

MATLAB EXPO 2017

KOREA

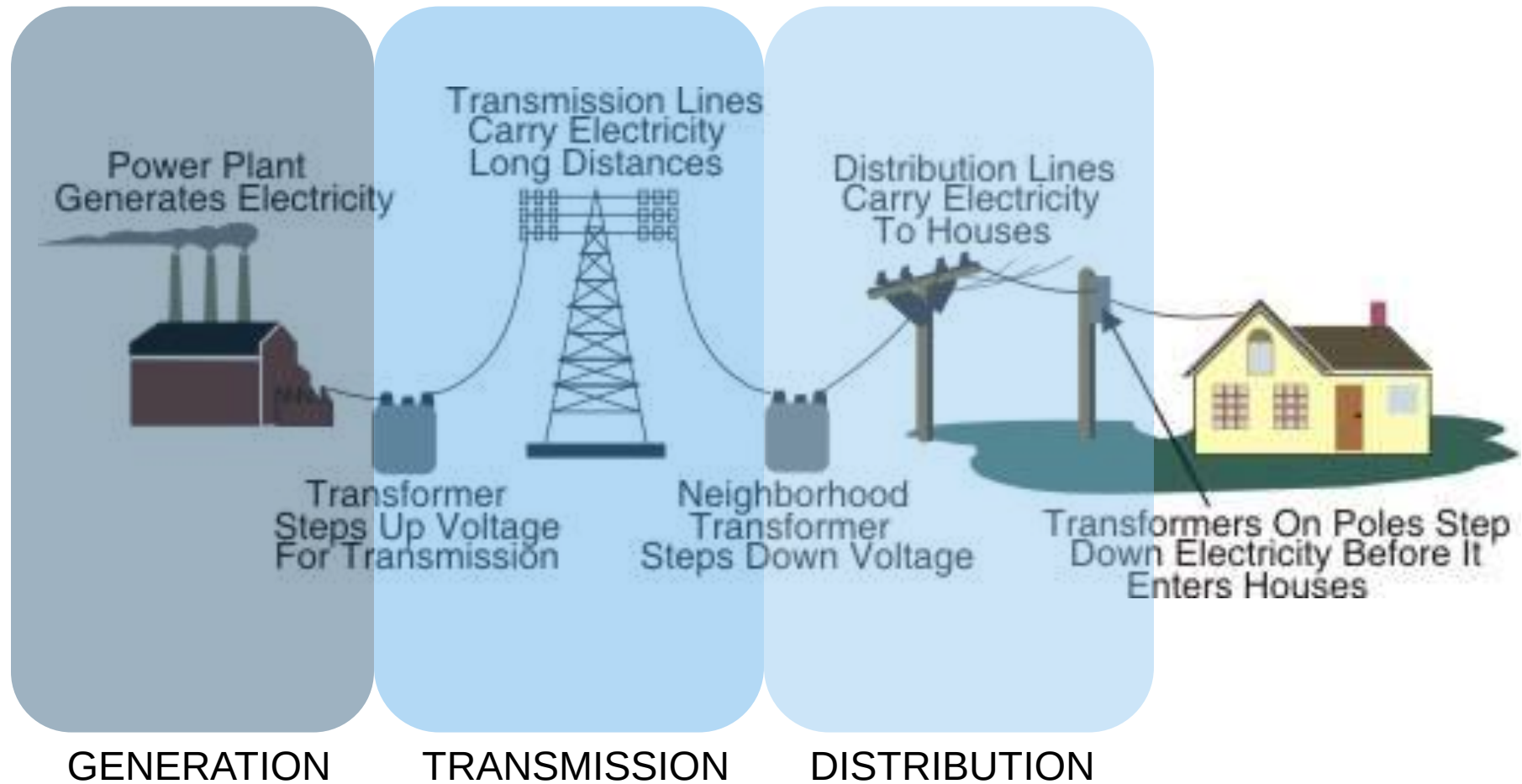
4월 27일, 서울

등록 하기 matlabexpo.co.kr

Power Electronics Design and Simulation with Simscape Power Systems

강효석 과장 / Ph. D.
Application Engineer
MathWorks Korea

Electrical Power System



Industry Needs of Power Electronics

- Technology for the control and conversion of electric power
- One of main technology to overcome energy problem
- Key factor is energy conservation through high efficiency



Diverse User in Power Electronics



OMRON

Sandia
National
Laboratories

Power
Electronics

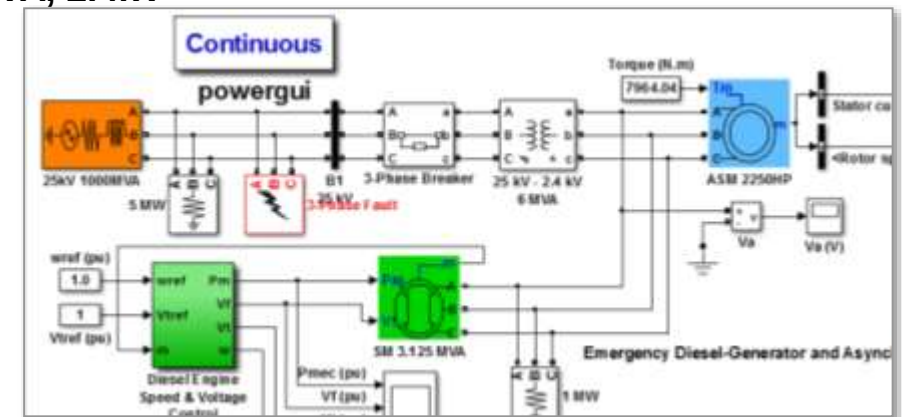
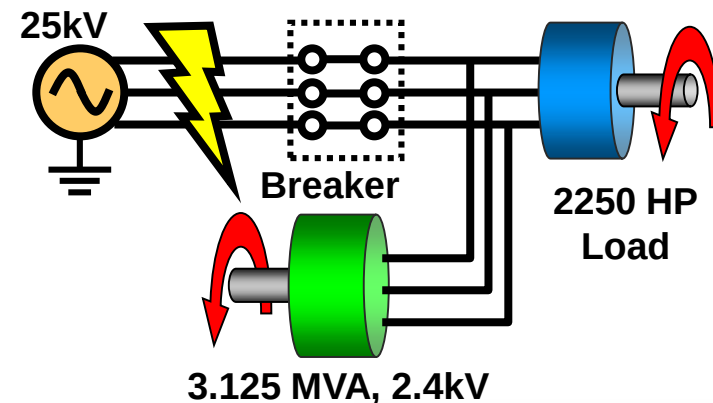
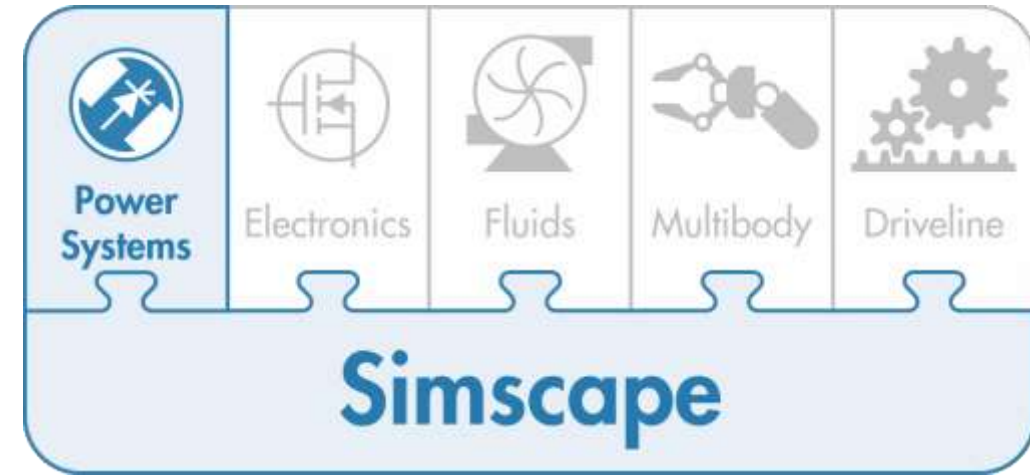
ABB

Alstom Grid



Introduction to Simscape Power Systems

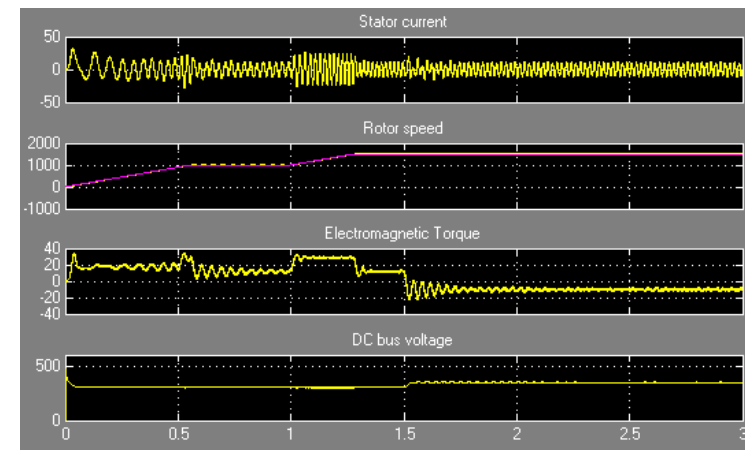
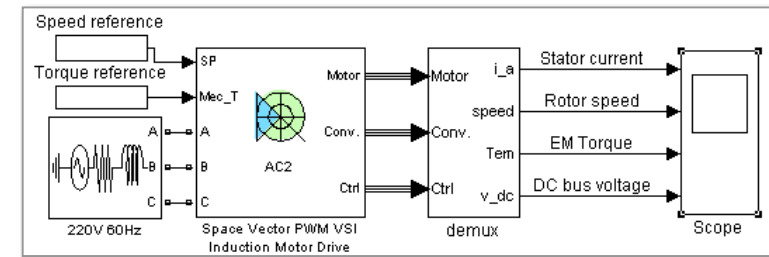
- Enables physical modeling (acausal) of electrical power systems and electric drives
- Electrical system topology represented by schematic circuit
- Used by electrical, system and control engineers to develop plant models and test control systems



