

# A Testbed for Agent Oriented Smart Grid Implementation

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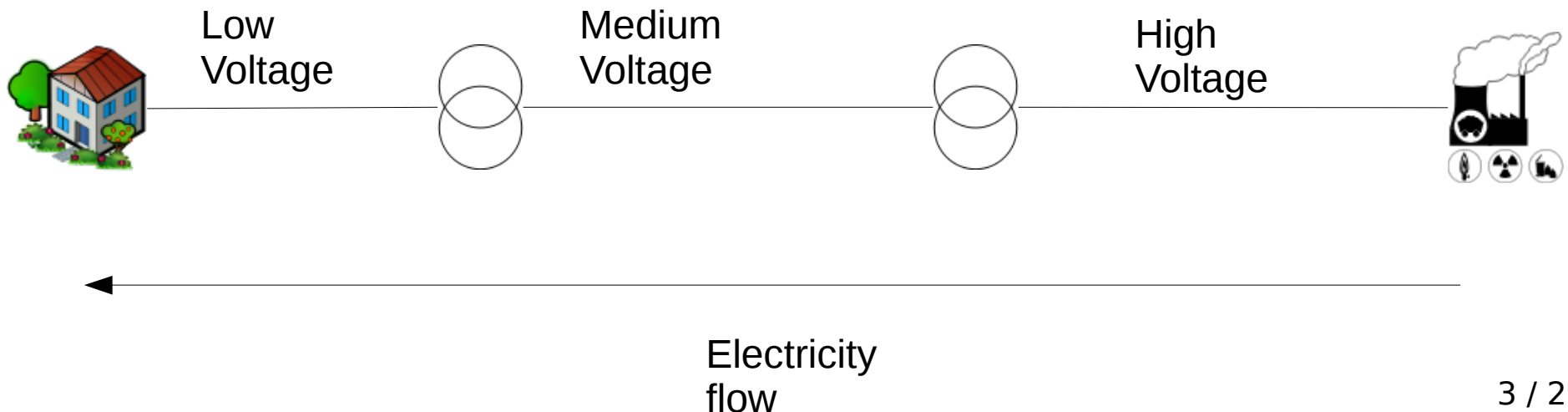


# Introduction

- MIREC-CON project: ZIV, CEDER-CIEMAT, University of Zaragoza, and Universidad Complutense
- Powergrid technology has issues dealing with a dynamic power generation
- Smart Grids. An enhanced powergrid
- The contribution is a framework for developing agent oriented solutions for controlling Smart Grids

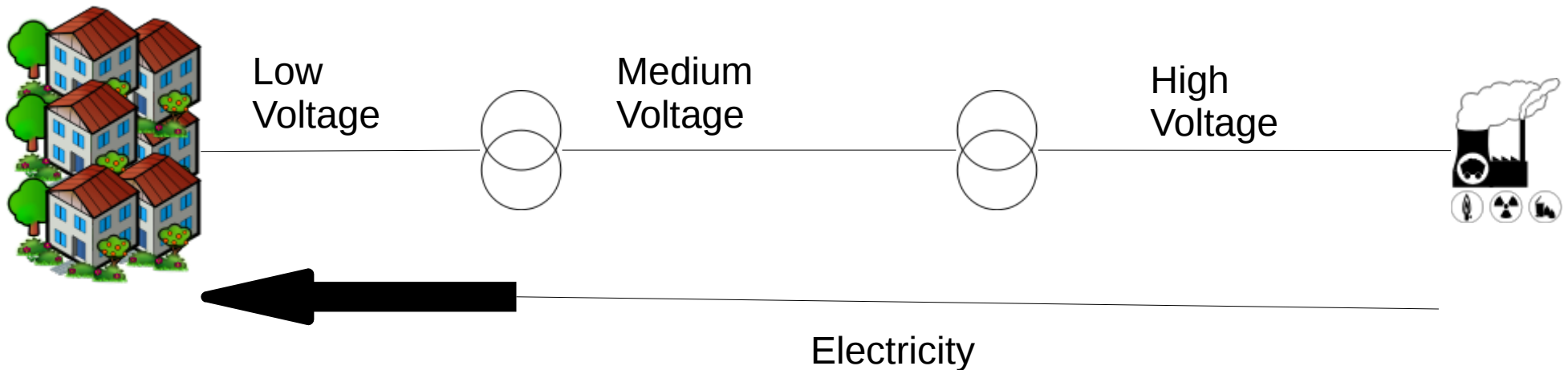
# Sketching the limitations

- AC electricity is not stored
  - It can be stored only by transforming into something else
- It has to be produced as it is demanded
- The power lines and transformers are designed to work with specific operational parameters.
- It behaves as water: it flows following a gradient



# Sketching the limitations

- Once designed the network, it requires effort to scale. You just cannot plug anything or ask as much energy as you want
- A higher demand in one extreme may reduce supply into another. Extreme case: a blackout
- High capacity Energy Production Plants? Not in my Backyard!

