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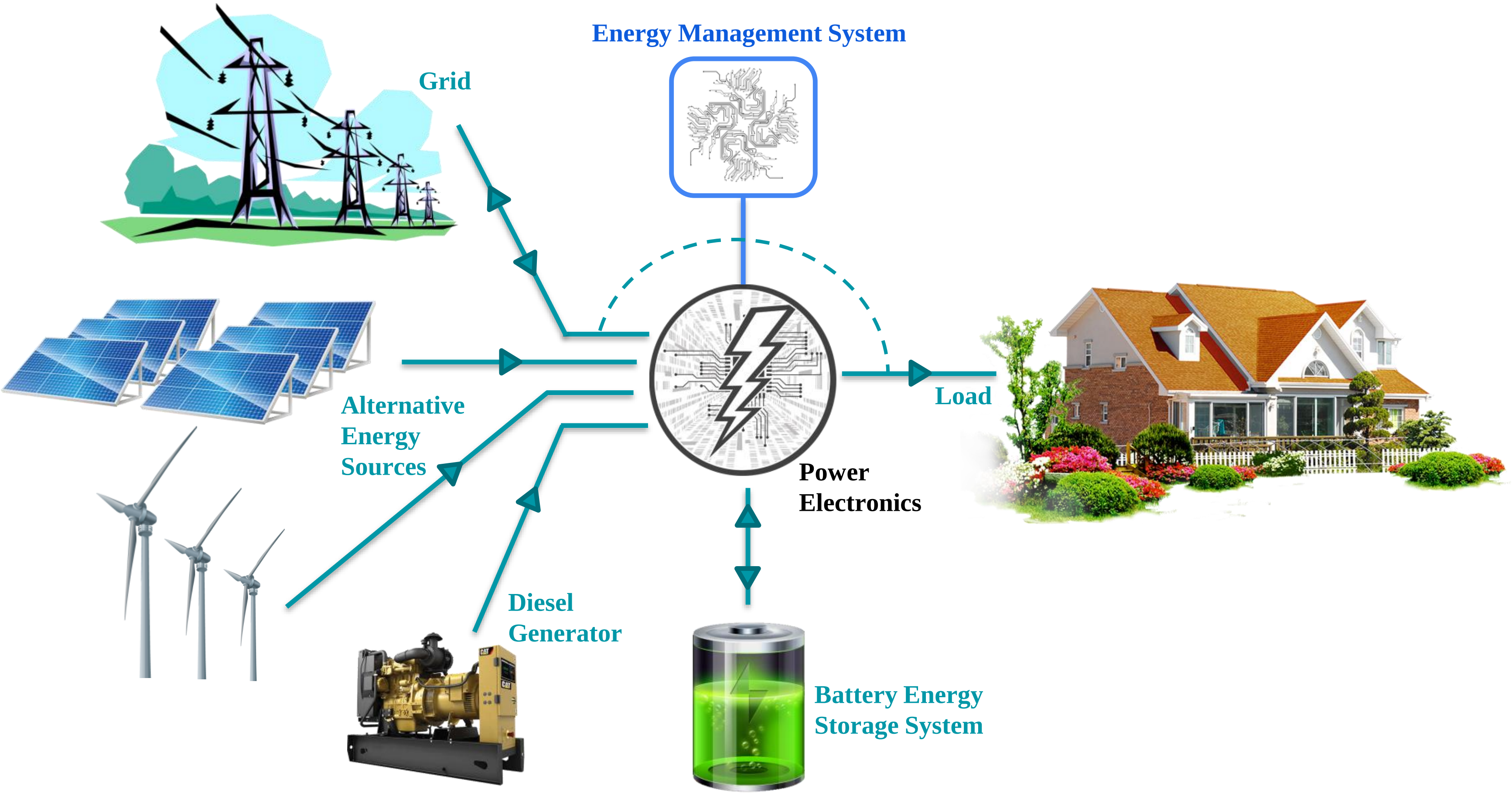
We find the optimal solution

Microgrid based on Battery Energy Storage System

Optimization

Energy Management System

Hybrid Energy System (Microgrid)



Before implementing a hybrid system, the customer faces the following questions:

- ❑ What are the technical advantages of a hybrid system?
- ❑ Capital Costs
- ❑ Payback period
- ❑ Automation of control
- ❑ Modularity and possibility of system expansion in the future

Technical advantages

- ➢ Energy independence
- ➢ Uninterruptible power supply
- ➢ Efficient use of energy resources (smart management)