Working with Simscape Power Systems

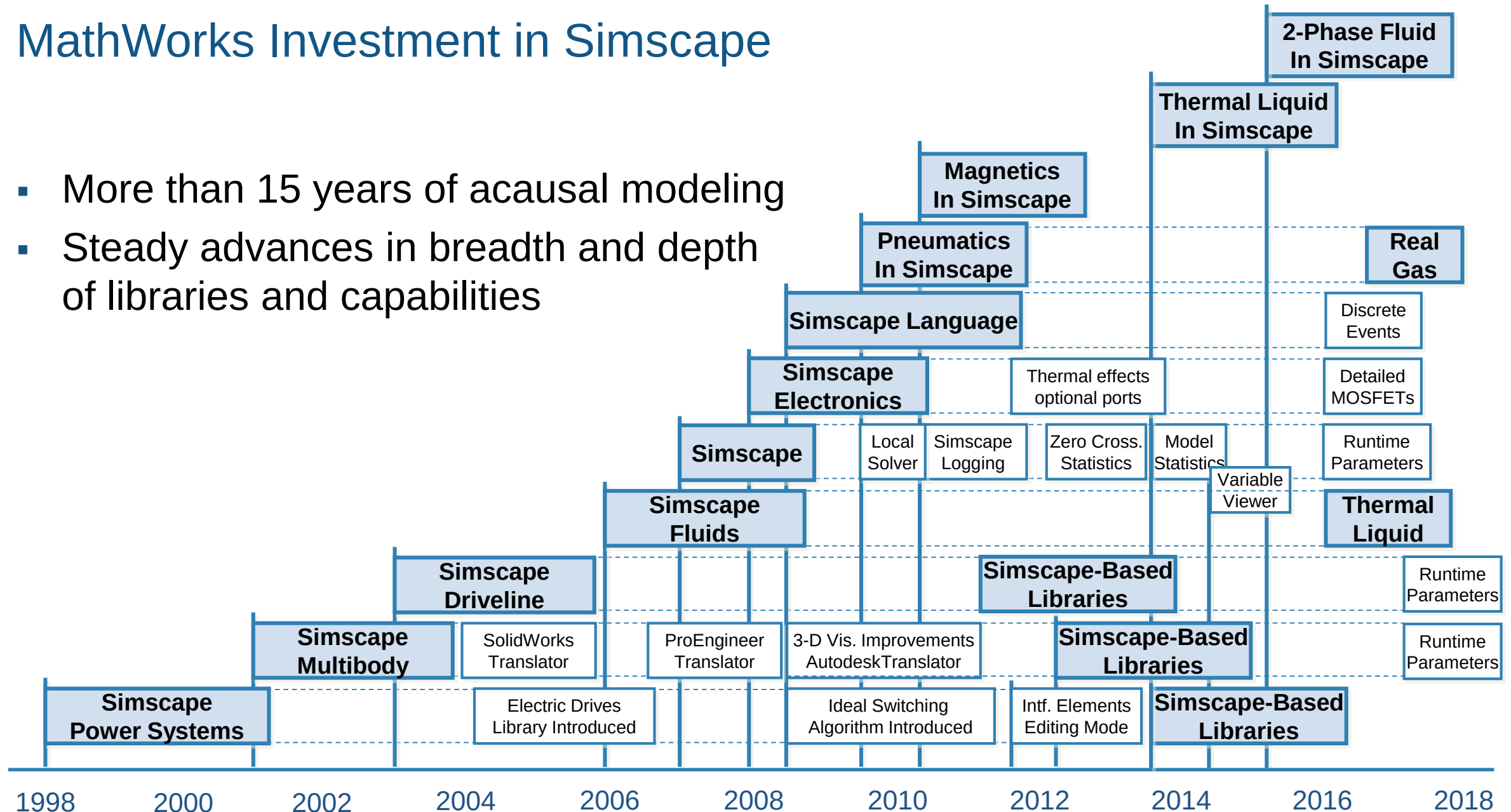
Simscape Power Systems is a tool for modeling the generation, transmission, distribution, and consumption of electrical power

- With Simscape Power Systems you can:
 - Quickly build electrical power system models
 - Model synchronous and asynchronous electric drives
 - Perform common electrical system analysis tasks
 - Develop and test controls
 - Generate code for improved performance



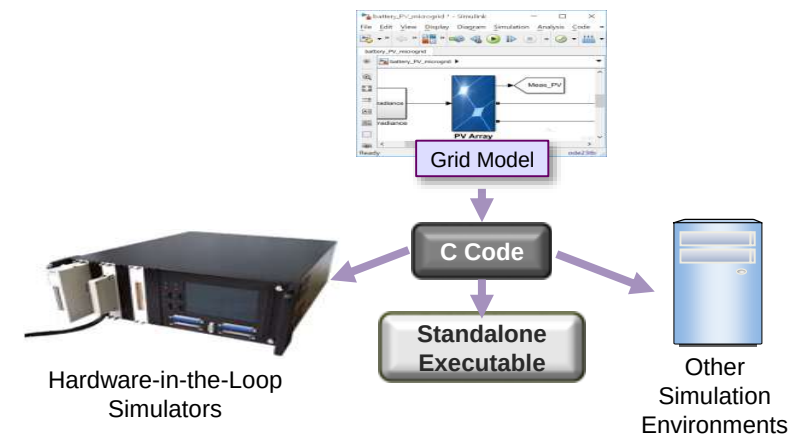
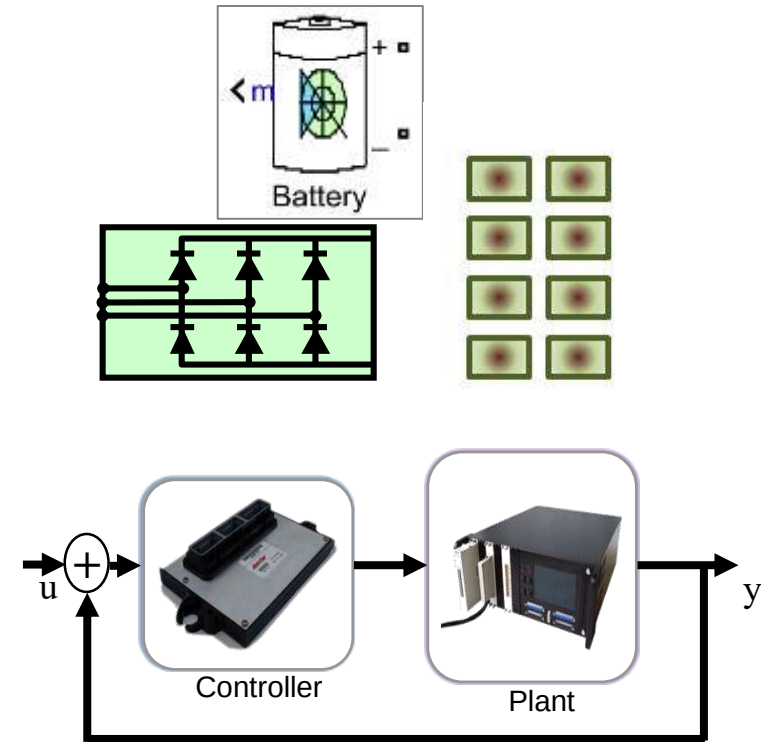
MathWorks Investment in Simscape

- More than 15 years of acausal modeling
- Steady advances in breadth and depth of libraries and capabilities



Key Points

- Physical component models at various levels of fidelity are necessary for Power Electronics
- Modeling the plant and controller in a single environment enables system level optimization
- Deploy the model as C code to other simulation environments, or use it as a standalone executable