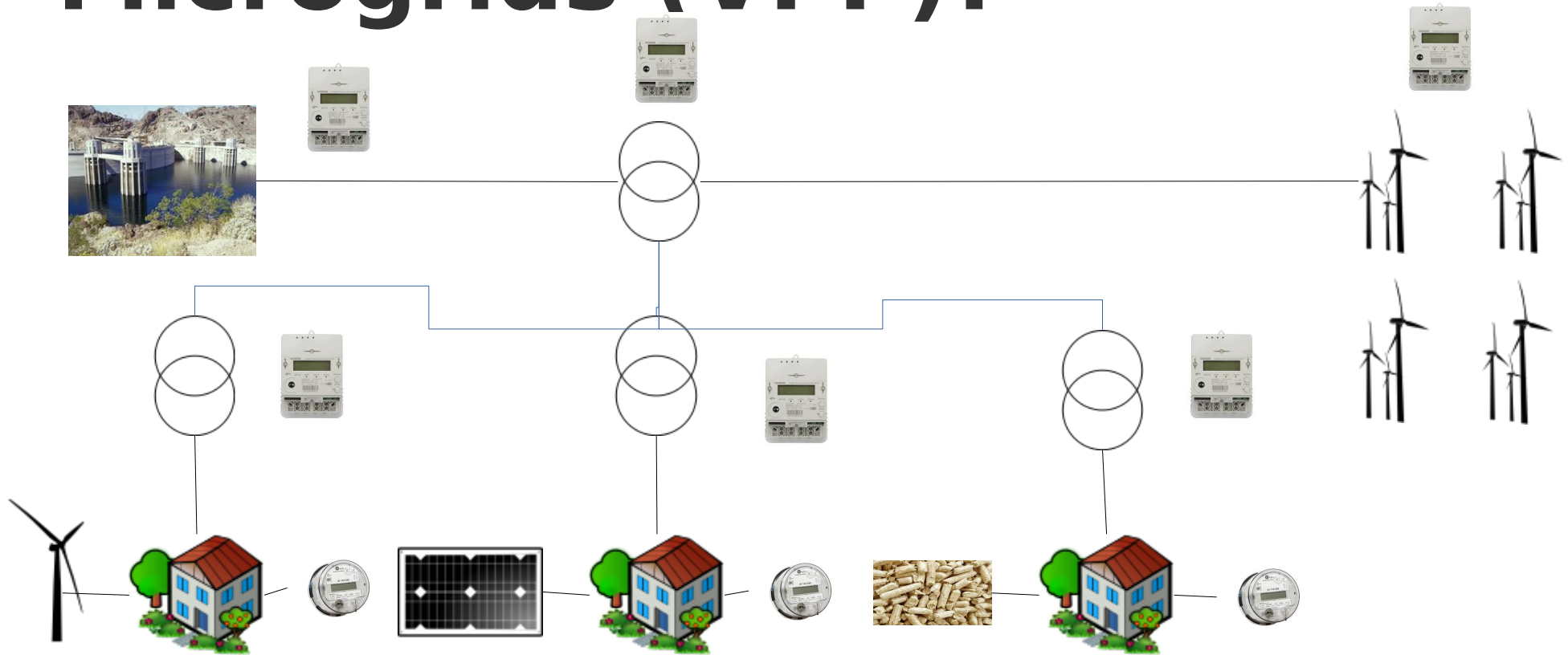




# Elements of change

- Advance Metering Infrastructure: measuring the amount of current, reactive current, consumed kWh,.... Not in real time, though
  - They are micro-computers
- Renewal Energy Sources. Yes In My Backyard. Cheap. Most are unreliable.
- SCADAS (Supervisory Control and Data Acquisition). A system capable of sending control signals to devices.