Optimization

- ➢ Opportunity to reduce capital costs by up to **20%**
- ➢ Define **optimal power/capacity** of ESS
- ➢ **Accurate** calculation of the **payback period** due to taking into account many factors

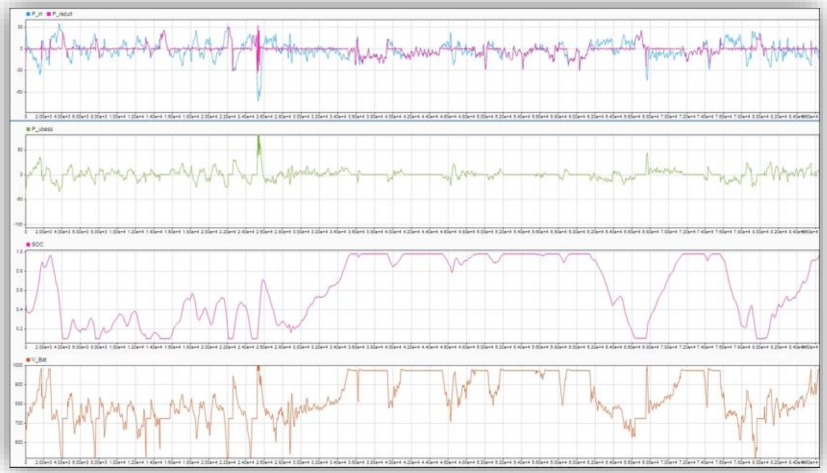
Energy Management System

- ➢ Smart Control
- ➢ Day-Ahead Prediction
- ➢ Participation in the ancillary services market

Optimization

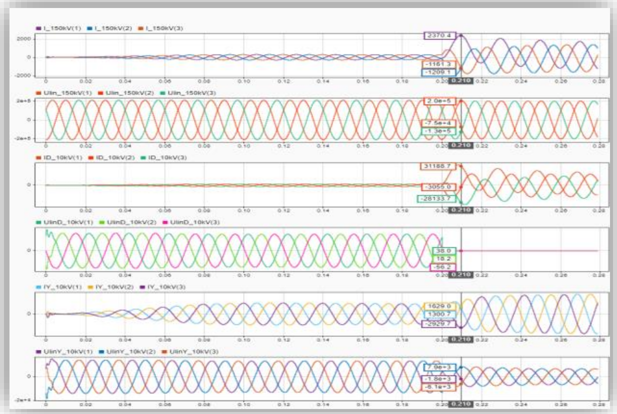
Main Outcomes:

- Due to object-oriented calculation, optimization makes it possible to reduce capital costs by up to 20% compared to standard recommendations for equipment selection
- Estimation the performance of future equipment with existing equipment, based on current consumption and generation power measurements
- Define optimal power/capacity of Battery Energy Storage System (BESS)
- Define ratings of the grid inverter and associated electrical equipment
- Feasibility study, accurate calculation of the payback period due to taking into account many factors



Simulation:

- Comprehensive study of modes in the power grid during equipment operation - short-circuit currents, protection actions, harmonics, power flows
- The ability to see the operation of equipment in emergency / abnormal mode
- The possibility of finding errors in technical solutions, analytical calculations, at an early stage, which has a positive effect on the timing of the project and cost

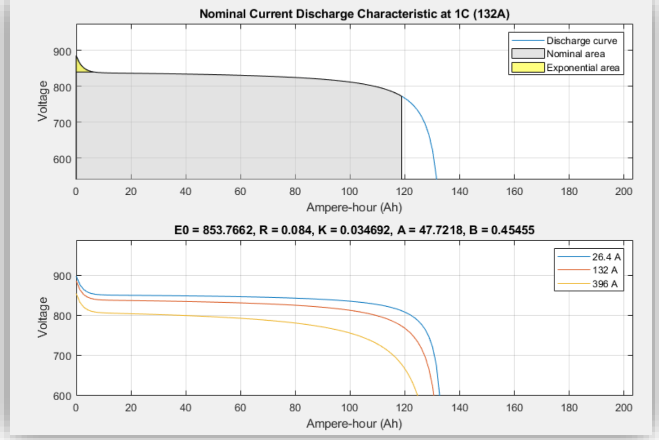


Analytics:

- Estimate number of cycles and resource of ESS
- Analysis of ESS process technological shutdowns caused by max/min SOC, max/min Vbat. Taking into account shutdowns in payback calculations
- Evaluation of different EMS control strategies to optimize the technical and economic performance of the system
- The need to install a new/additional solar station, gas generator, determine their power
- Analysis of results, development of recommendations