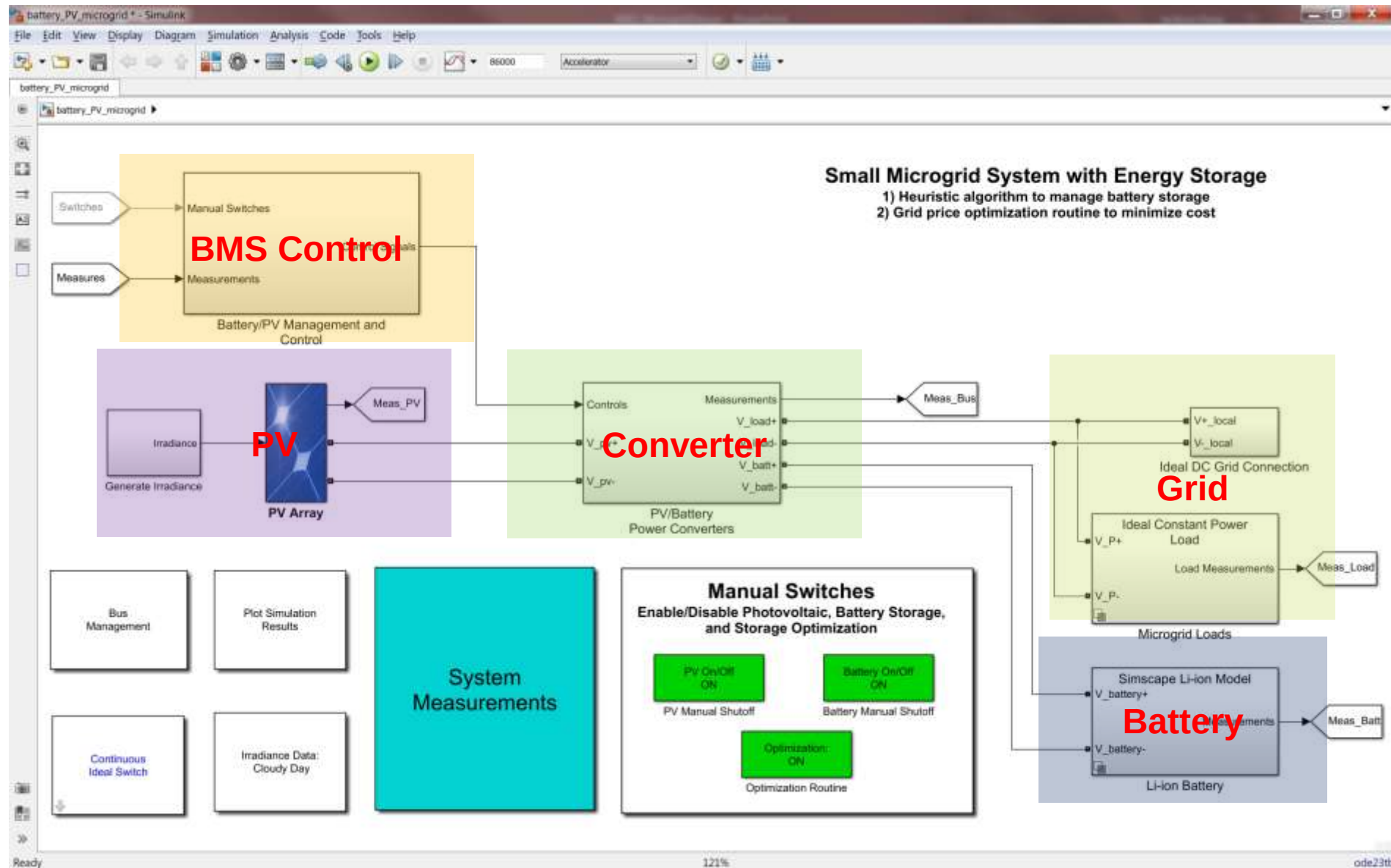
Agenda

- Modeling electrical and electronic components
 - Modeling Electrical Circuit : Buck Converter
 - Battery Modeling using Simscape Power Systems
- Designing control algorithms
- Simulating in Real Time
- Summary

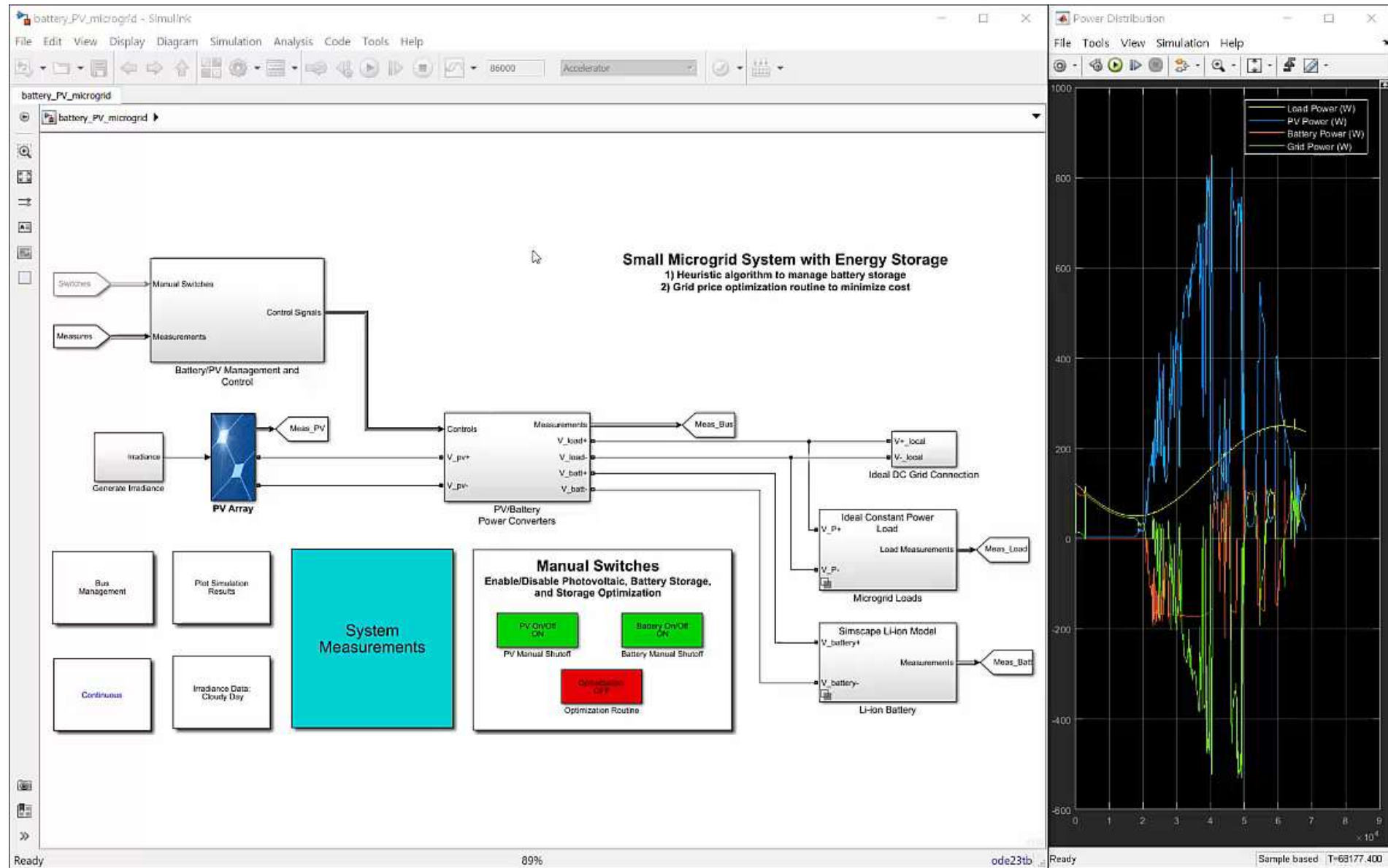
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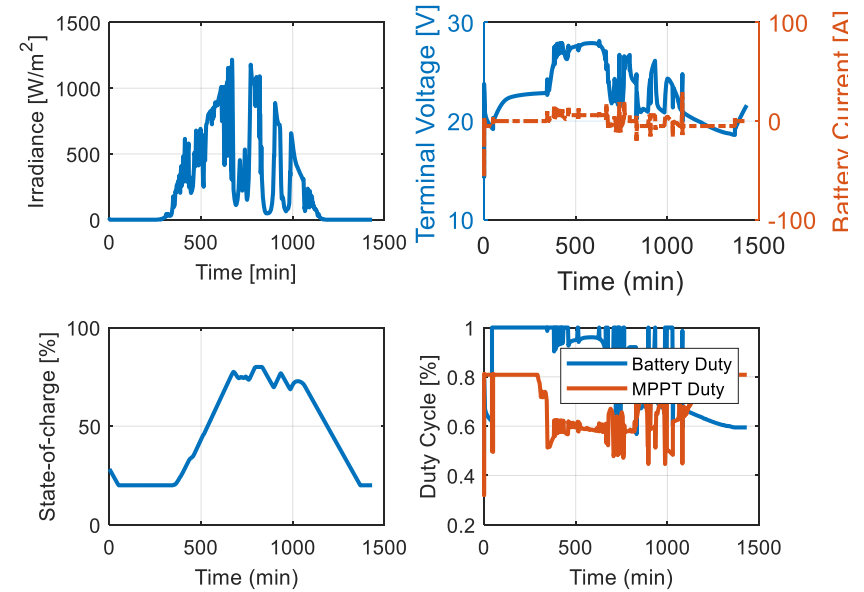
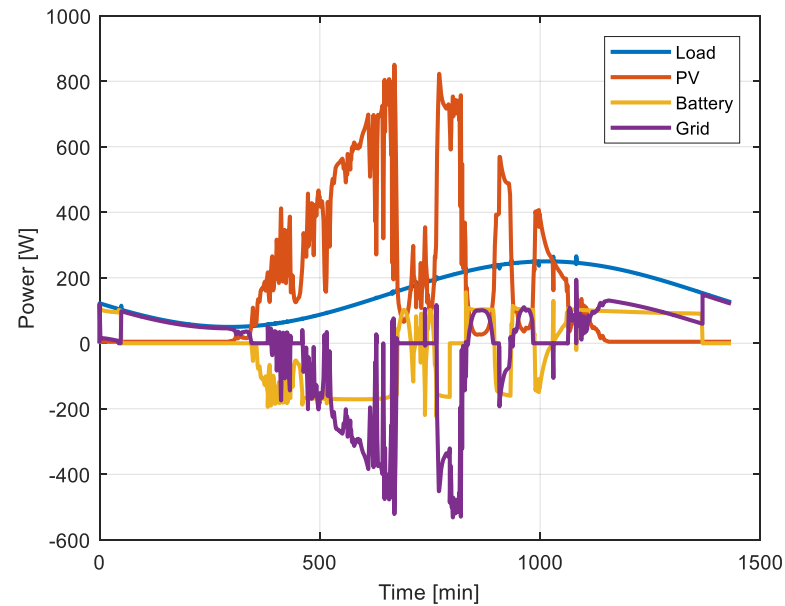
Demo : Small Microgrid System with Energy Storage



