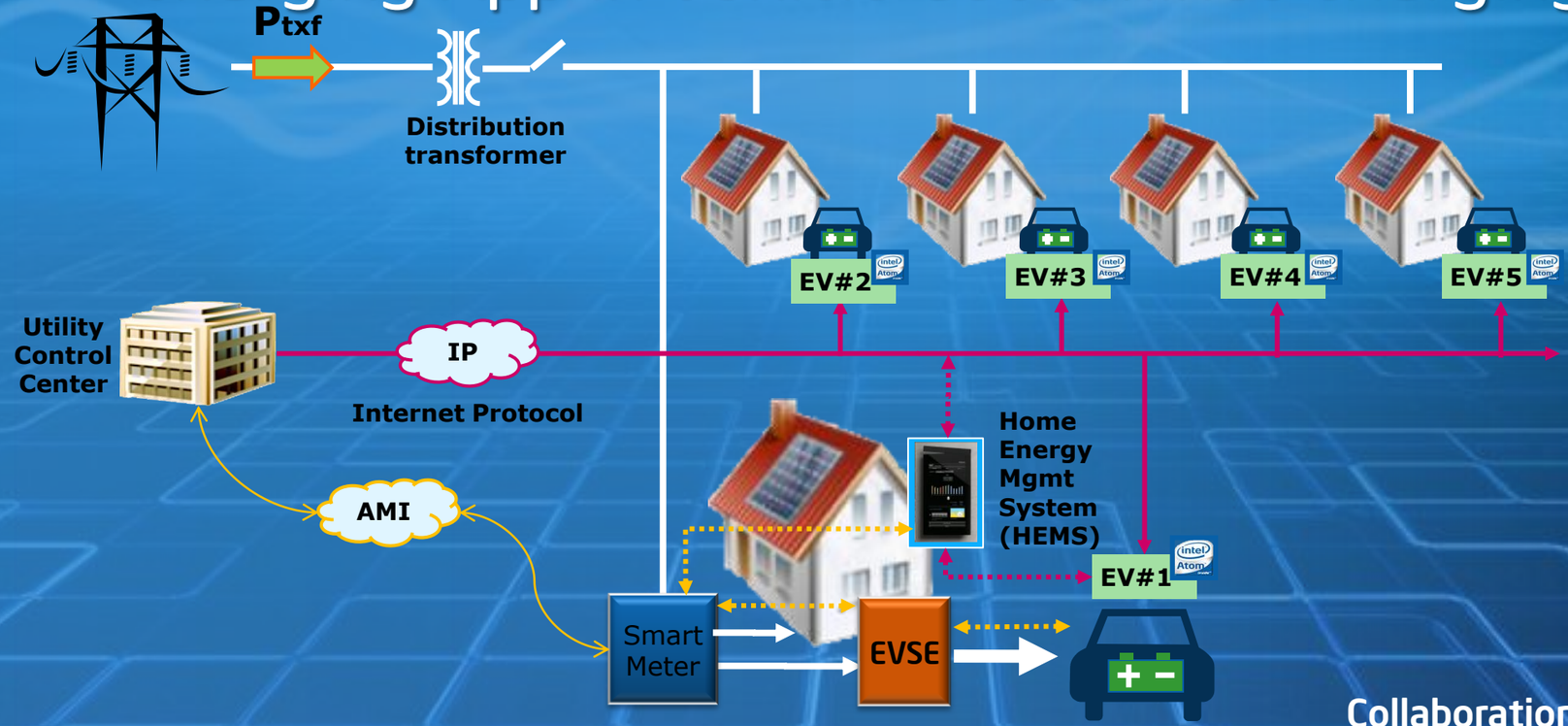
- Charges during minimum load period

Collective
Building
Device

Smart charging of individual EVs

Electricity cost profile provided to vehicle

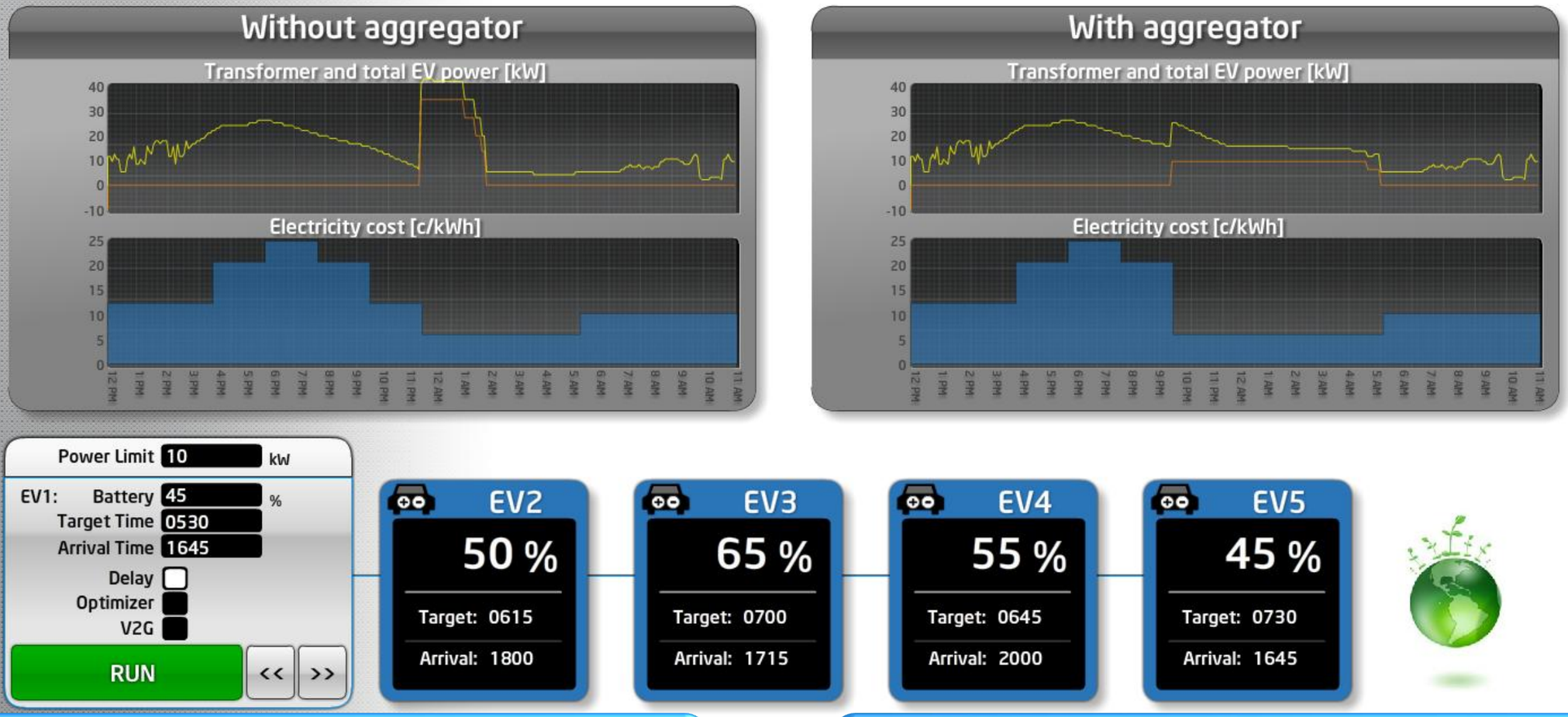
Charging App in vehicle determines charging profile



