Positive-Energy Buildings thru Better control dEcisions PEBBLE

FP7-ICT-2009.6.3: ICT for Energy Efficiency
B. ICT support to Energy-Positive Buildings and Neighborhood

Model-assisted control design to improve building energy performance

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24th October, 2011
ICT for Sustainable Homes
Nice, France

PEBBLE
Project Information

For information regarding this Project:

Check the Project Web-Site: http://www.pebble-fp7.eu

	PEBBLE Participants
1	Technical University of Crete (GR)
2	Fraunhofer Institute for Building Physics (DE)
3	RWTH Aachen University (DE)
4	Graz University of Technology (AU)
5	ARMINES (FR)
6	CSEM (CH)
7	Saia-Burgess Controls (CH)

Project Acronym: PEBBLE

Project Number: 248537

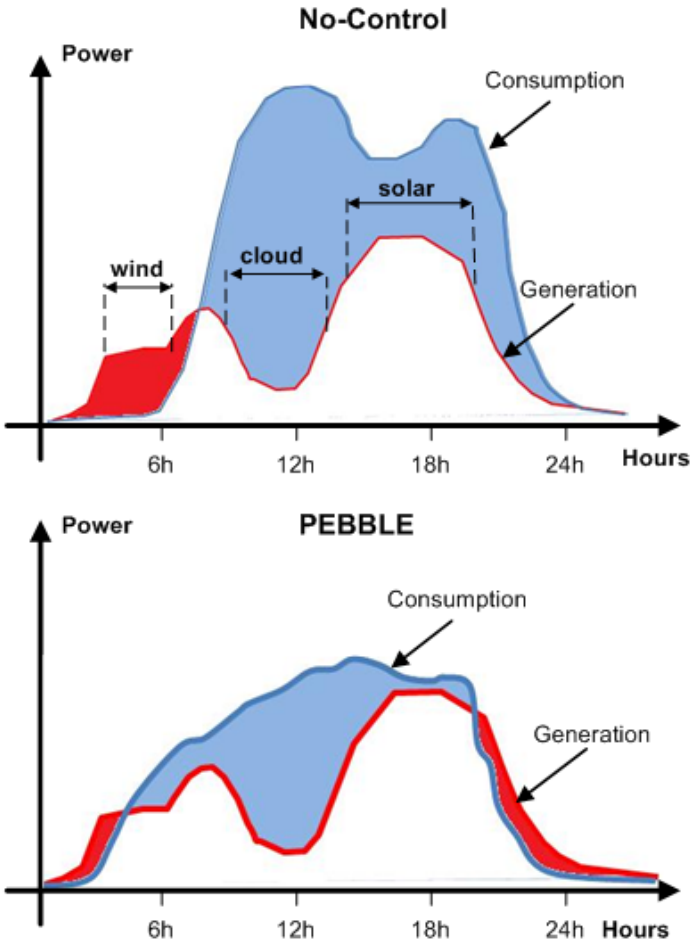
Project Start Date: January 2010

Duration: 3 Years

Funded by: EU FP7

Program Name:
ICT for Energy Efficiency,
FP7-ICT-2009.6.3

Key Issues Toward Energy-Positive Buildings (EPBs)



Area under consumption curve: energy required for building operation.
Area under generation curve: energy available by installed renewable energy sources.
Red Area: Surplus energy available.
Blue Area: Energy purchased from the grid.

Current View: "Static"

PEBBLE View: "Dynamic"
Select a relevant performance metric, the Net Expected Benefit (NEB) (e.g. the net energy produced over a certain period).

Maximize NEB by:
intelligently shaping demand to perform generation-consumption matching subject to constraints (end-user thermal comfort, atypical availability of energy, reduced capacity demand at a certain time).

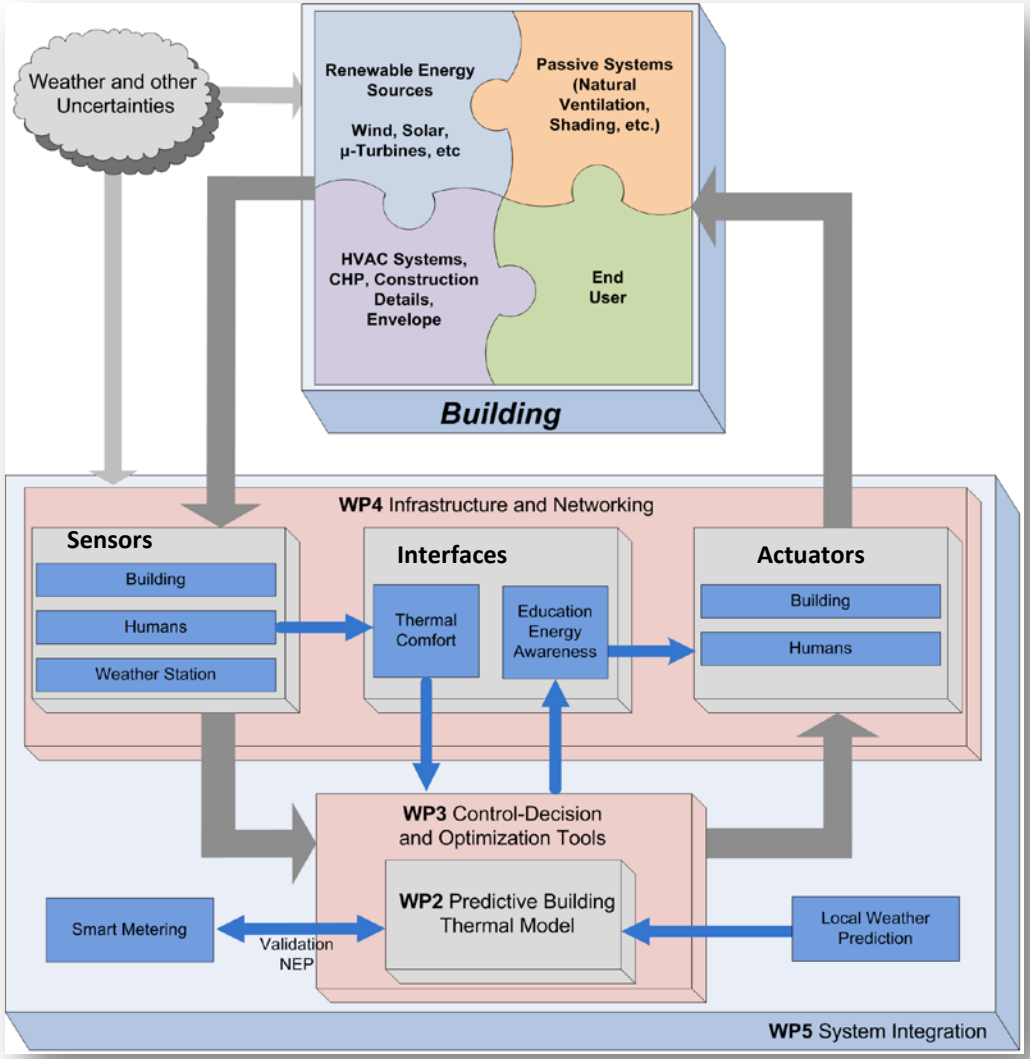
Which Require:

- Decisions in (almost) real-time:
  - to operate building subsystems and
  - to account for:
    - unpredictable user-behavior,
    - occupancy scheduling and occupants' activity,
    - changing weather conditions, and
    - signals from the grid.