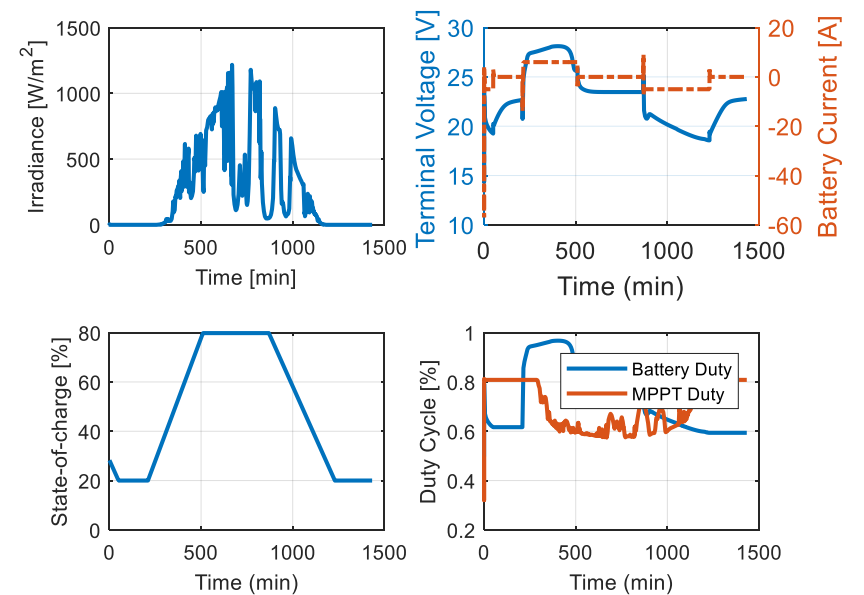
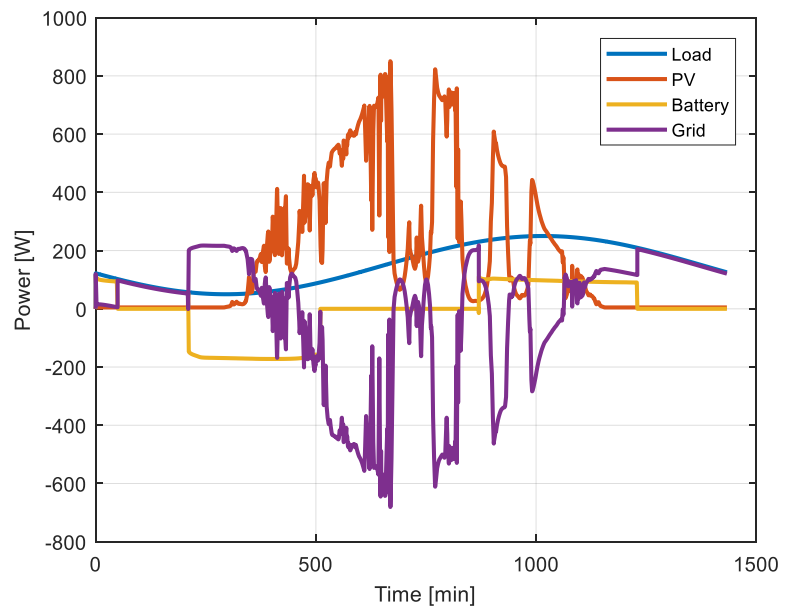
Small Microgrid System with Energy Storage



Heuristic Logic



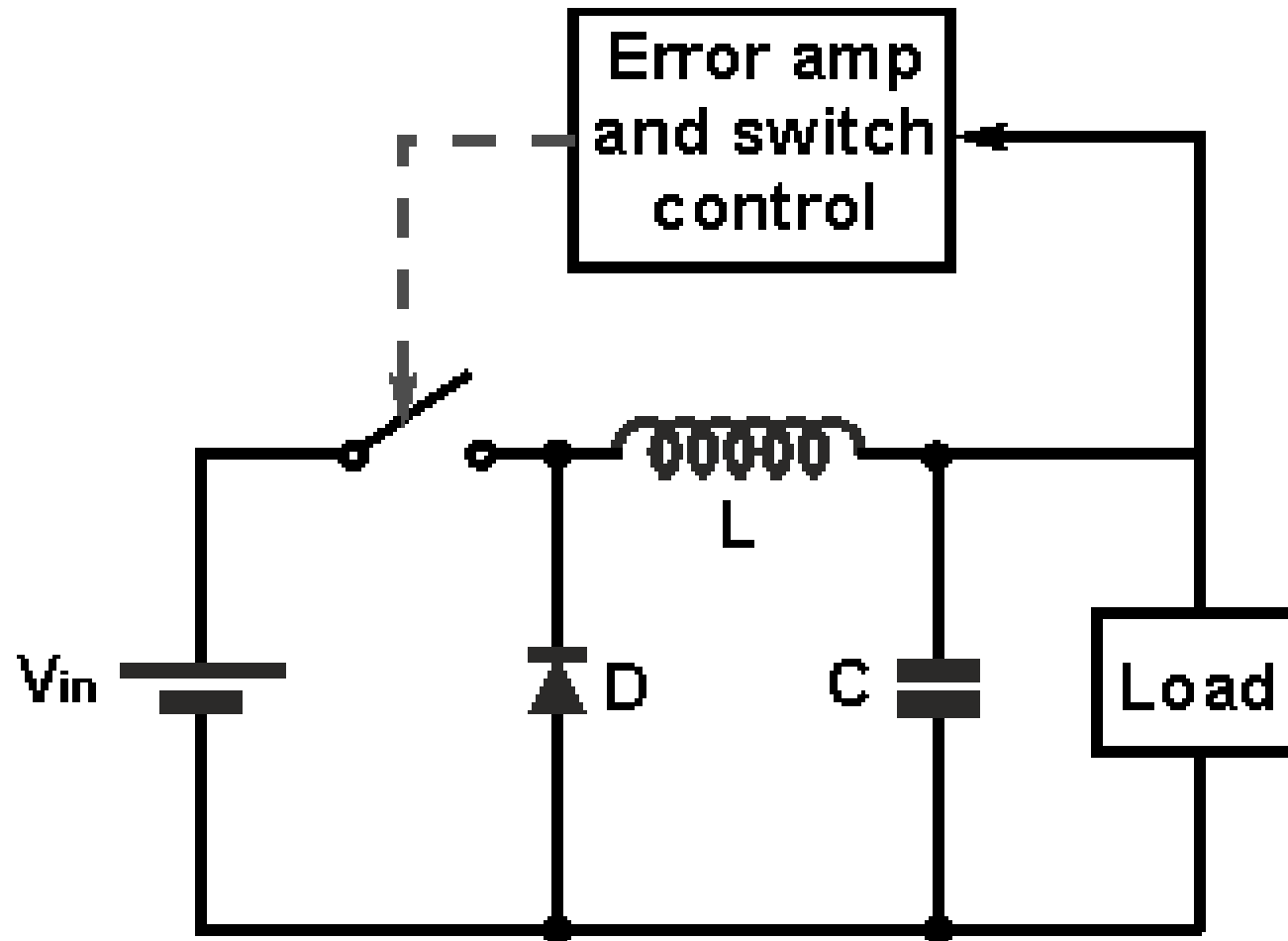
Optimization Logic



Agenda

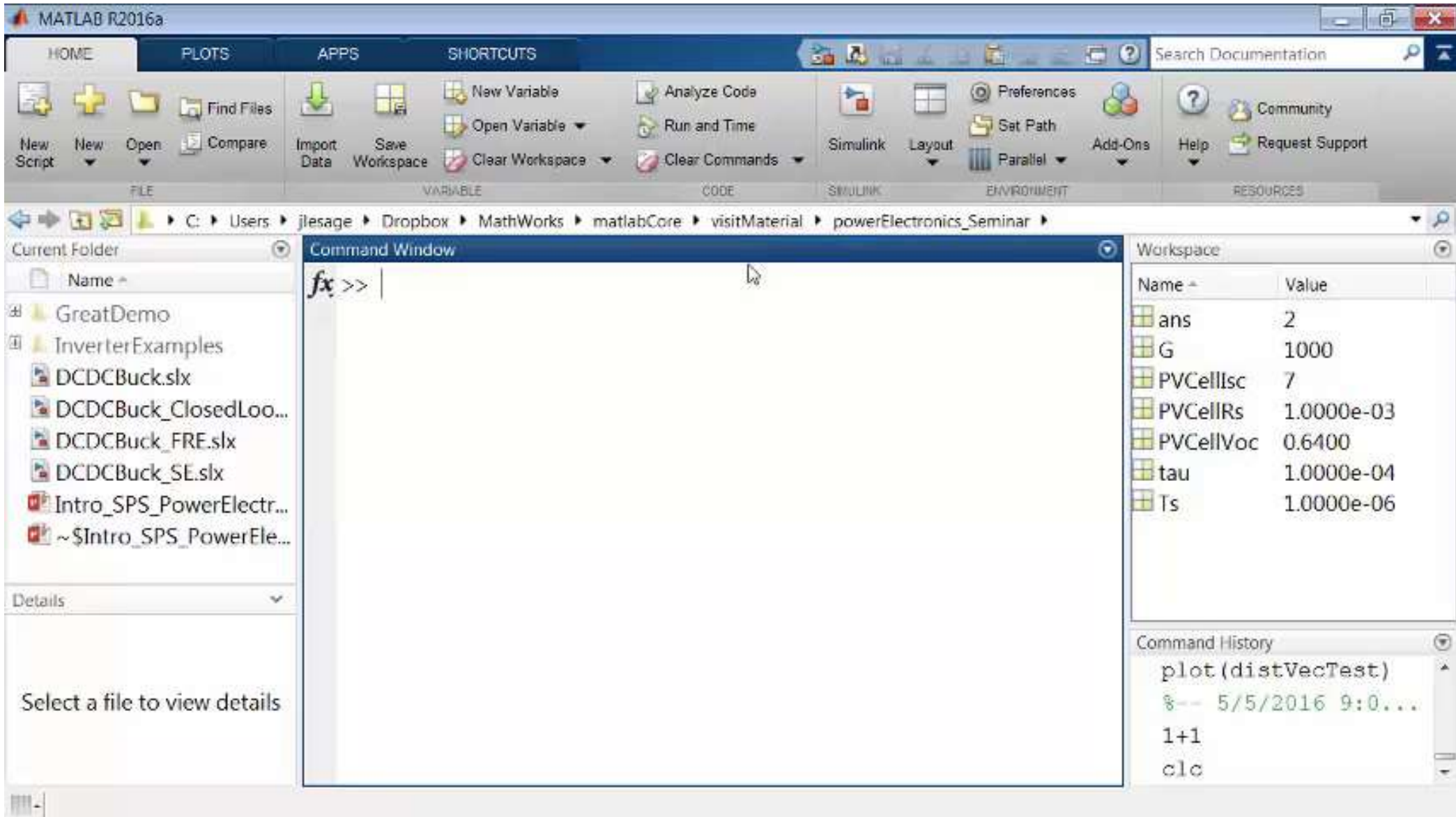
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DC-DC Converter (Buck Converter)