# Smartgrid: a big one or a combination of Many Microgrids (VPP)?





# Constraints

- Devices can fail (control+generation)
- Powerlines can fail
- Restoring an isolated network is not trivial
- Prices are unstable
- Renewal sources are not reliable today
  - Too much weather dependent
- The energy demand is not predictable



# Goals

- Control systems in power grids are very well known and implemented at hardware level
  - Keep system stability and Quality of Service
  - When in doubt: disconnect
- Coordinate systems to produce what is needed
- Produce in a way that energy is not wasted
- Produce in a way that it is cheaper





# A fertile ground for agent technology

- Inherently distributed
- Decentralized control (if P2P is applied)
- Coordination solutions
- Hierarchical Organizations vs Holons
- Intelligence: reasoning, prediction

# SGSimulator

- It is a simulator for SmartGrids developed in the MIREDCON project
  - <http://sgsimulator.sf.net>
  - Based on the GridLab-D software
    - <http://www.gridlabd.org/>
- It permits developer to plug agents to the control elements of a simulated powergrid in a real time simulation.
  - Agents can connect and disconnect
- Also to create predefined grids more easily
  - You may still need some electrical engineer at hand

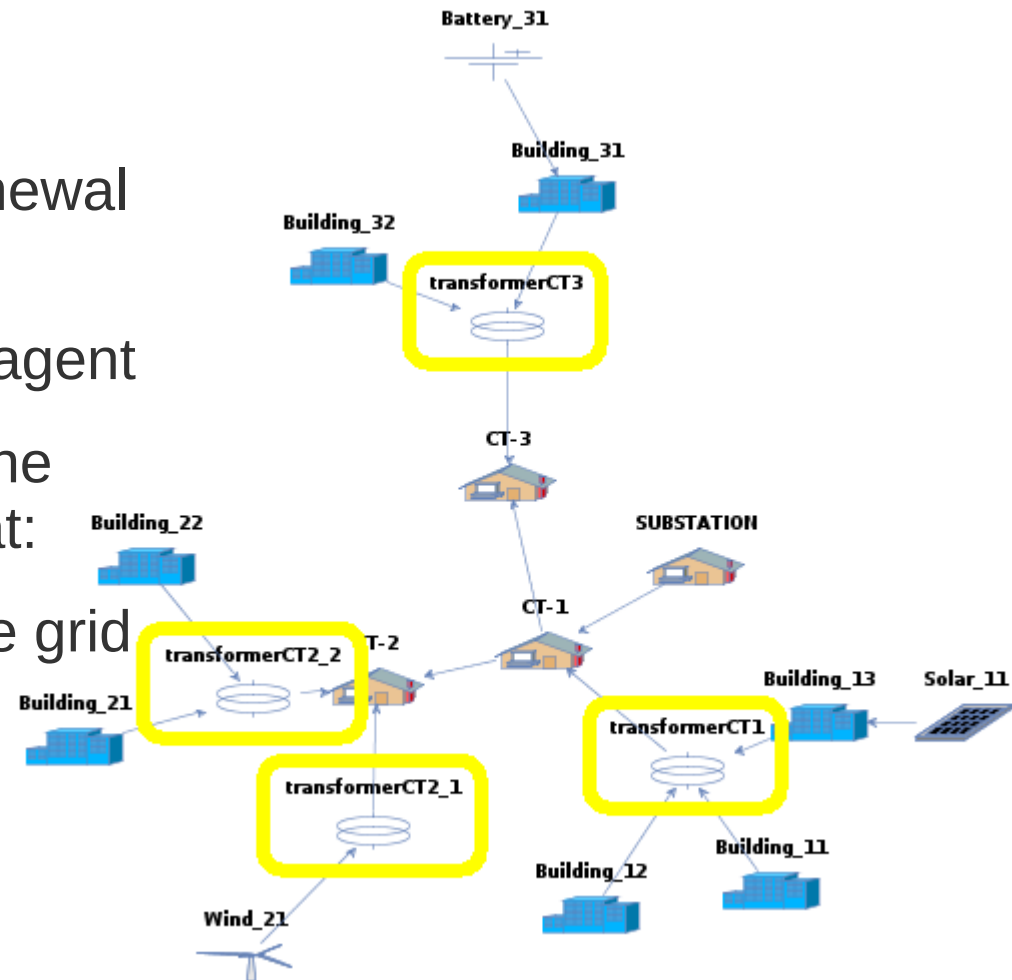


# Features

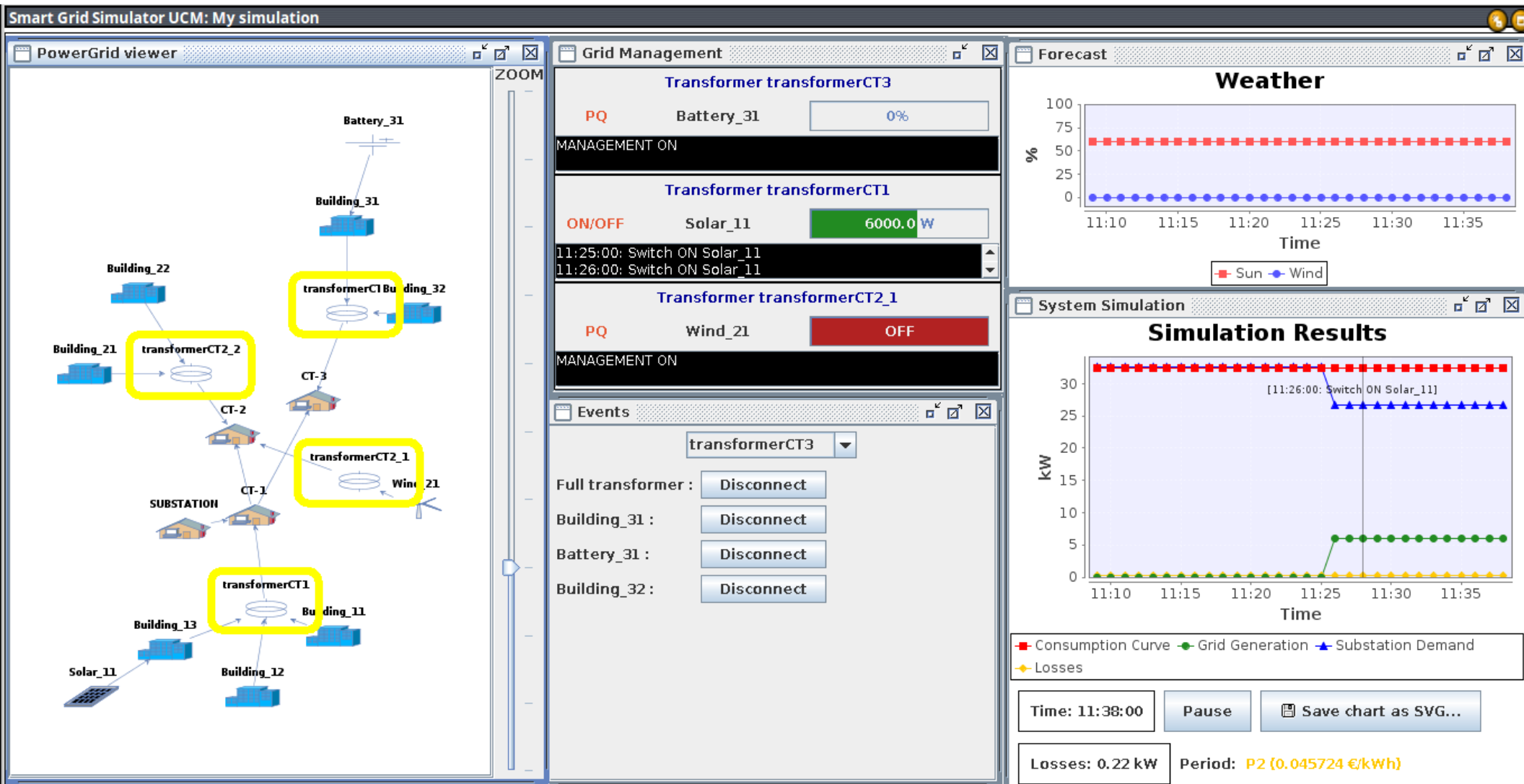
- Static analysis
  - No harmonics
  - No peaks when powering on a device
- Real Time Simulation
  - It is about having a simulation running close to real time instead of event driven
  - Useful for software-in-the-loop developments
- Alternative to Matlab /simulink solutions
  - Allowing the execution of different simulations at the same time
- Simulation Cycle length can be modified
- Scenarios of load/weather conditions can be defined