What is taken into account in calculation

- **Load (private house, apartment house, factory)**
  - Measurements of electricity consumption over time. This characterizes the behavior of the load during the day/week/month/year.
  - Specific industrial equipment that provides reactive power, inrush currents, additional harmonics, etc (if available)
- **Grid**
  - Measurements of electricity consumption over time
  - Grid limitations (e.g. power limitations, power outages for a certain duration, unstable voltage, etc.)
  - The cost of electricity, taking into account zones or different prices during the day
- **Solar power plant**
  - Measurements of electricity generation over time.
  - Variation in the power of a solar power plant
  - Generation variation depending on seasonality
- **Battery energy storage system**
  - Battery capacity variations
  - Inverter power variations
  - Battery characteristics (NMC/LFP/LTO, serial/parallel connection of cells, dependence on load current)
  - CC/CV controller
  - Charge/Discharge logic
  - Limitation on SOC and charge overvoltage
- **Diesel/Gas generator**
  - Load consumption characteristics
  - Efficiency characteristic
  - Fuel cost
- **Energy Management System**
  - Conventional home control system
  - Grid controller (when considering grid-related modes - peak shaving, Frequency Containment Reserves (FCR), Frequency Restoration Reserves (FRR), Replacement Reserves (RR) etc.)



What initial data is needed for calculation

- Single-line diagram, equipment power ratings
- Measurements of electricity during a year with 5 minutes interval using the following meters:
    - Main input (total consumption)
    - Charging electric vehicles
    - Solar power plant
    - Diesel generator
    - Other powerful consumers/generators
- Price of electricity for purchase / sale vs time of day
- Expected result criteria:
    - minimization of capital costs
    - Energy independence / guaranteed power supply
    - profit maximization in the energy balancing market
    - other

Energy Management System

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Smart EMS Microgrid Basic
For local hybrid system
<100 kW (house)

- ✓ **Smart Control:** efficient use of energy resources
- ✓ Smart accumulation / discharge using different electricity costs during the day
- ✓ **Energy independence**, Uninterruptible power supply
- ✓ **Quasi Power:** quasi-increase the power of the main input by Peak shaving
- ✓ **Fuel Saver:** generator control to reduce the number of starts, engine hours, use the generator at the point of maximum efficiency
- ✓ **Load Shifting:** load transfer during overloads by powering consumers from the ESS and restoring the battery charge when favorable conditions exist
- ✓ **Peak Shifting:** accumulation of energy from a solar power plant at moments when generation exceeds local consumption
- ✓ **Source Priority:** selection of power supplies for the consumer

Smart EMS Microgrid Pro
For a local hybrid system with prediction
>100 kW (enterprise)

- ✓ All previous features
- ✓ **Day-Ahead Prediction**
- ✓ **Quality of supply:** ensuring the necessary parameters of power supply quality - voltage, phase synchronization, harmonic distortion
- ✓ **Smart Charge:** smart power management of charging stations for electric vehicles, prioritization
- ✓ **Peak Shaving:** reduction of load peaks at the start stage of such consumers as pumping equipment, ventilation system motors, etc.
- ✓ Local reactive power compensation mode

EMS Grid
Power grid stabilization
>1 MW

- ✓ **Participation in the ancillary services energy market:**
  - ✓ Frequency Containment Reserves (FCR),
  - ✓ Frequency Restoration Reserves (FRR),
  - ✓ Replacement Reserves (RR) etc.
  - ✓ Virtual Power Plant Mode

This approach allows us to see the operation of equipment as an interconnected physical complex with control system, and determine the optimal control scenario to obtain the best technical and economic indicators.

Key projects:

1 Battery Energy Storage System
Optimal power definition of Battery Energy Storage System (BESS) based on energy measurements
https://www.m-works.pro/bess

2 Automatic voltage regulator for power generators
Improvement of Automatic voltage regulator (AVR) with stabilization channels (PSS) for excitation systems of power generators
https://www.m-works.pro/controlsystemdesign-avr

3 Static Var Compensator
Static Var Compensator (SVC) parameters definition for electric arc furnace without preliminary energy measurements. Harmonics analysis of SVC with TCR 13Mvar, 6kV and 3rd- and 5th-order harmonic filters in power grid
https://www.m-works.pro/svc

4 Active Front End rectifier
Simulation the Active Front End rectifier 1000V, 200A for Battery Energy Storage System
https://www.m-works.pro/afe

5 Different power rectifier circuit topologies
Simulation different power rectifier circuit topologies according to DIN 41761
https://www.m-works.pro/dinschemes

https://www.m-works.pro/projects-2

We look forward to discuss the details of our pilot project

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