High DC Voltage $\rightarrow$ Low DC Voltage

Modeling Electrical Circuit – Buck Converter



The screenshot displays the MATLAB R2016a environment. The top ribbon includes tabs for HOME, PLOTS, APPS, and SHORTCUTS. The Command Window is active, showing the prompt `fx >> |`. The Workspace window on the right lists several variables with their values:

Name	Value
ans	2
G	1000
PVCellIsC	7
PVCellRs	1.0000e-03
PVCellVoc	0.6400
tau	1.0000e-04
Ts	1.0000e-06

The Command History window at the bottom right shows the following commands:

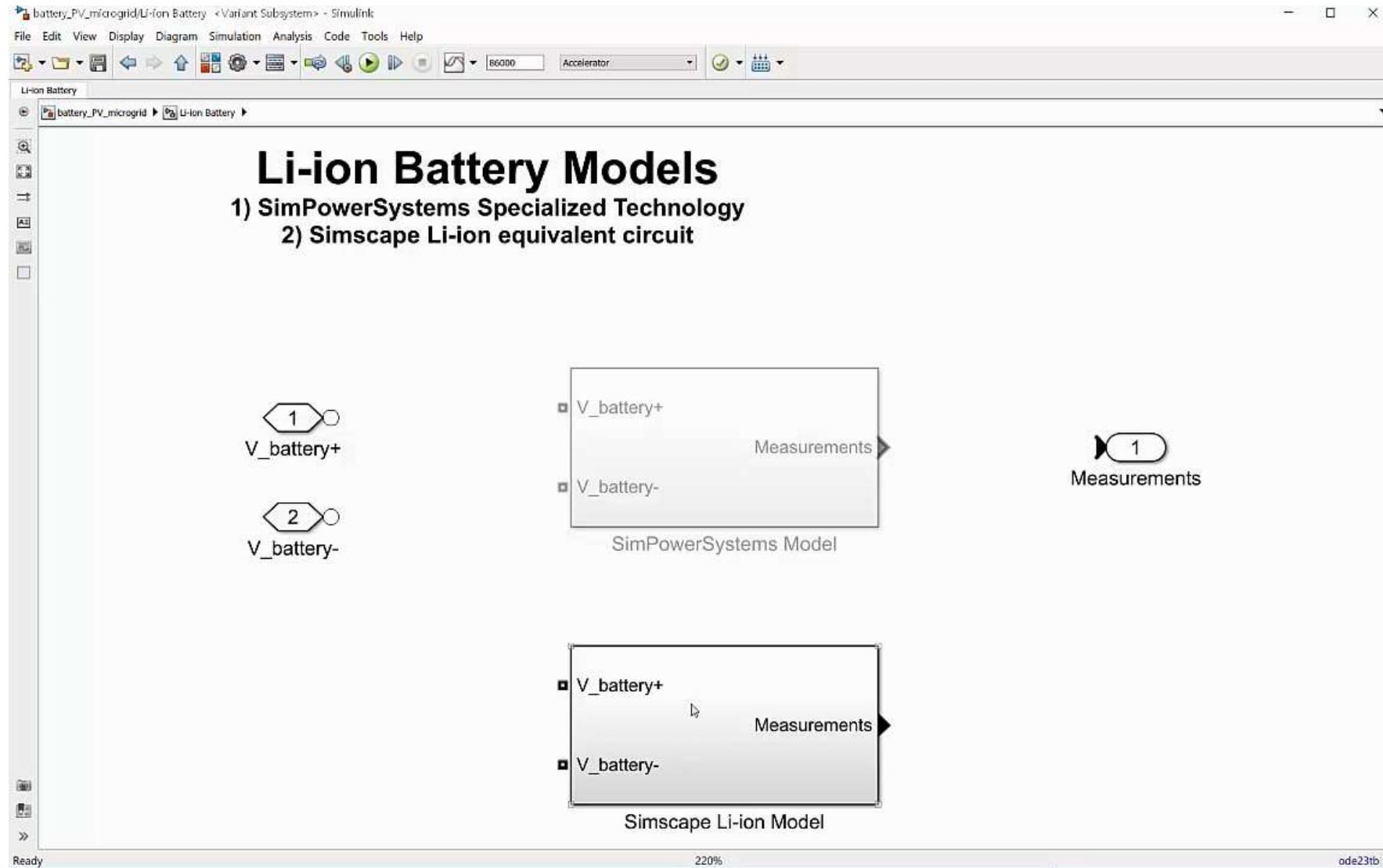
```
plot(distVecTest)
%-- 5/5/2016 9:0...
1+1
clc
```

The File Explorer on the left shows the current folder path: `C:\Users\jlesage\Dropbox\MathWorks\matlabCore\visitMaterial\powerElectronics_Seminar`. The folder list includes `GreatDemo`, `InverterExamples`, and several `DCDCBuck` subfolders and files.

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Battery Modeling using Simscape Power Systems

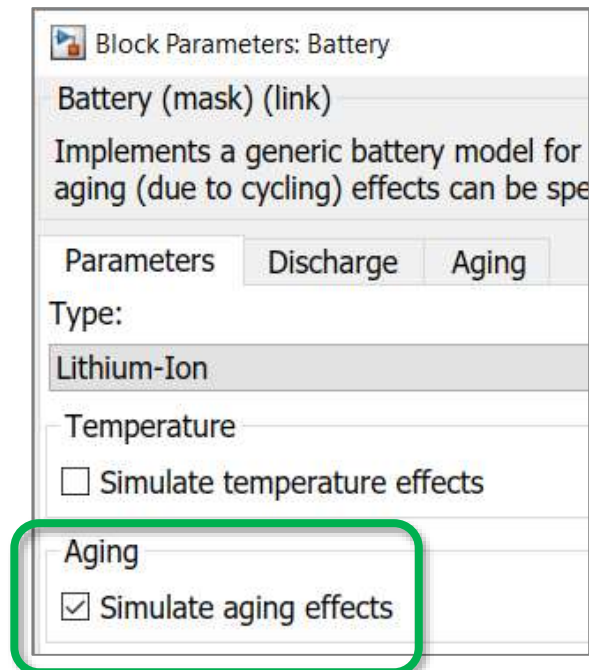
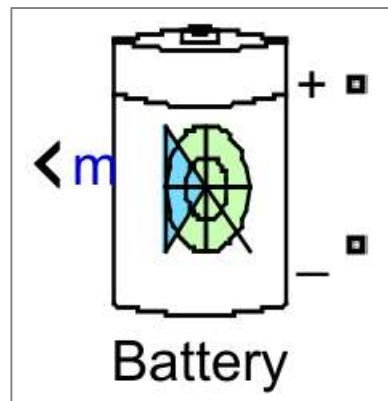


Simscape Power Systems **ST**

Lithium-Ion Battery Aging Model

R2017a New Feature

- Model the lifetime performance of a battery storage system
 - generic aging model with parameters that can be obtained from manufacturer datasheets or simple experiments



Parameters Discharge Aging

Initial battery age (Equivalent full cycles) 0

Aging model sampling time (s) 1e6

Aging characteristics at ambient temperature Ta1

Ambient temperature Ta1 (deg. C) 25

Capacity at EOL (End Of Life) (Ah) 5.4*0.9

Internal resistance at EOL (Ohms) 0.013333*1.2

Charge current (nominal, maximum) [Ic (A), Icmx (A)] [2.3478, 3]

Discharge current (nominal, maximum) [Id (A), Idmax (A)] [2.3478, 10]