- These decisions have direct consequences to:
  - occupant thermal comfort,
  - energy efficiency, and ultimately
  - to the Net Expected Benefit (NEB).

- The complex interplay between the many parameters precludes empiricism or rule-based decisions and necessitates the development of generic decision tools.

PEBBLE Project: Conceptual Schematic…



PEBBLE Demonstration Buildings

1. ZUB (FIBP)

2. RWTH

3. TUC

Integrated thermal modeling

RWTH Aachen

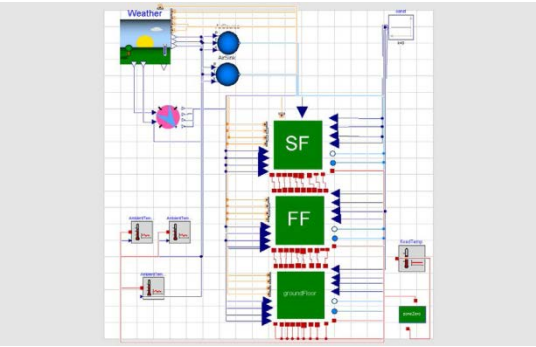
- Model in Dymola
- 3 floors
- 29 thermal zones
- 4 different zone types
- Active slabs
- Façade ventilation units

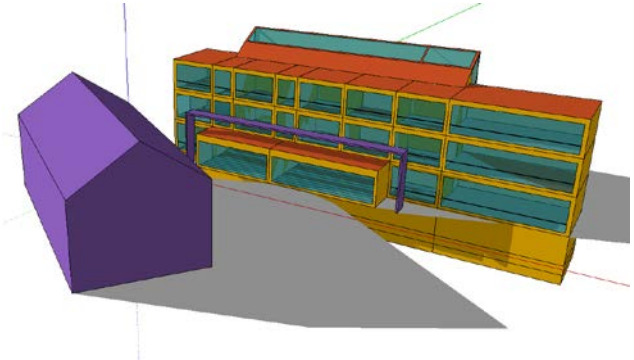
FIBP Kassel

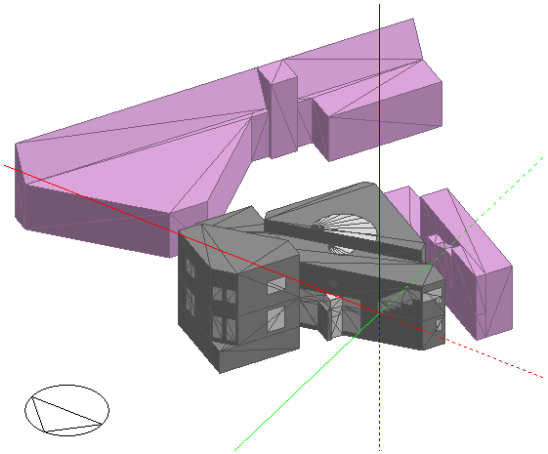
- Model in TRNSYS17
- 3 floors, cellar, atrium
- 29 thermal zones
- External shading groups included
- Active slabs

TUC Chania

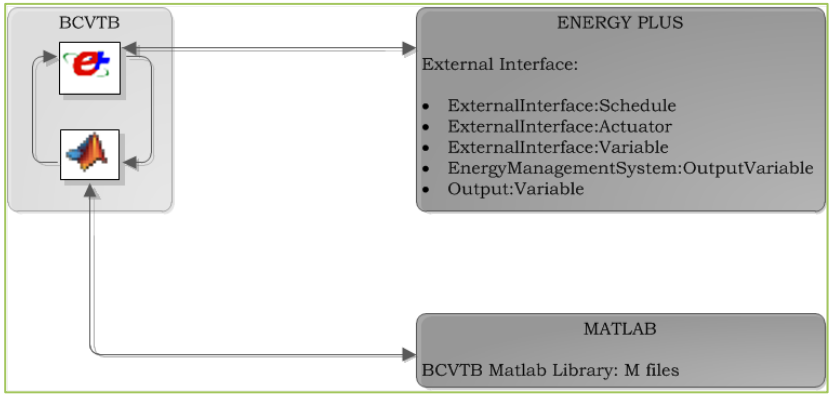
- Model in Energy Plus
- 2 floors
- 19 thermal zones
- External shading groups included
- Natural Ventilation