Collaboration with University of Colorado, Boulder

Collective
Building
Device

Intelligent Energy Management for Electric Vehicles



Simple time delay

- Charges during minimum load period

Intelligent vehicle optimizer

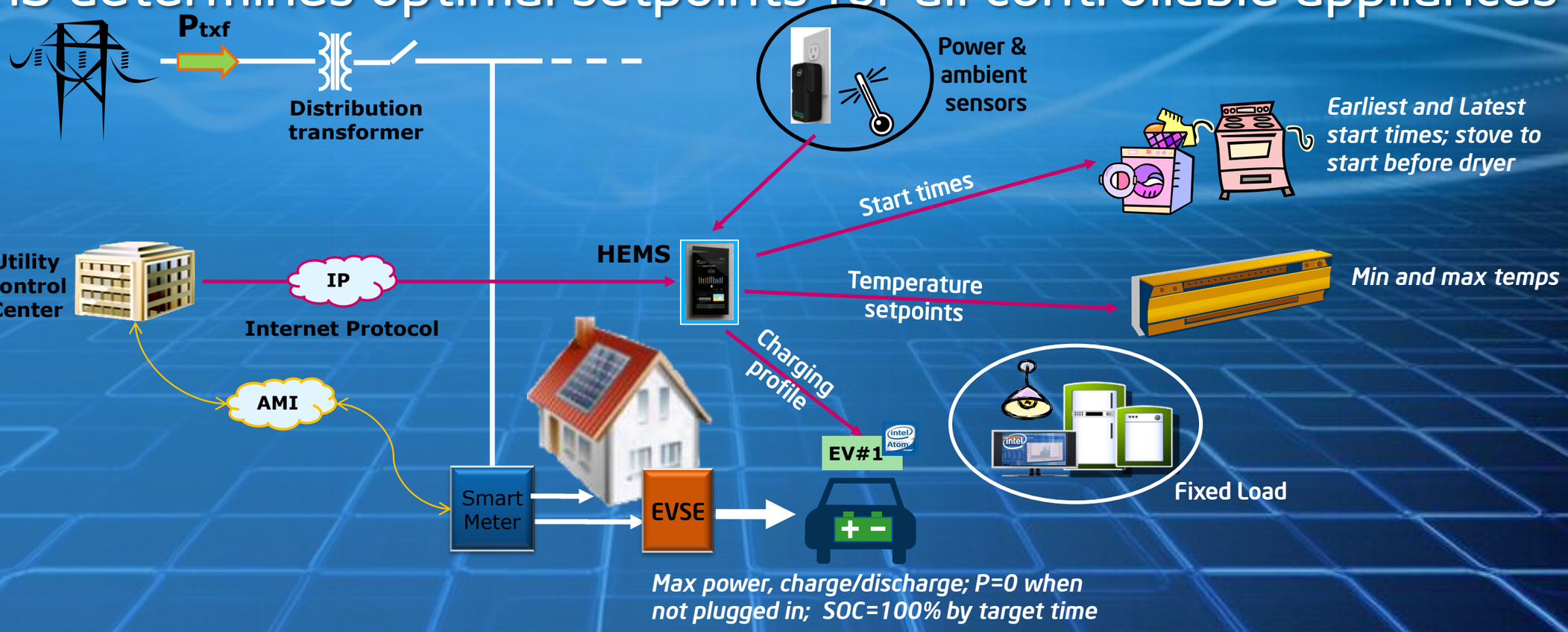
- Minimizes cost and charging rate of PEV