# Scenario

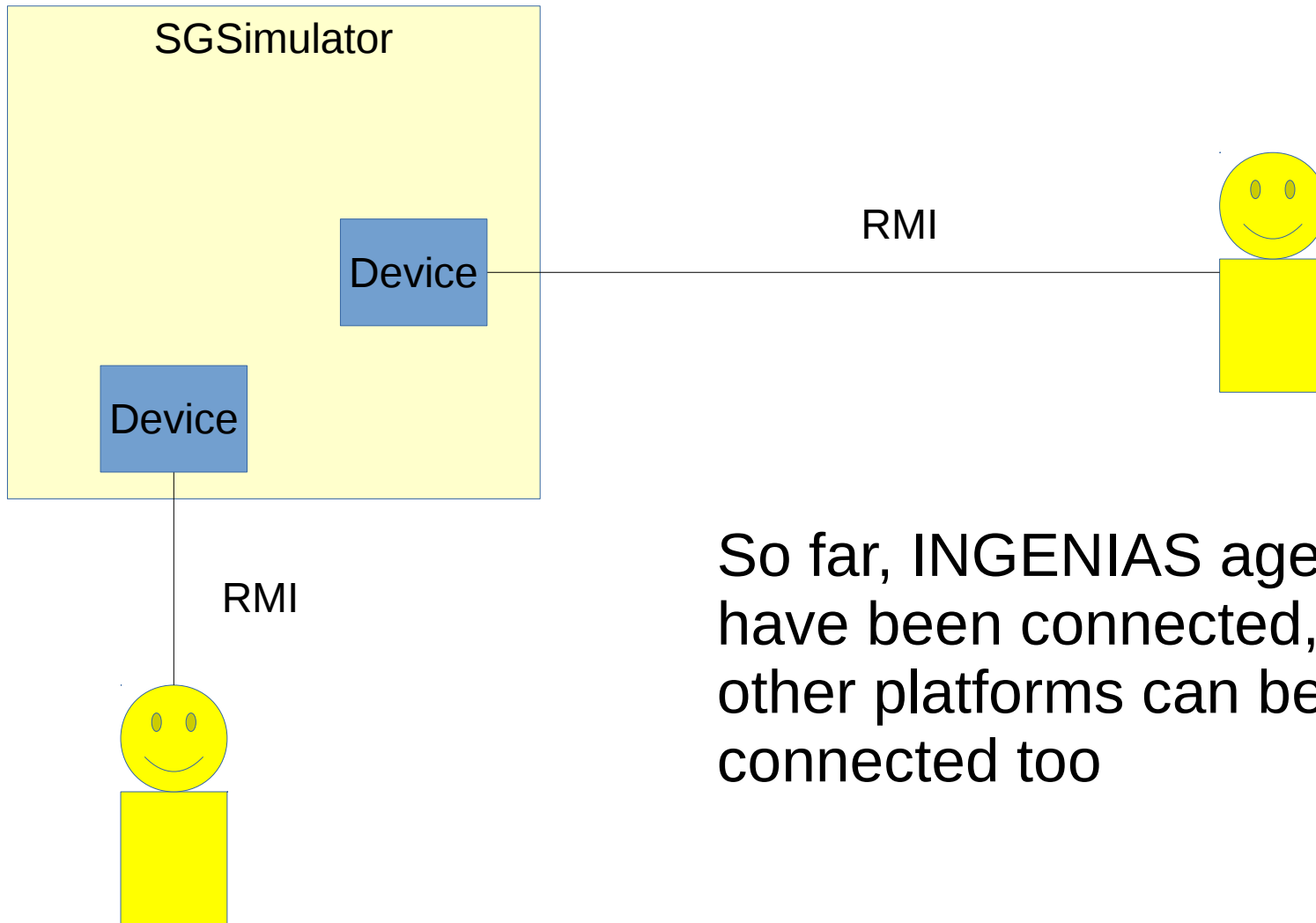
- There is a Microgrid with multiple renewal sources
- Each generator is controlled by one agent
- We want to dynamically coordinate the production of each plant in a way that:
  - The operational capabilities of the grid or not exceeded
  - The closer energy sources to the demand load are used
- There is no centralized control
  - Nodes can be cut down and reconnected