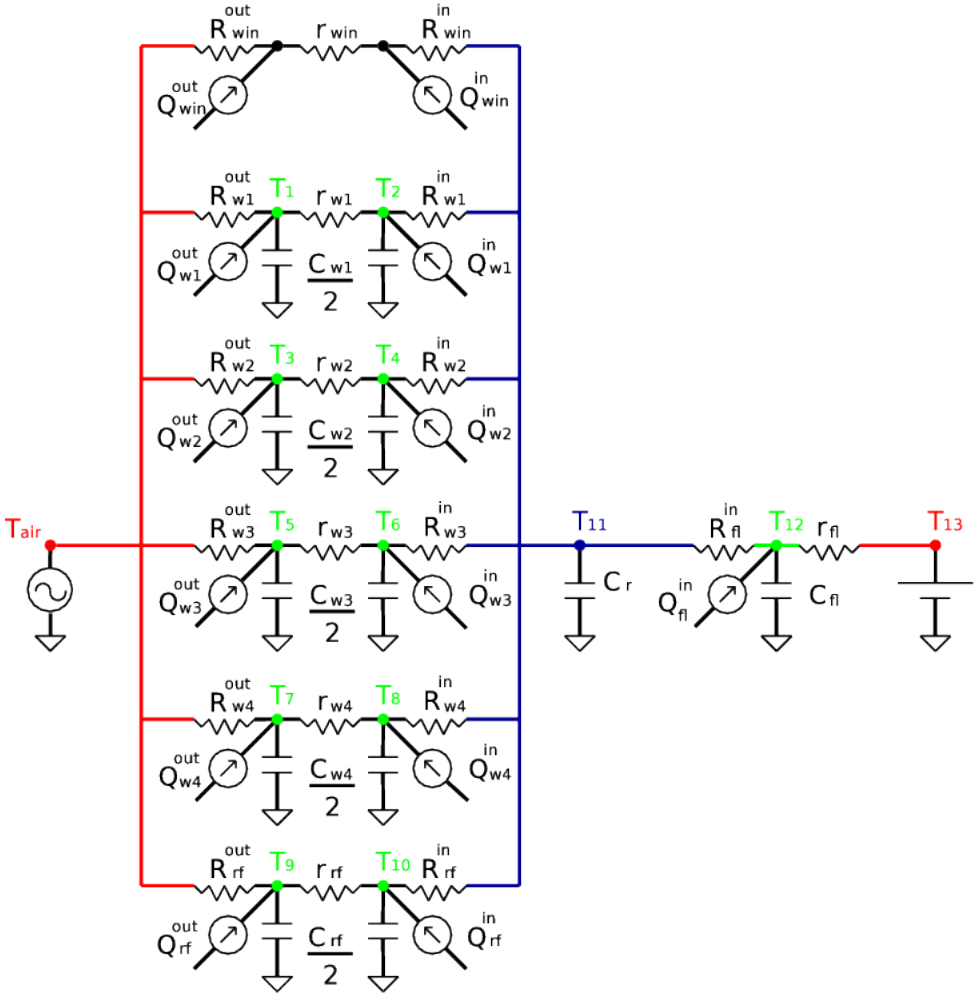
Co-Simulation

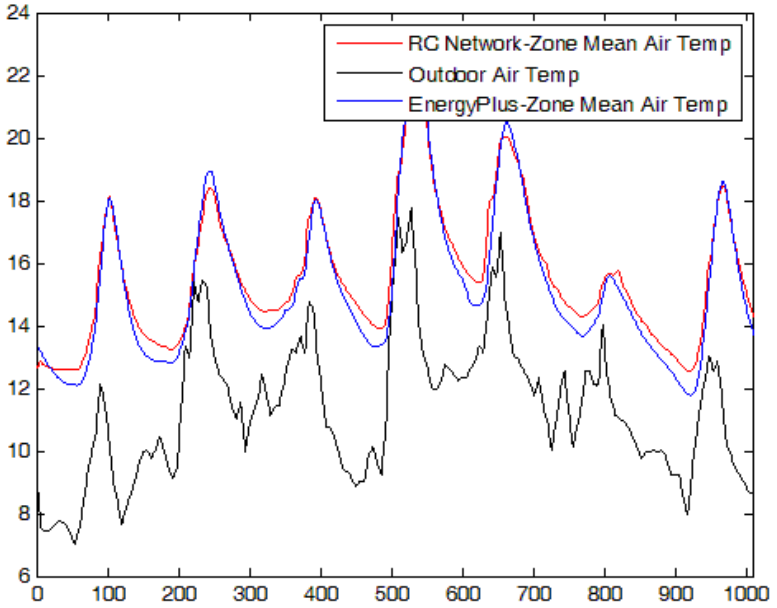


- Establish dynamic connection between Thermal Energy Simulation Engines (EnergyPlus , TRNSYS) and MATLAB.
- Apply control optimization strategies at the model acting as a surrogate of the building.
- Allows for model-identification to create state space models (useful for control design).

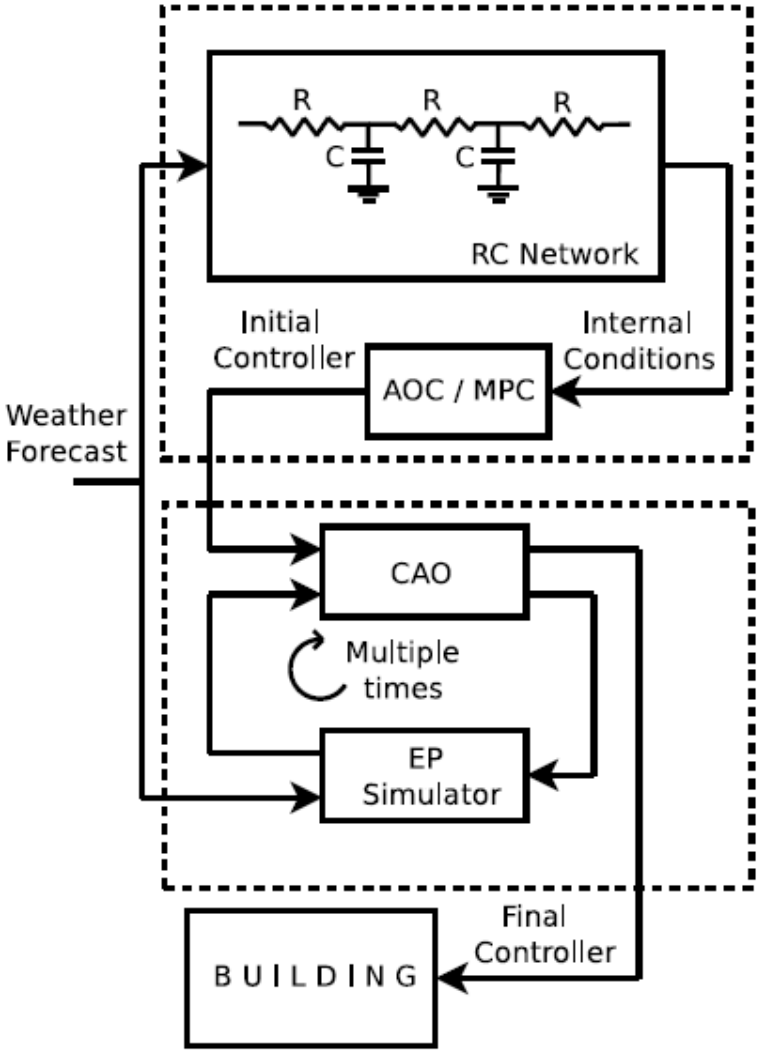
Ab initio State-Space Model via RC Network