Collective
Building
Device

Home Energy Management System

Electricity cost profile provided to the HEMS

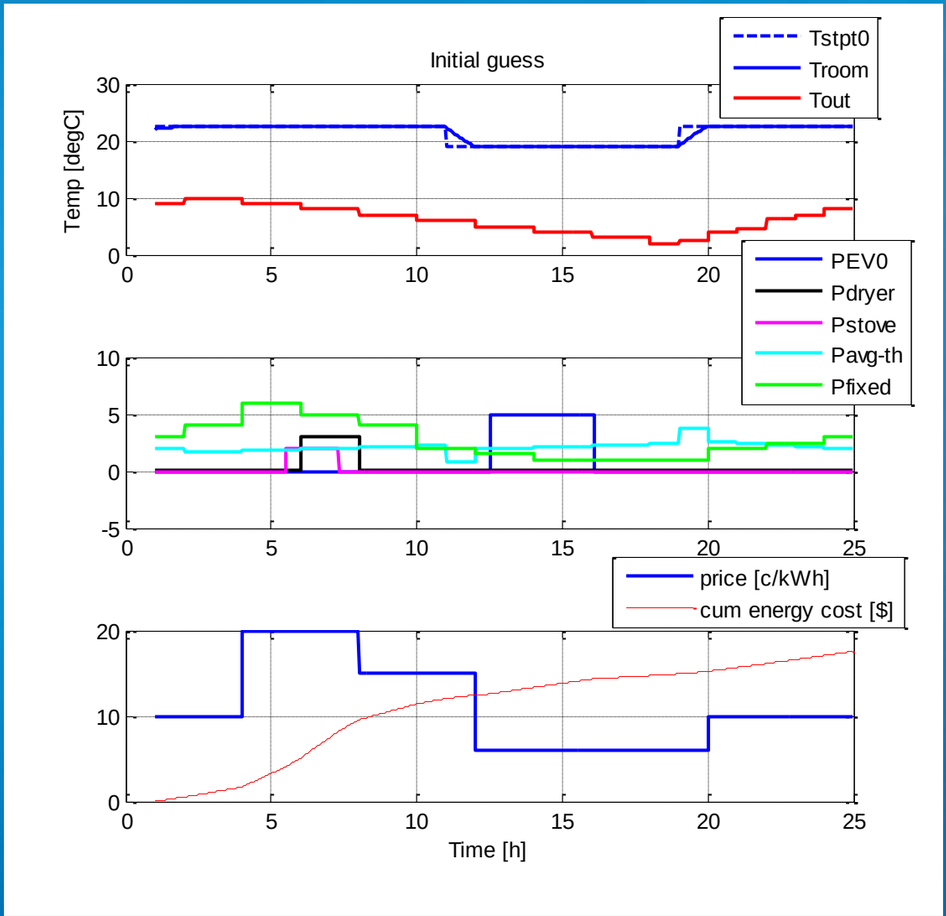
HEMS determines optimal setpoints for all controllable appliances