# The simulator

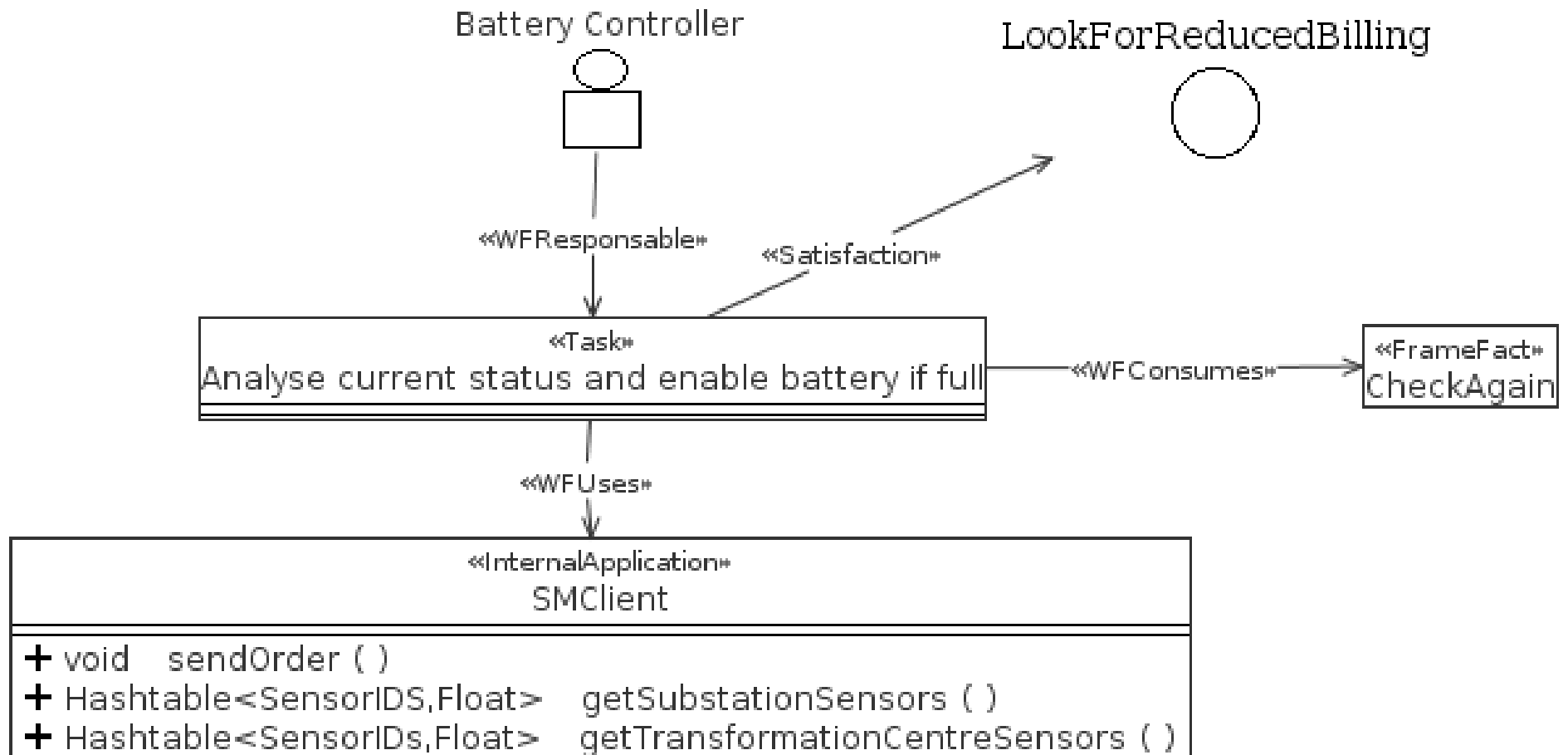


# Connecting the agents



So far, INGENIAS agents have been connected, but other platforms can be connected too

# Proof of concept



# Agents integration

- Get information of the status of their connected meters
  - Cheating: Global network status
- Send instructions to devices assigned to them (downstream)
  - Power on/off, Deliver P/Charge
  - Cheating: sending orders to other upstream devices
  - FIPA messages to