Cycle life at 100 % DOD, Ic and Id (Cycles) 1500

Cycle life at 25 % DOD, Ic and Id (Cycles) 10500

Cycle life at 100 % DOD, Ic and Idmax (Cycles) 1000

Cycle life at 100 % DOD, Icmx and Id (Cycles) 1400

Aging characteristics at ambient temperature Ta2

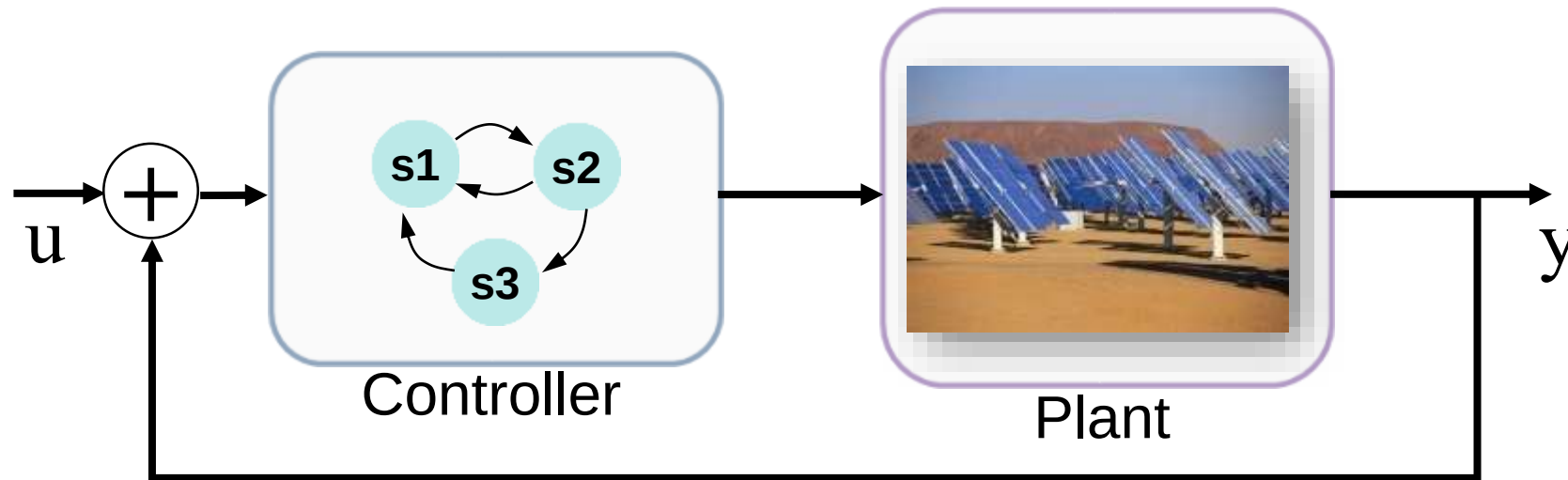
Ambient temperature Ta2 (deg. C) 45

Cycle life at 100 % DOD, Ic and Id (Cycles) 950

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Designing control algorithms

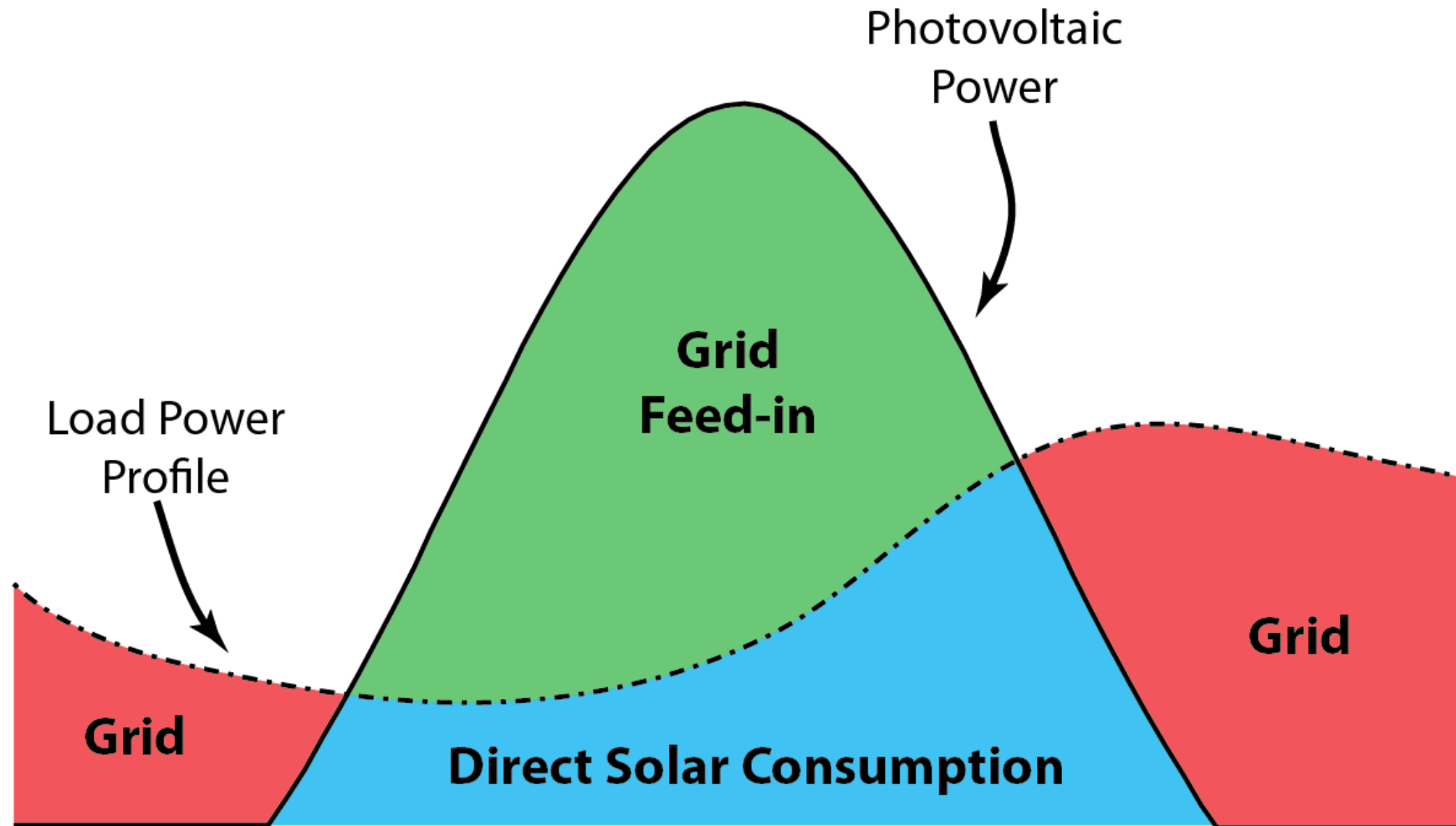


Simulating plant and controller **in one environment** allows you to **optimize system-level performance**

- Automate tuning using optimization algorithms
- Accelerate process using parallel computing