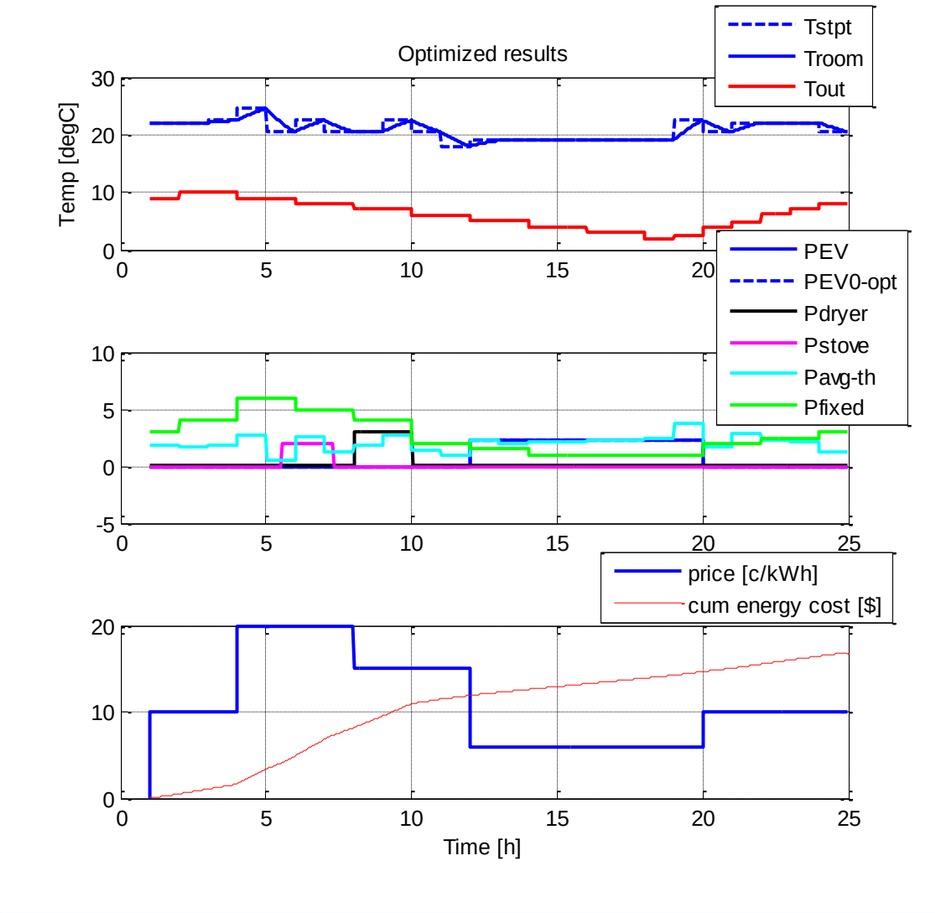


Collective
Building
Device

Preliminary results : Single optimization result

- 8.5% cost savings; balanced with user comfort
  - EV charging not lower cost, but grid-friendly