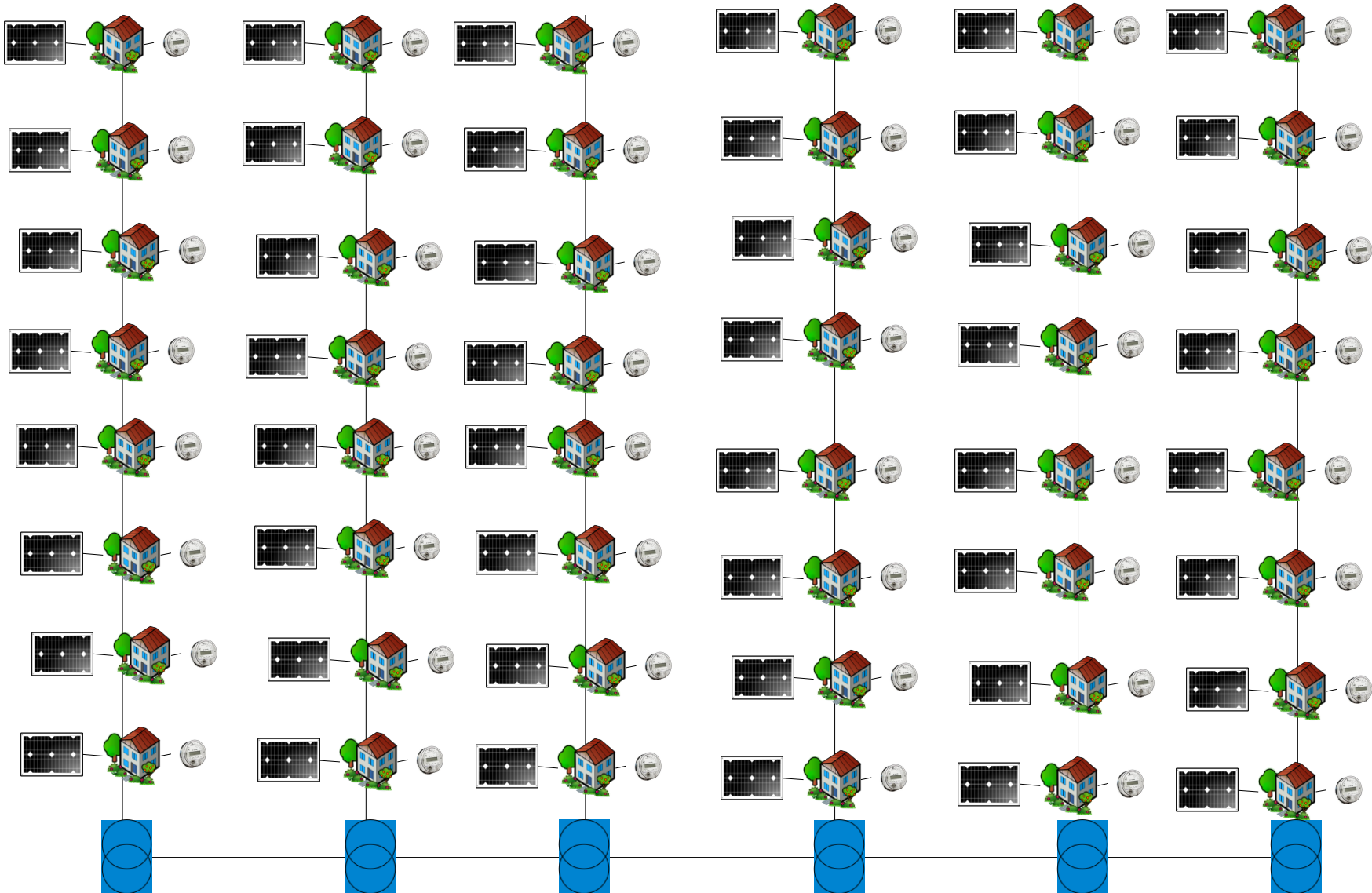




# Some thoughts

- Simulation of the powergrid is a weak point of most work
  - Where is your grid definition so that I can repeat your experiment?
- Markets and agents
  - Different works simulating the markets, fewer integrating grid simulation with market simulation
- Enabling research
  - Increasing the pool of tools for agent researchers will push advances from agent research community

# Can we coordinate the generation of this much PV panels?





# Conclusions

- Results come from MIREN-CON project (LGPL)

**<http://sgsimulator.sf.net>**

- The agent researcher may not be the most qualified to prepare a Microgrid
  - Collaboration with experts requires using experts tools
- Need affordable easy to use frameworks to test controls solutions with agents
  - At the same time, enabling collaboration with experts
- More possibilities
  - What if we connect this with Ambient Intelligence and control in-house energy demand?