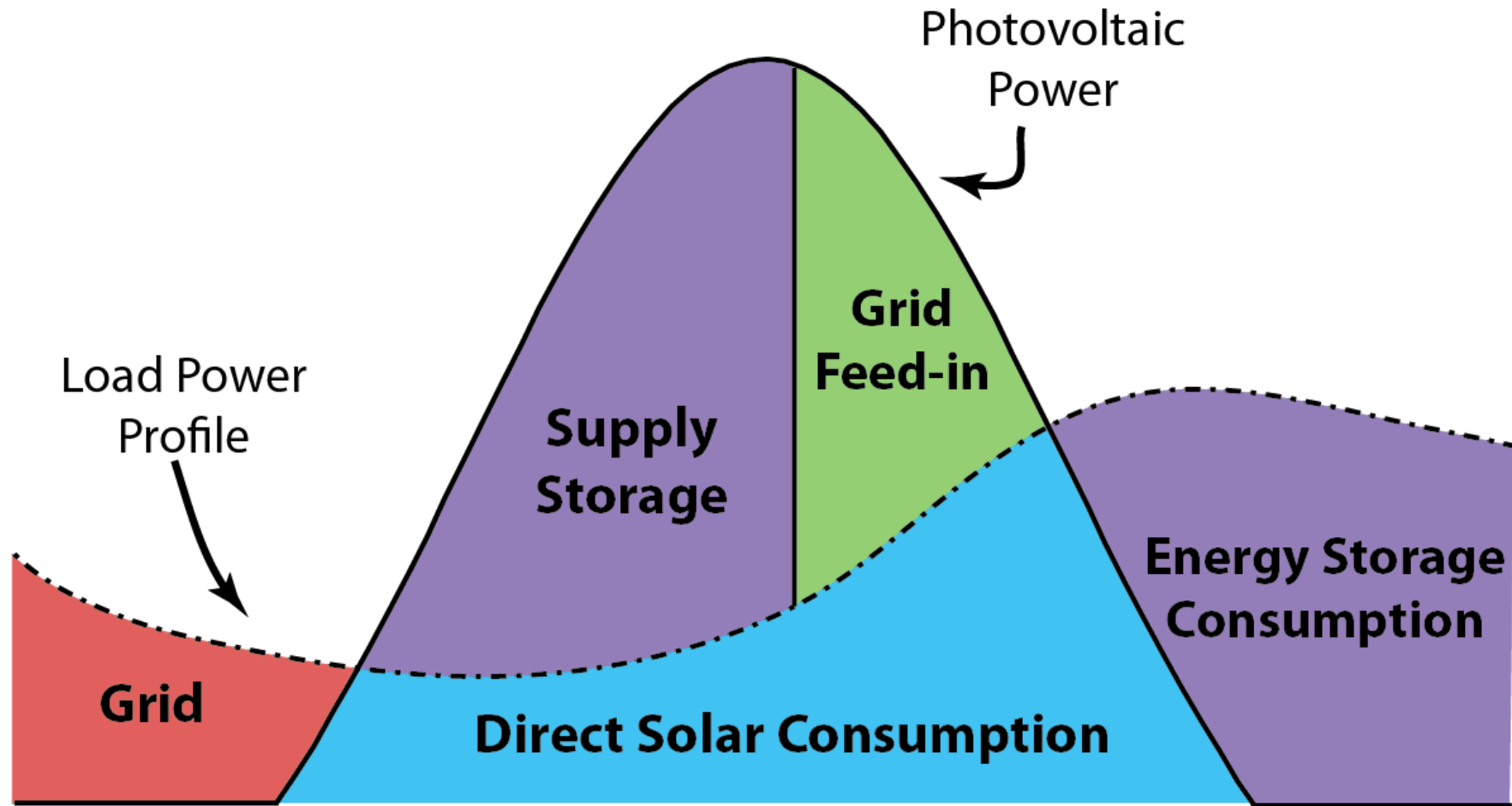


Defining Control Logic for Battery Management System



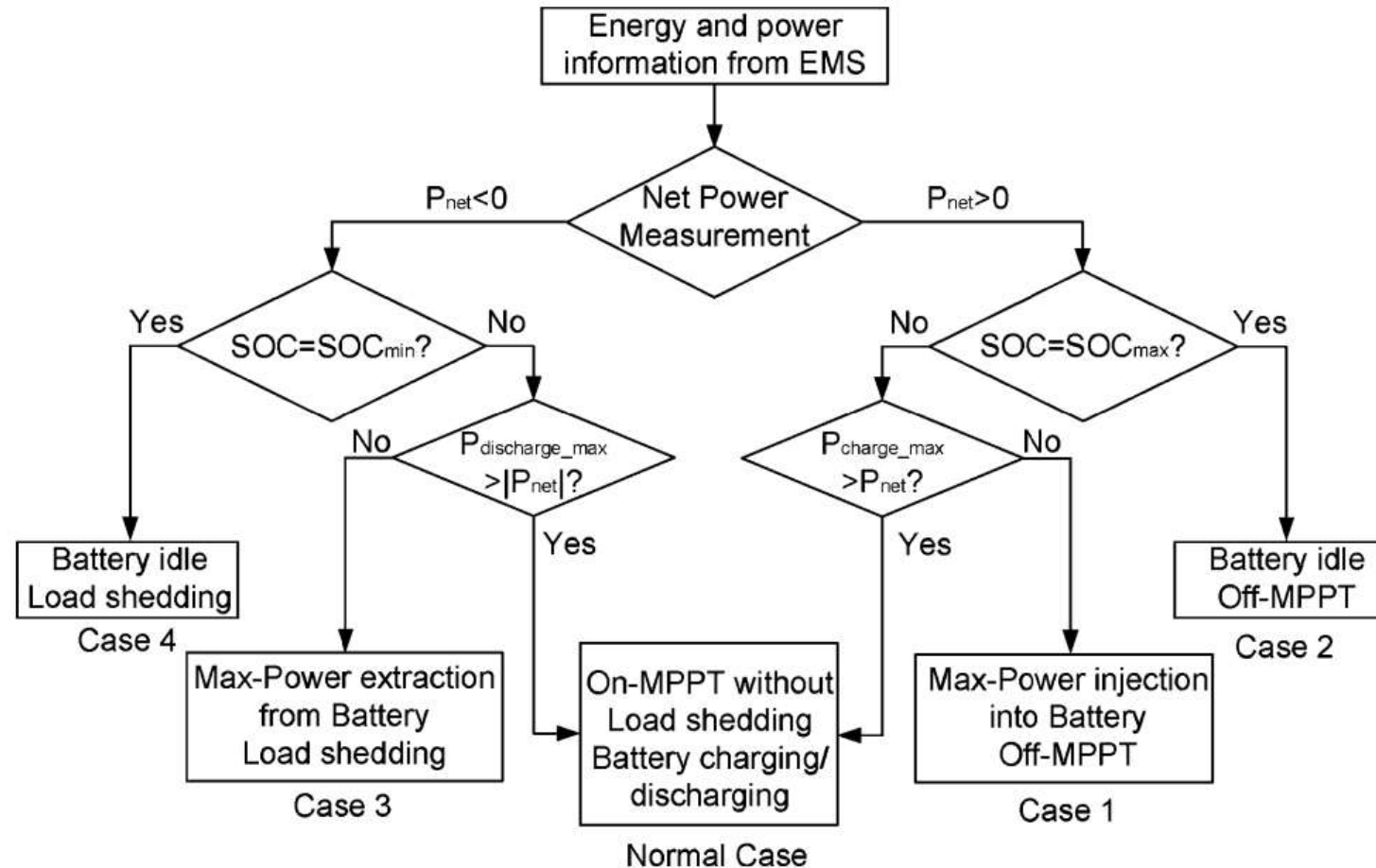
Adapted from: Smart EnergySystems Website
<http://www.smart-energy.ag/products/ac-gekoppelte-speicherlosung-smartenergy-ac/?lang=en>