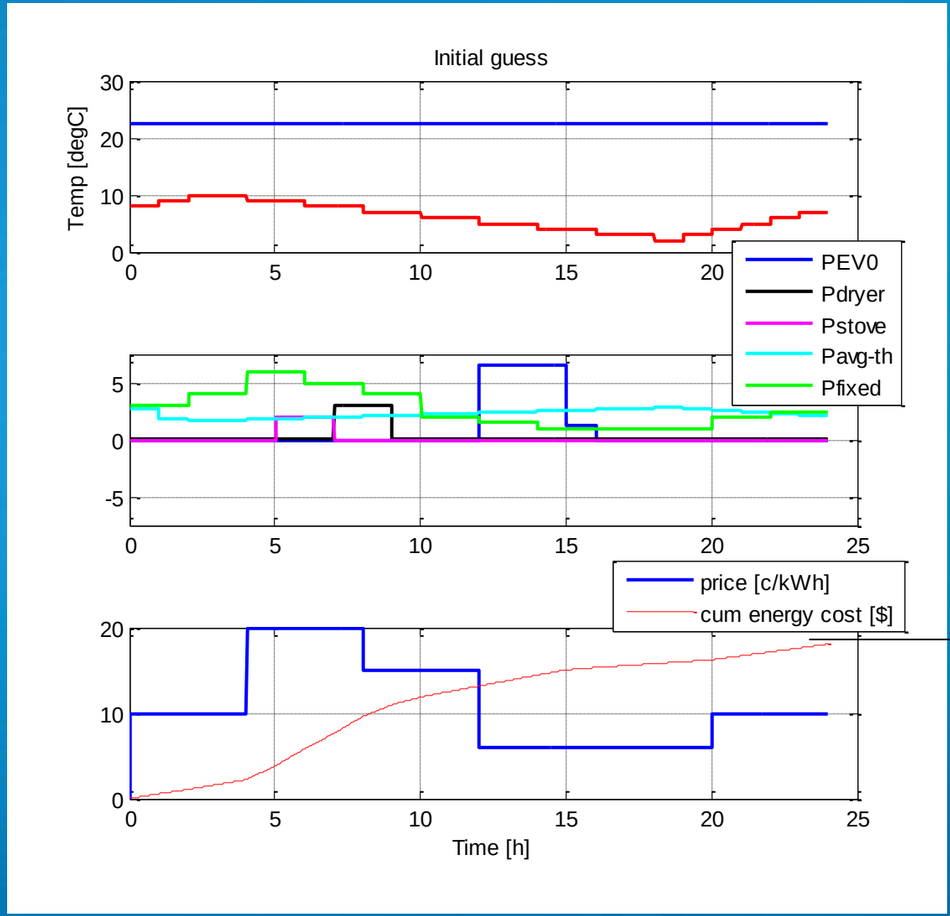


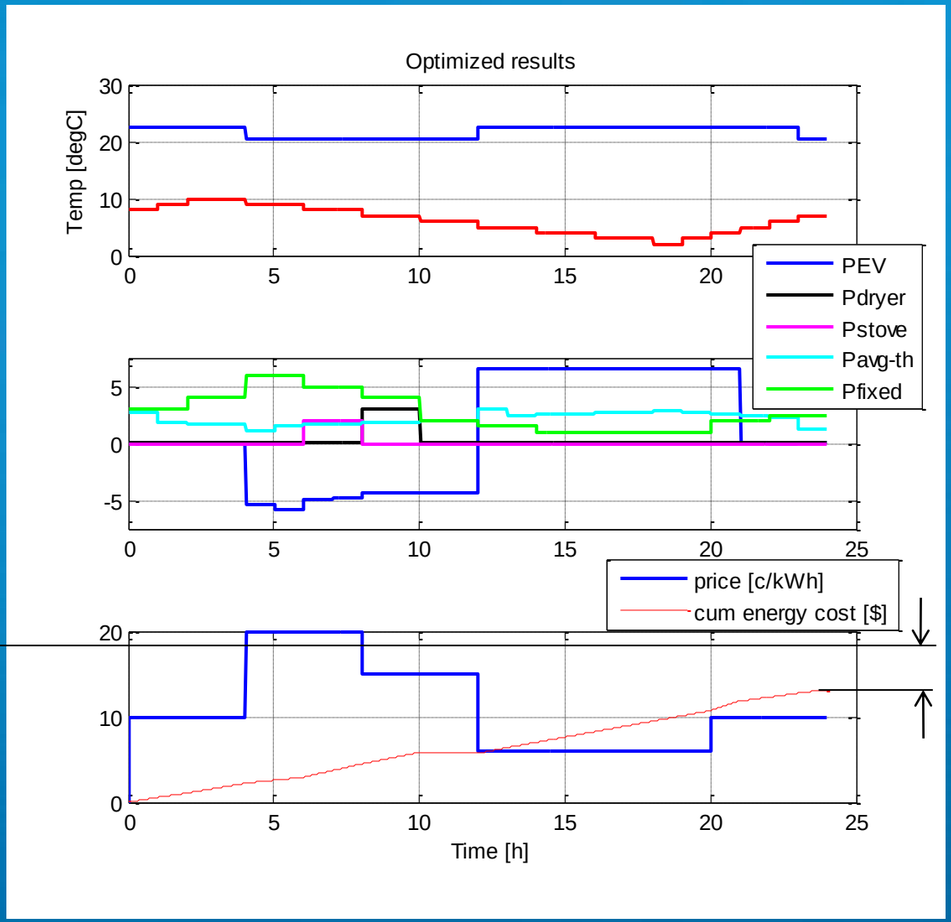


Aggregator
Building
Device

Preliminary results : V2G enabled / home storage

- 27% energy cost savings with V2G enabled → higher load at night
  - not direct comparison with previous





$4.95/day
–27%

Collective
Building
Device

Proposed Aggregator

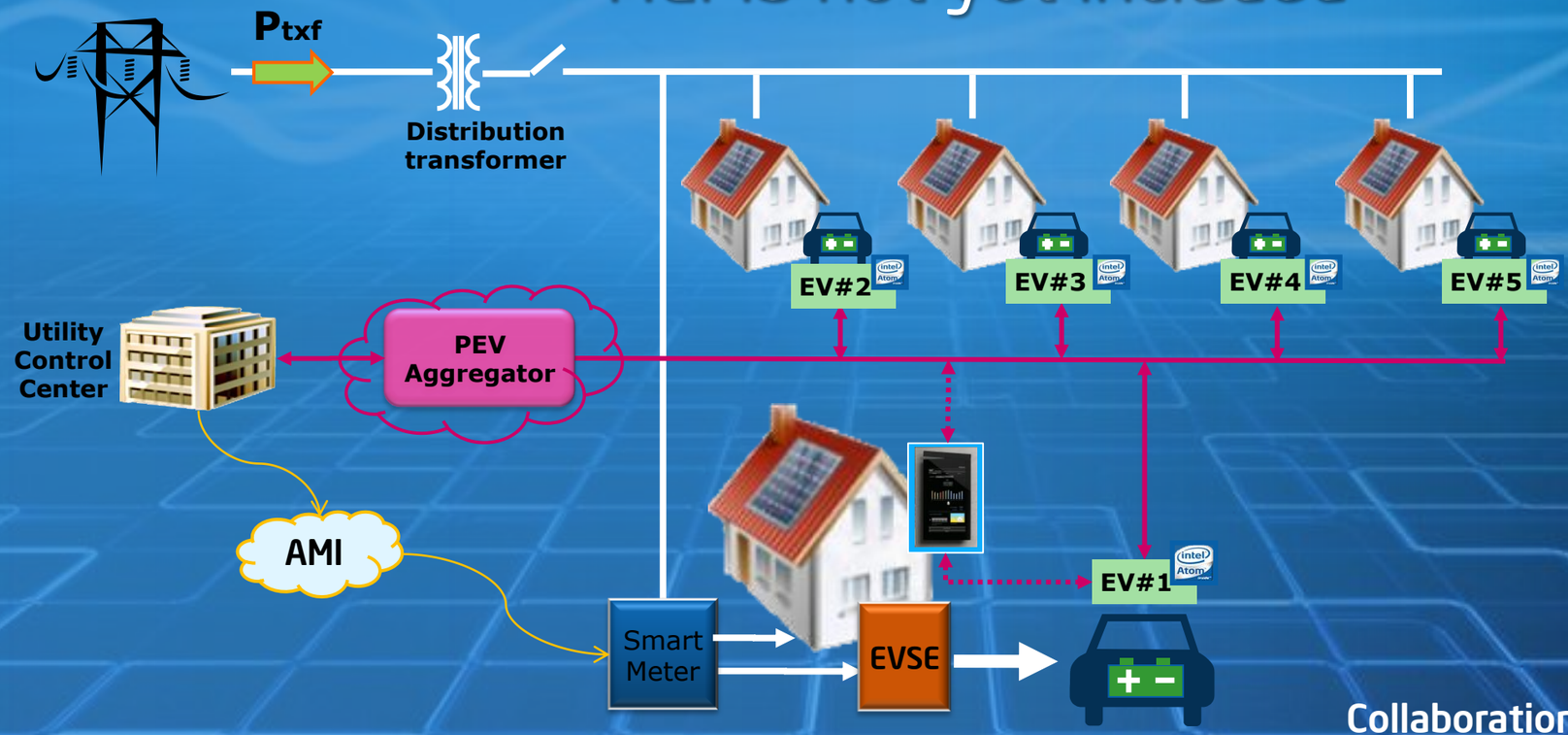
- Coordinates with all the HEMS/BEMS.
- May be implemented on a local device or as a cloud service
- Example functions :
  - Determining the optimal solution for a collection of buildings. Most applicable to a campus with a single building owner
  - Interacting with the utility-issued demand response requests
  - Maximizing run-time when operating off-grid, e.g. for a microgrid.
  - Protecting local infrastructure (distribution transformer) through adjustment of local electricity price