- One zone example



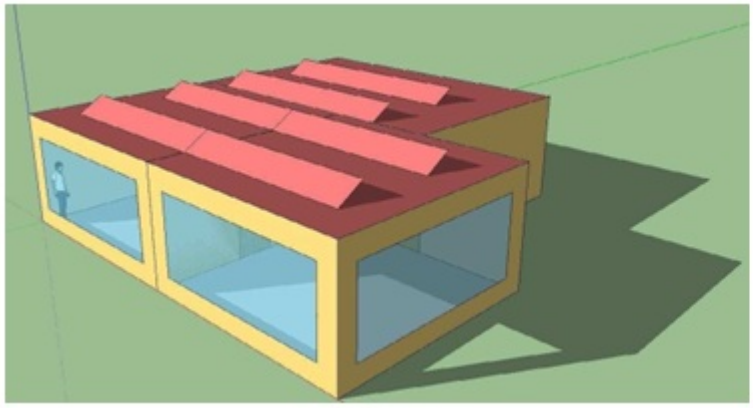


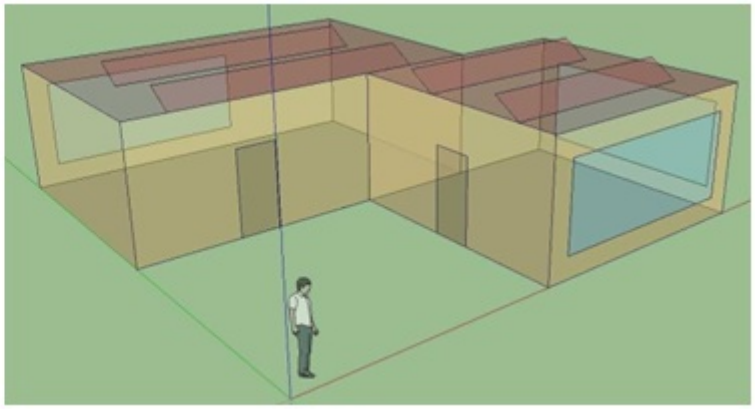
Model Assisted Control Process



- Create an RC Network describing the building thermal model
- Design an Approximate Optimal Control strategy (AOC) to estimate an initial controller
- Use Cognitive-based Adaptive Optimization (CAO) approach to further fine-tune the initial controller, using an EP Simulator, weather & occupancy forecasts

Control Example





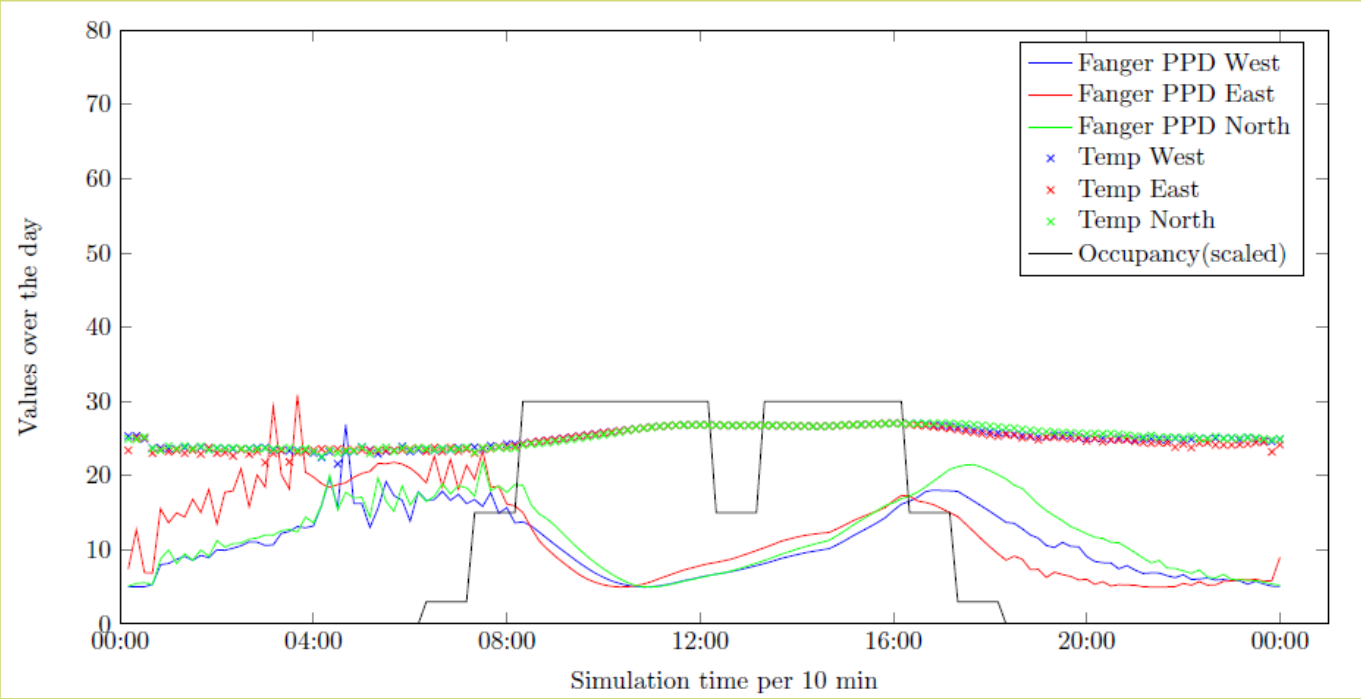
Three-zone building (Real weather data from Chania Greece)

- Variable set point for each of HVAC systems in the zones
- Window opening

Optimization Outcome:

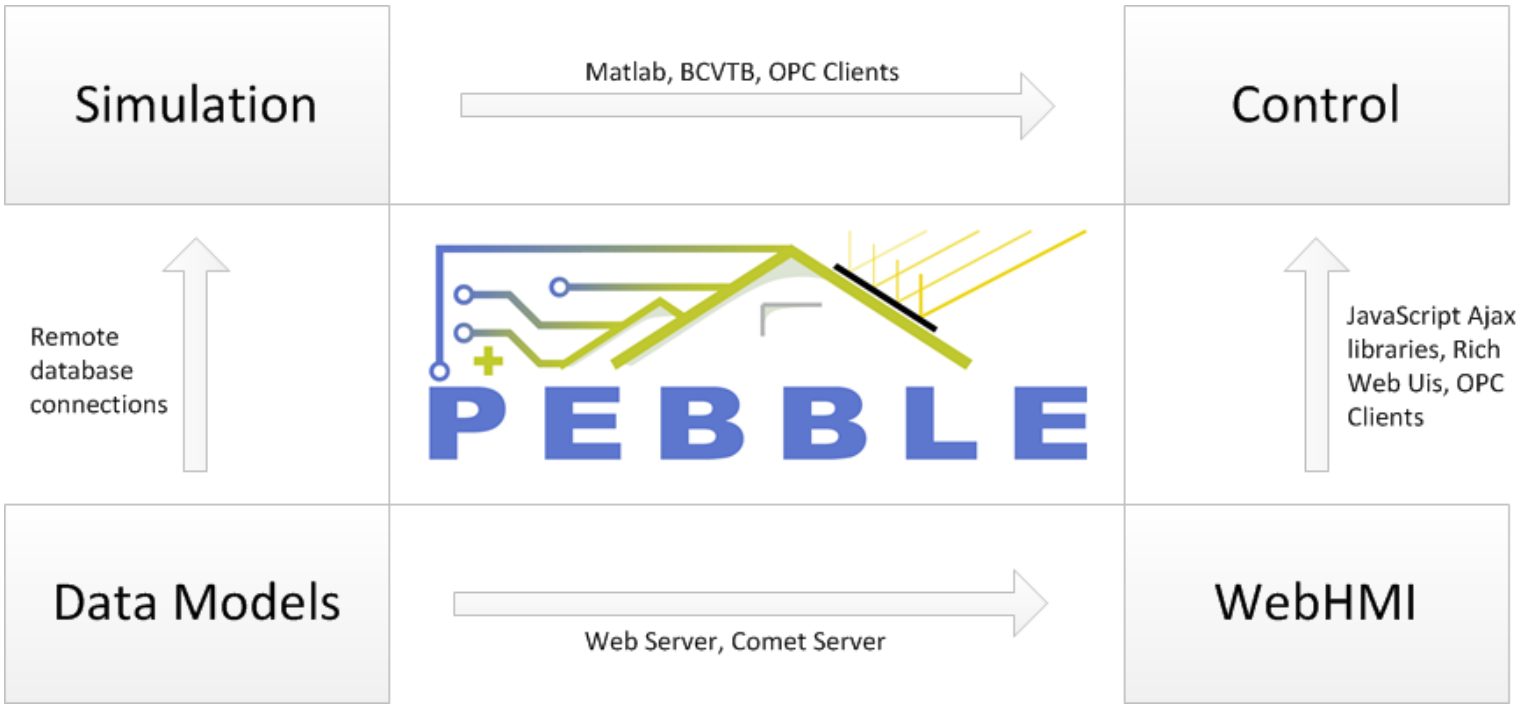
- Night ventilation
- Variable Set Point (adapted to the building occupancy schedules)

Building Optimization and Control Indicative Results

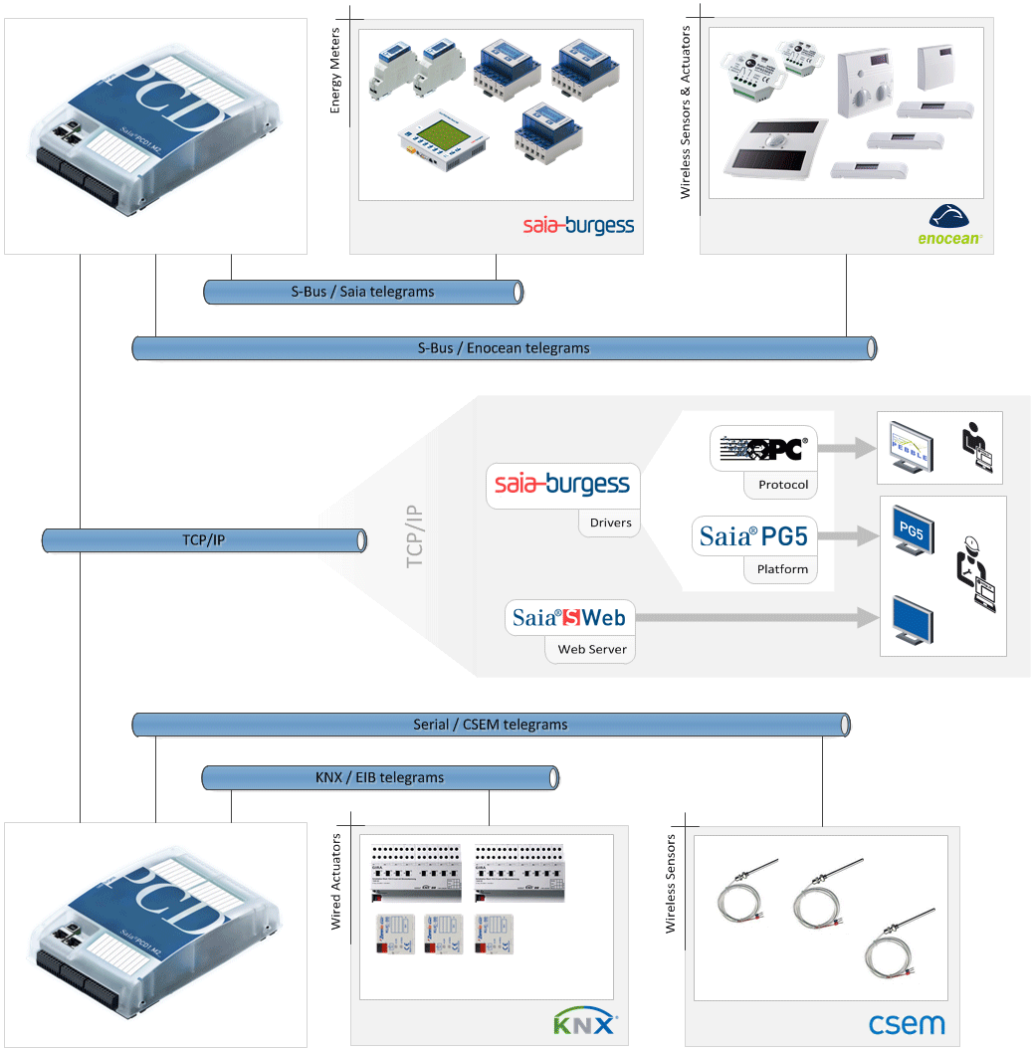


- Energy Saving Potential of over 27% (compared to "good" rule-based control).
- Trade-off between energy consumption and thermal comfort (different metrics yield different strategies)

System Integration



Zone Infrastructure



Wireless devices:

- Temperature sensors
- Humidity sensors
- Occupancy sensors
- Brightness sensors
- Relay actuators

Wired devices:

- Motor controllers
- HVAC actuators
- Energy meters

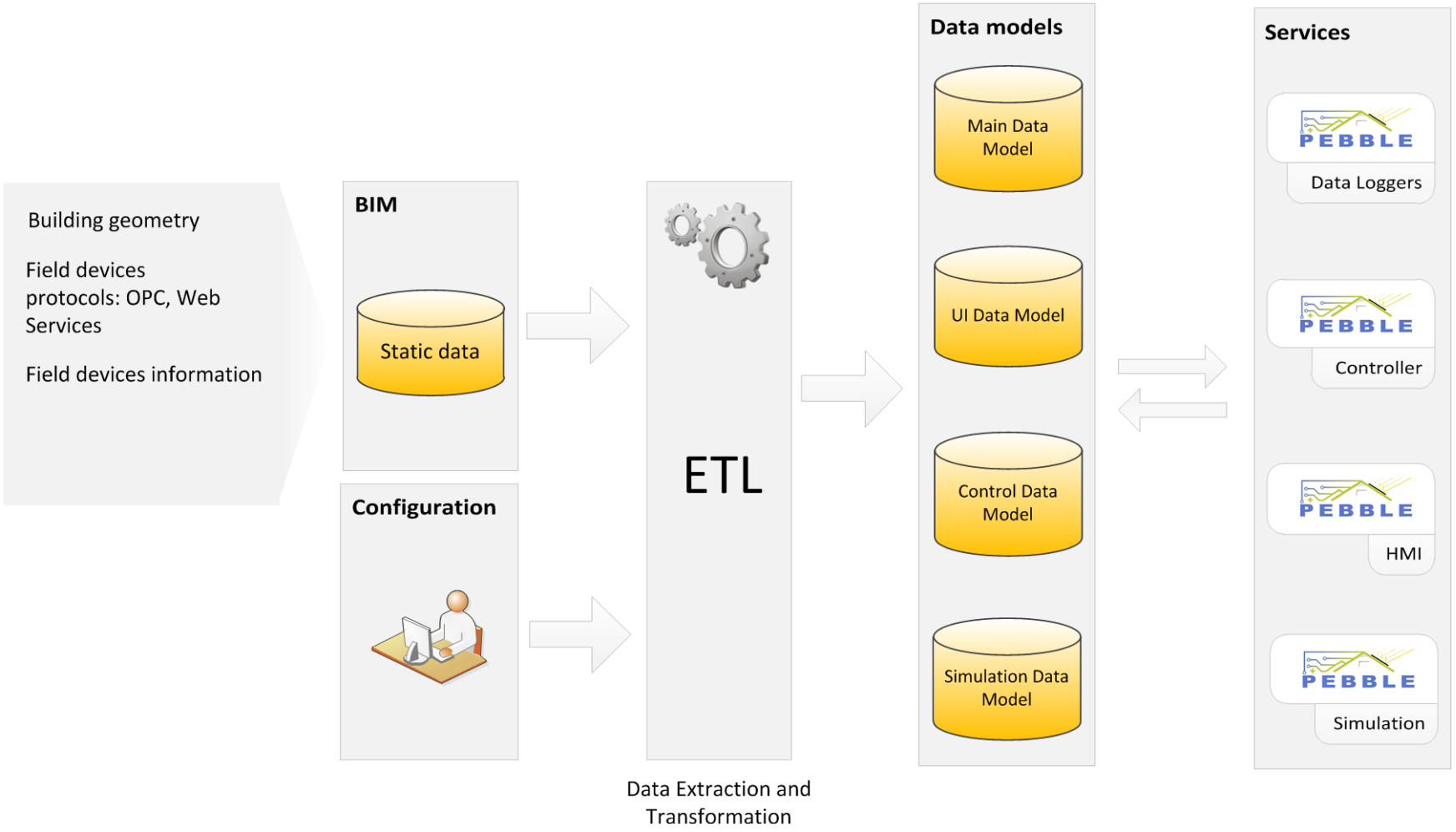
Field devices protocols:

- S-Bus
- EnOcean
- KNX/EIB
- WiseMAC

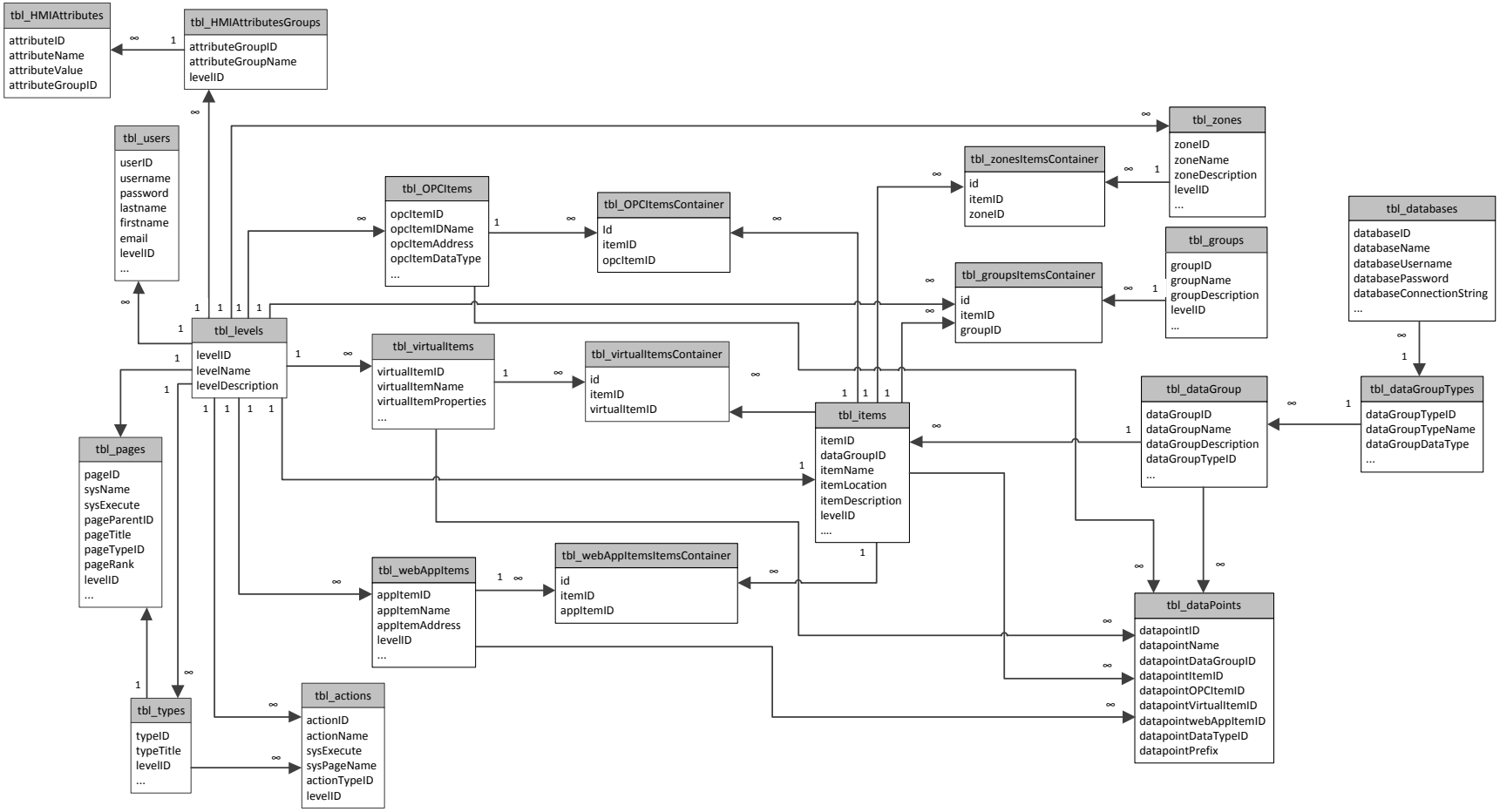
Software protocols:

- OPC (DCOM)
- Web Services (XML, JSON)

Data Model Architecture



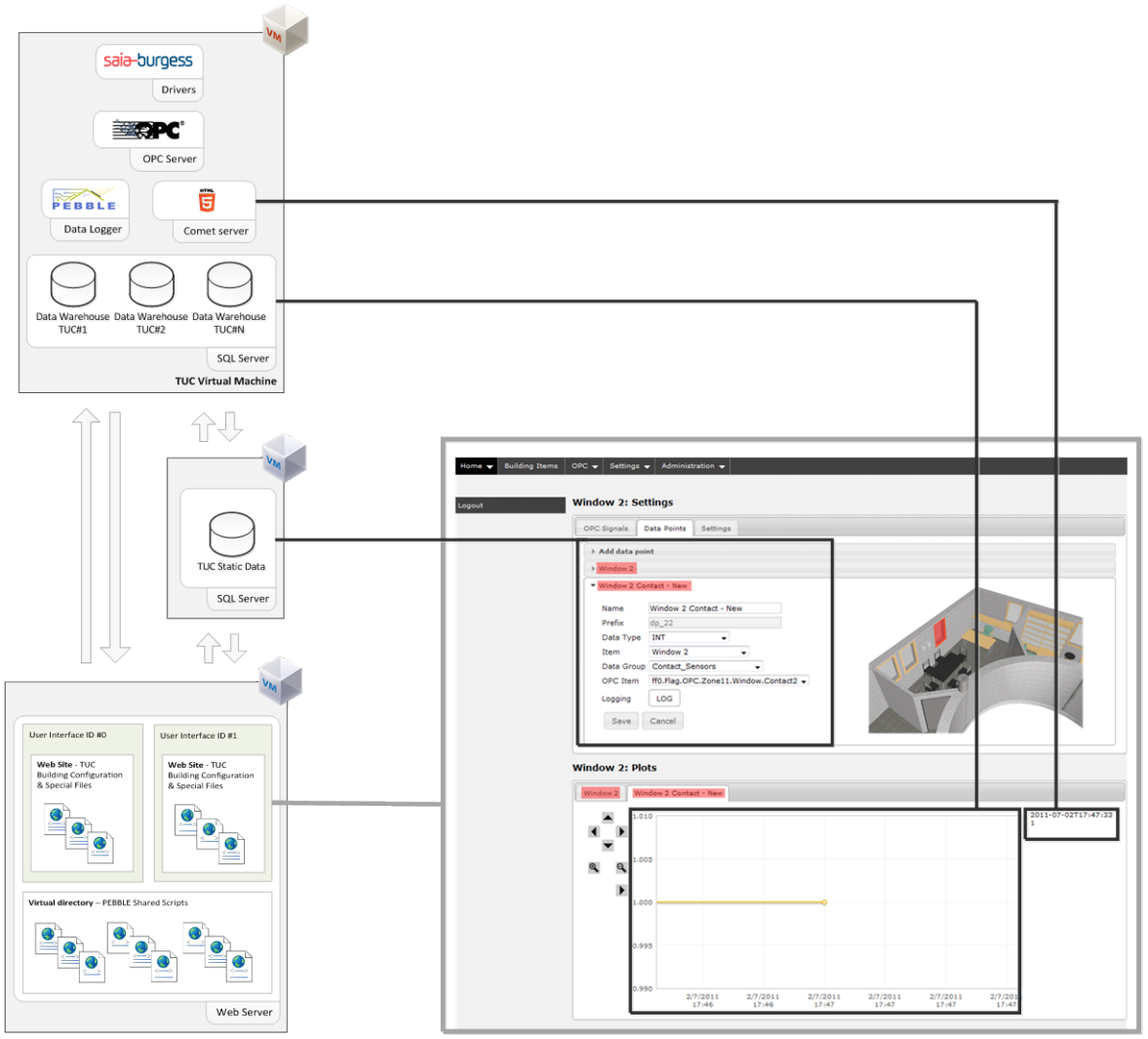
“Main Data Model” Database



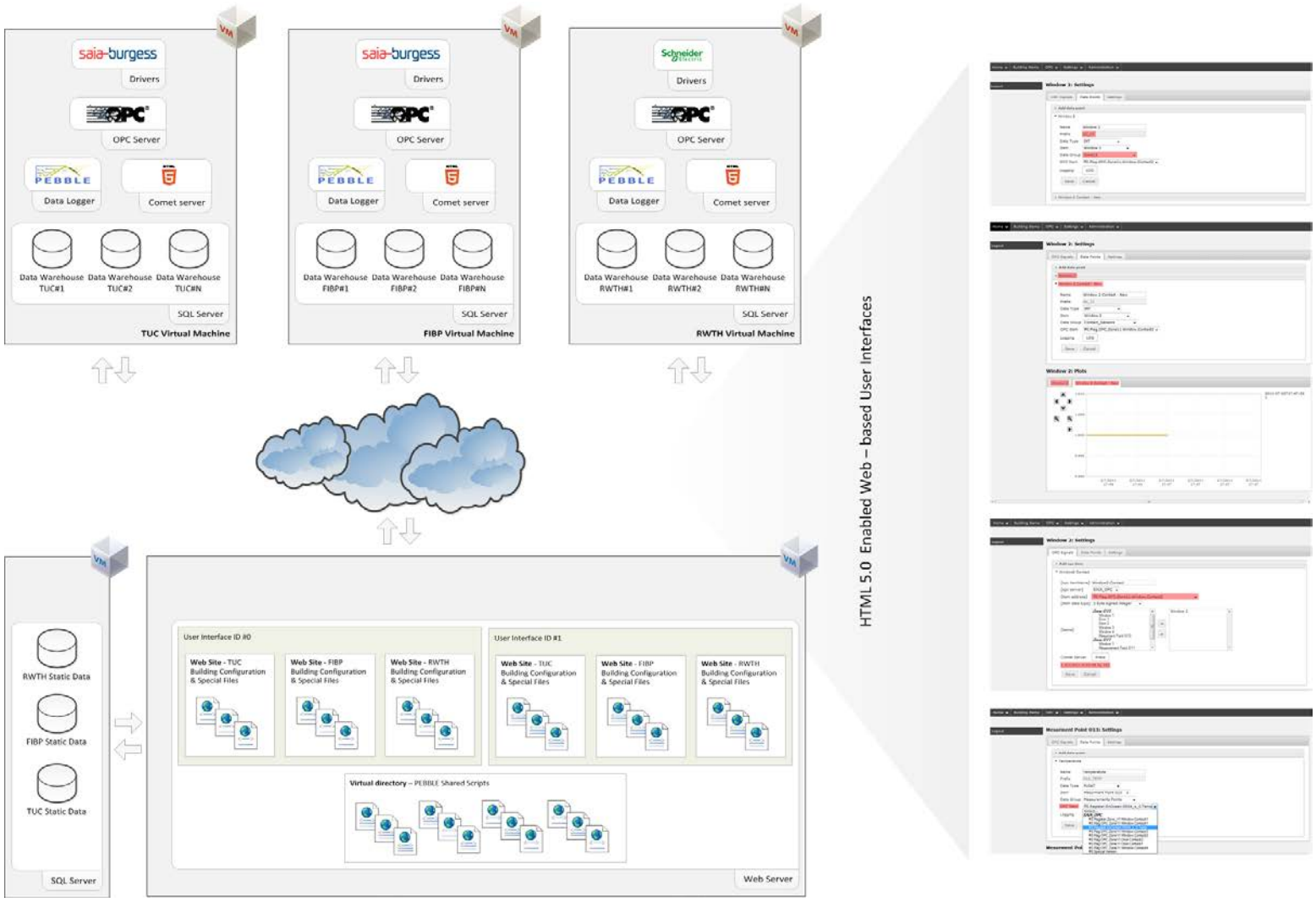
HMI UI – Web Technologies

Web-HMI UI includes:

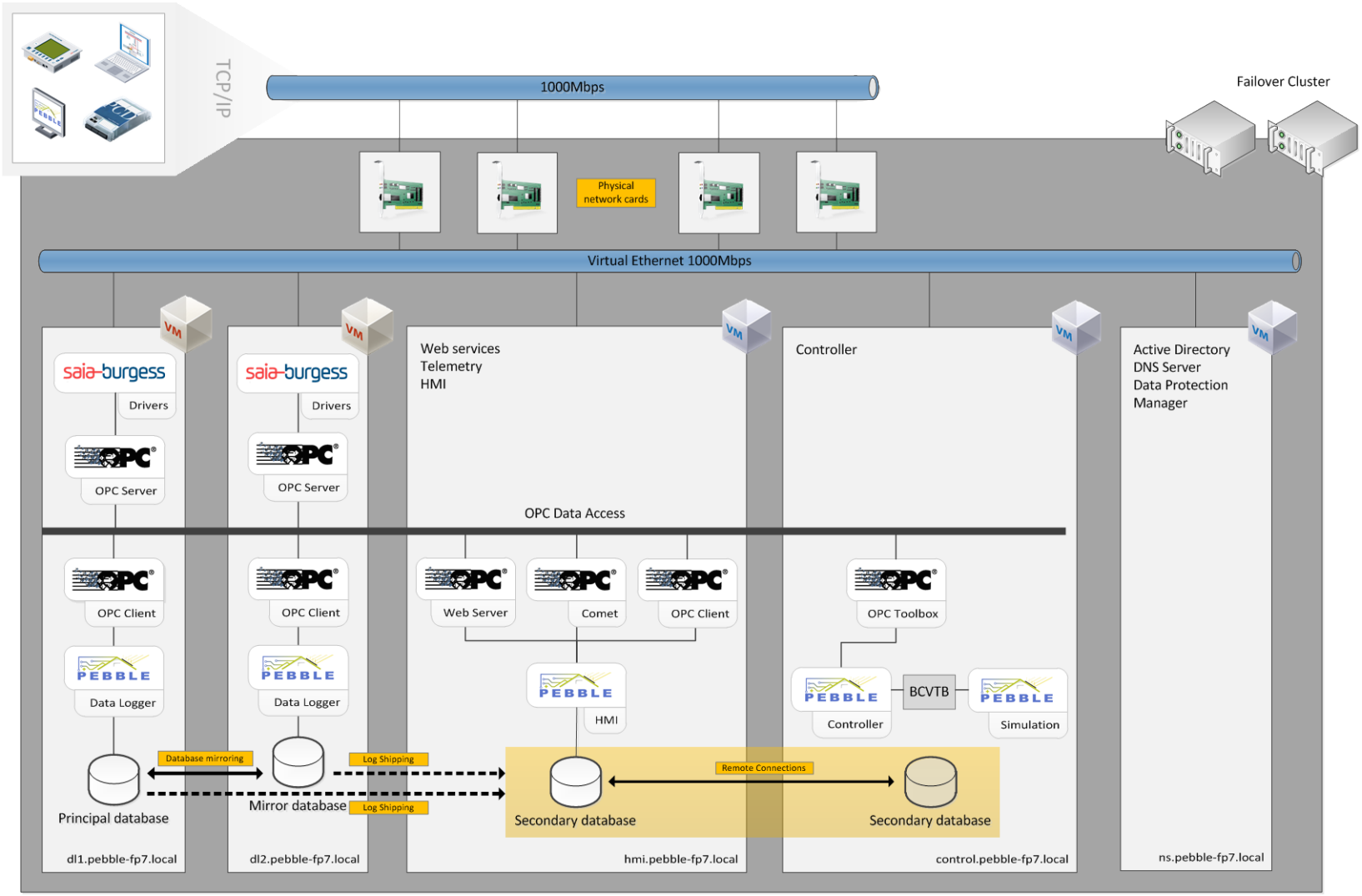
- "Static Data" warehouses for the main Data Model design.
- "Dynamic Data" warehouses for data delivery and historical diagrams.
- Comet server for real time data streaming through the Web.
- Ajax enabled UI components for the best interactive user experience.
- Shared code files in virtual directory that every PEBBLE UI can call and execute.



Infrastructure



System Architecture



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