Collective
Building
Device

EV charging aggregator

Aggregator sets local electricity price

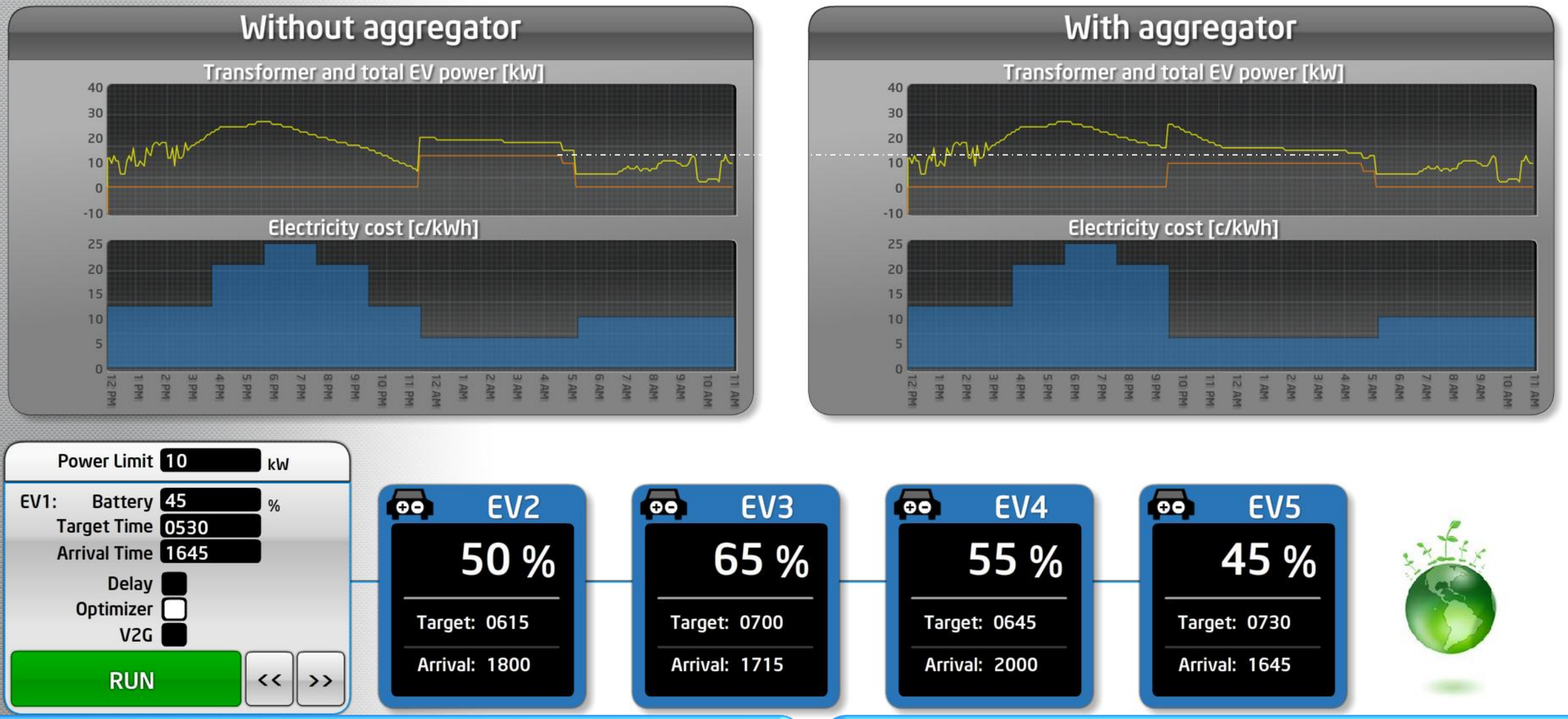
HEMS not yet included



Collaboration with University of Colorado, Boulder

Intelligent Energy Management for Electric Vehicles

Collective
Building
Device



Intelligent vehicle optimizer only

- Minimizes cost and charging rate of PEV

With PEV Aggregator

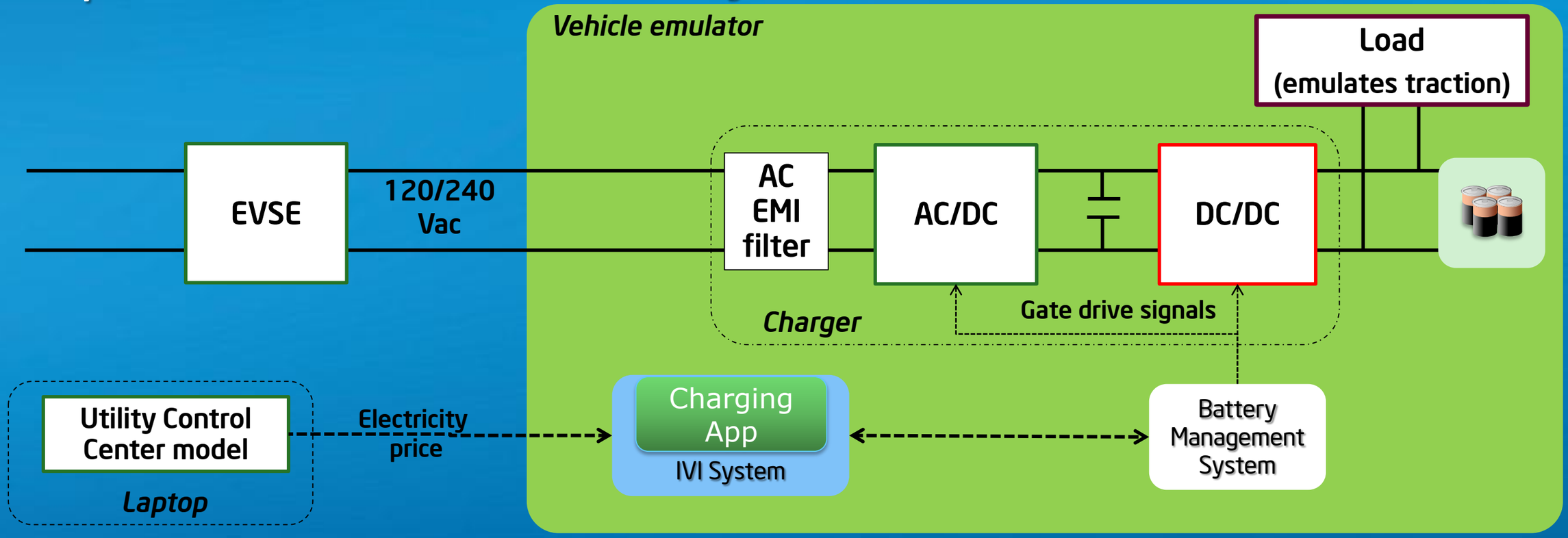
- Limits total PEV power by adjusting local electricity price

Collaboration opportunities

- Energy Management algorithms
  - Optimization engines, load forecasting, thermal models for buildings, user behavior modeling and influencing, etc.
- Prototyping
  - Device level: smart charging on PEV emulator *and then on PEV*
  - Building level : test HEMS optimization algorithms in a home
    - as allowed by *controllable appliances* available, *and EV capabilities*
  - Collective level : *HEMS interaction with utility through aggregator*

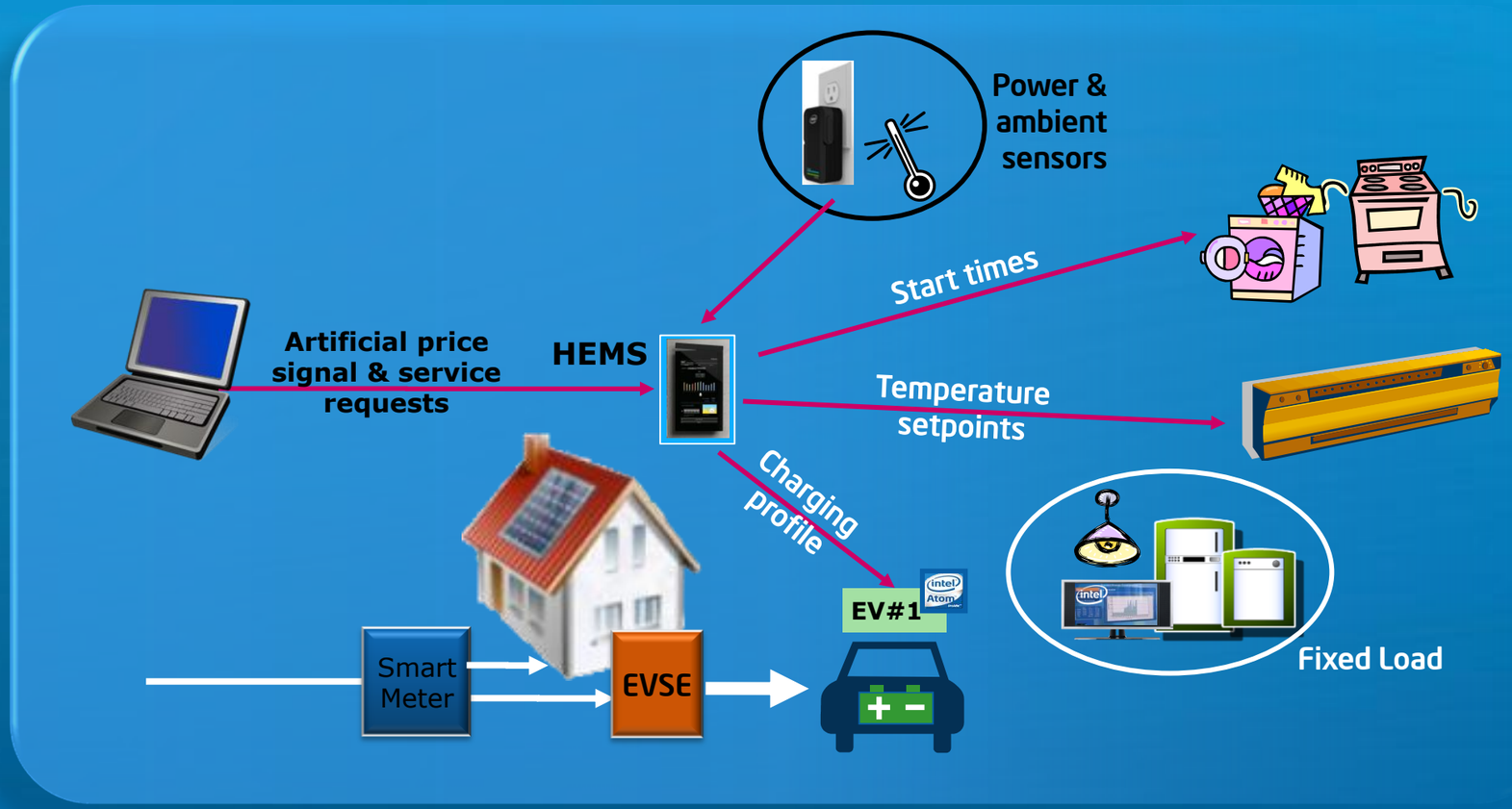
Device level : PEV

- Demonstrates operation of Charging App in conjunction with Battery Management System to implement optimal charging
- *Implementation on vehicle to follow*



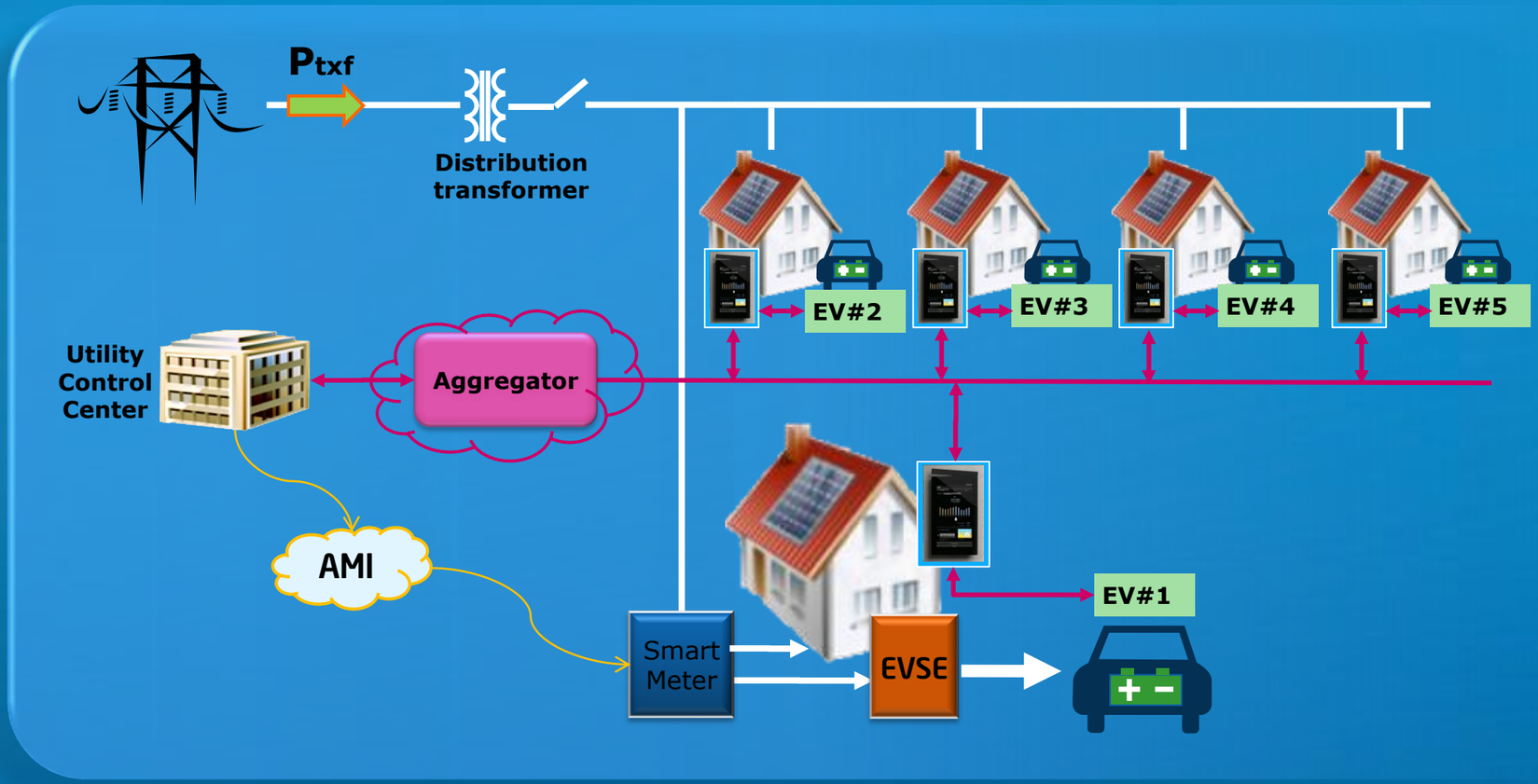
Building level : HEMS

- Demonstrate HEMS algorithms in real (occupied) homes
  - to the extent possible, determined by *controllable appliance* availability and *PEV capabilities*
  - First in ESR homes
  - Then Intel homes
  - Then external



Collective level : neighborhood

- Detailed simulations
- *Field trial with external partner*



Thank You

Please visit the

Intelligent management of Electric Vehicles

demo

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