Peak Demand Shift using Energy Storage

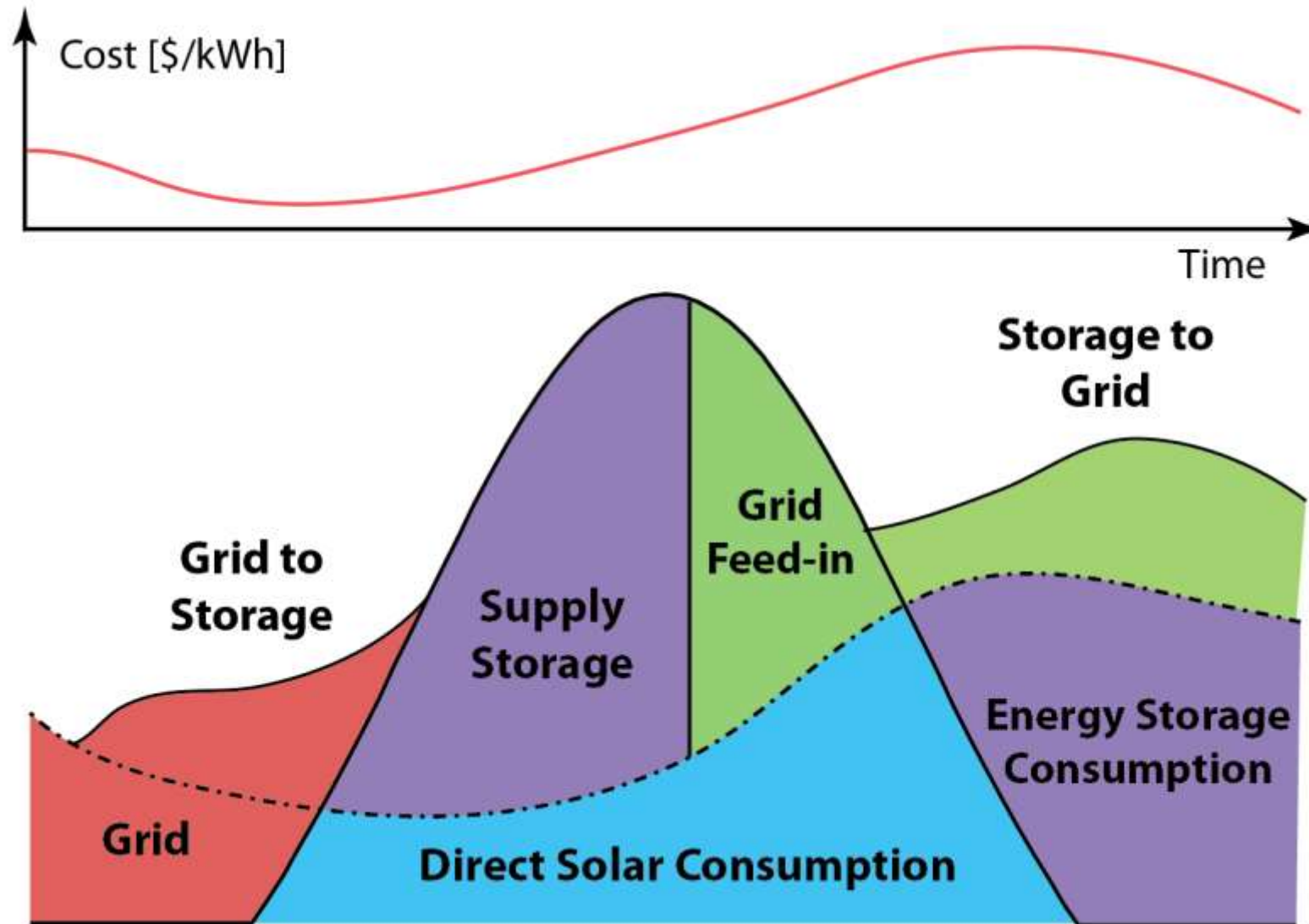


Adapted from: Smart EnergySystems Website
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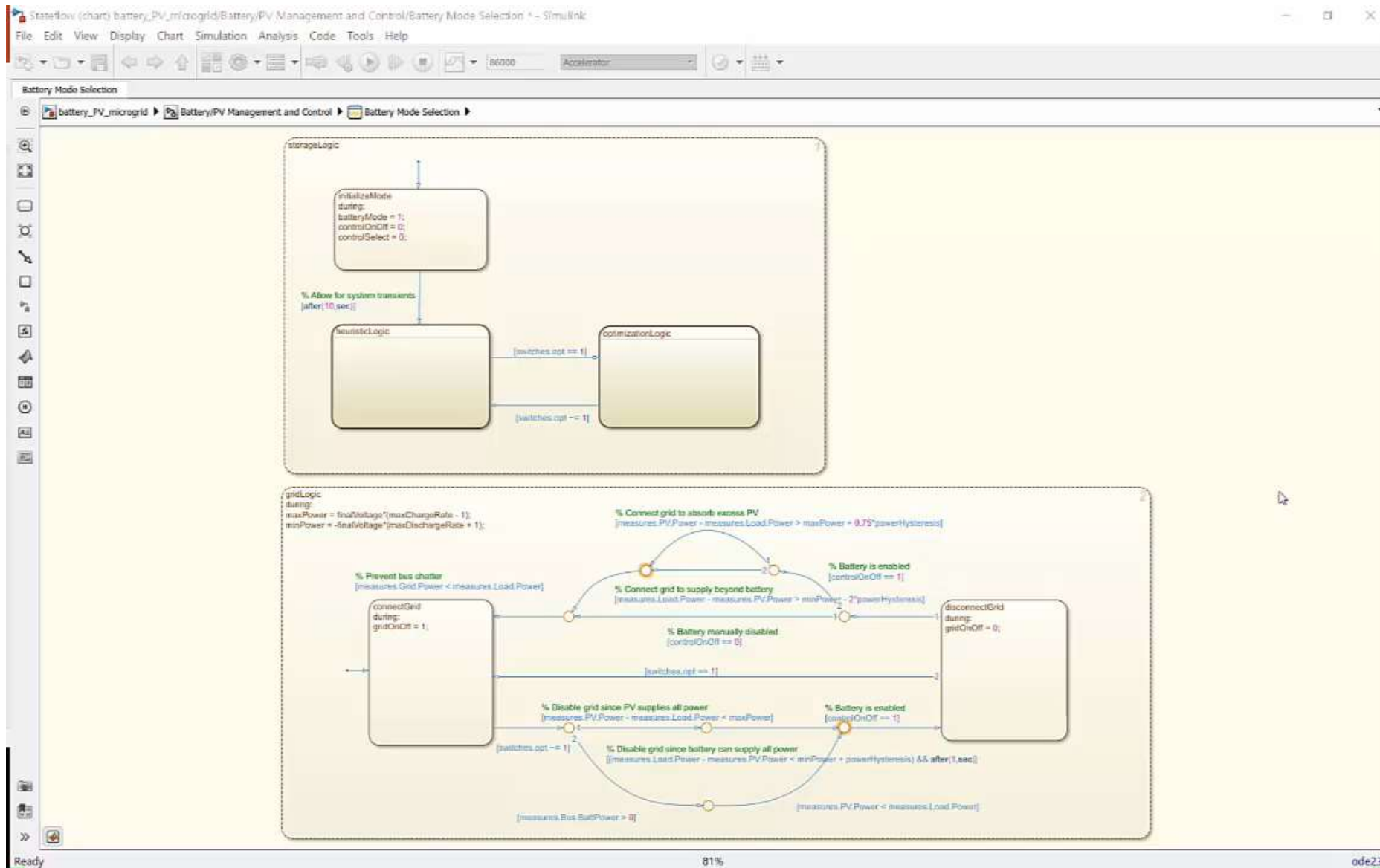
Implementation of Energy Management Logic



Factoring in Variable Electricity Cost



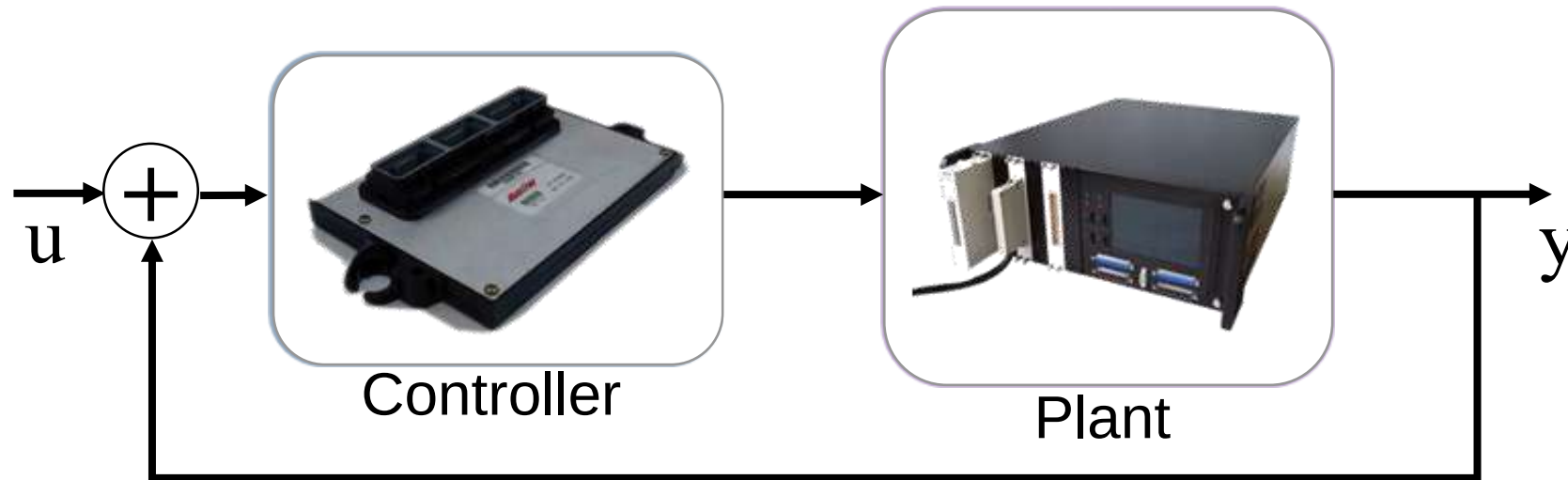
Defining Control Logic for Battery Management System



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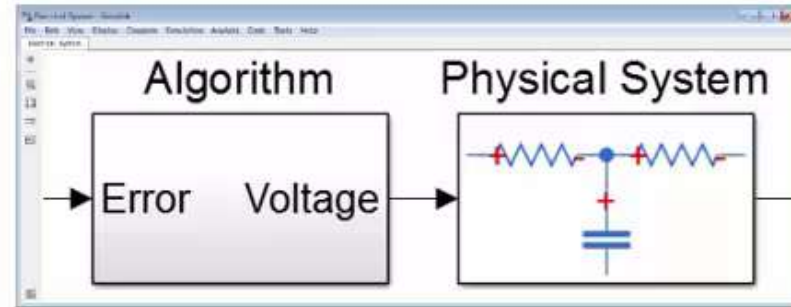
Detect Integration Issues Earlier



Controls engineers and domain specialists can work together to **detect integration issues in simulation**

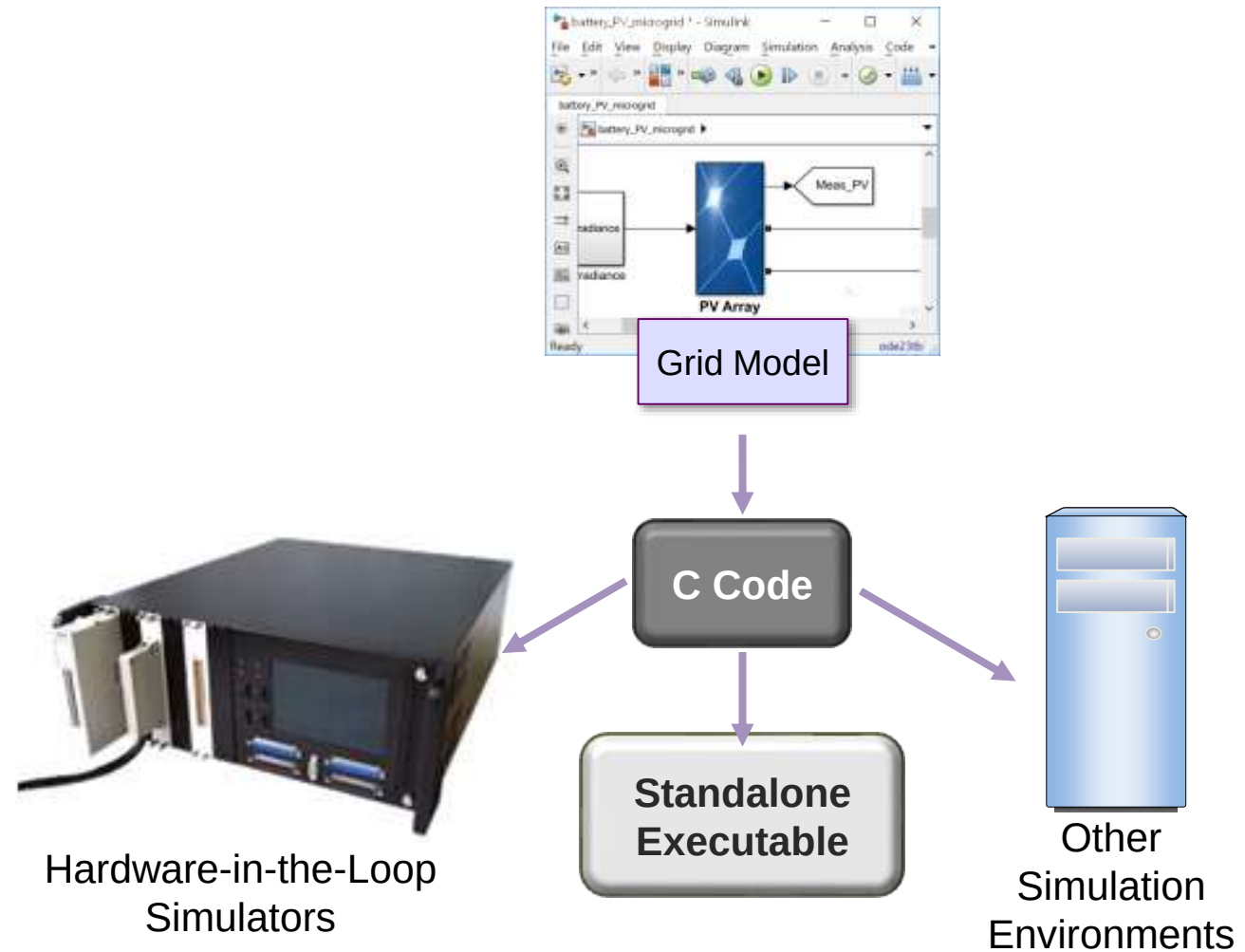
- Convert models to C code for HIL tests
- Share with internal users with fewer licenses
- Share with external users while protecting IP

Process-in-the-Loop (PIL) & Hardware-in-the-Loop (HIL) Simulation



Integrate Your Models into Other Simulation Environments

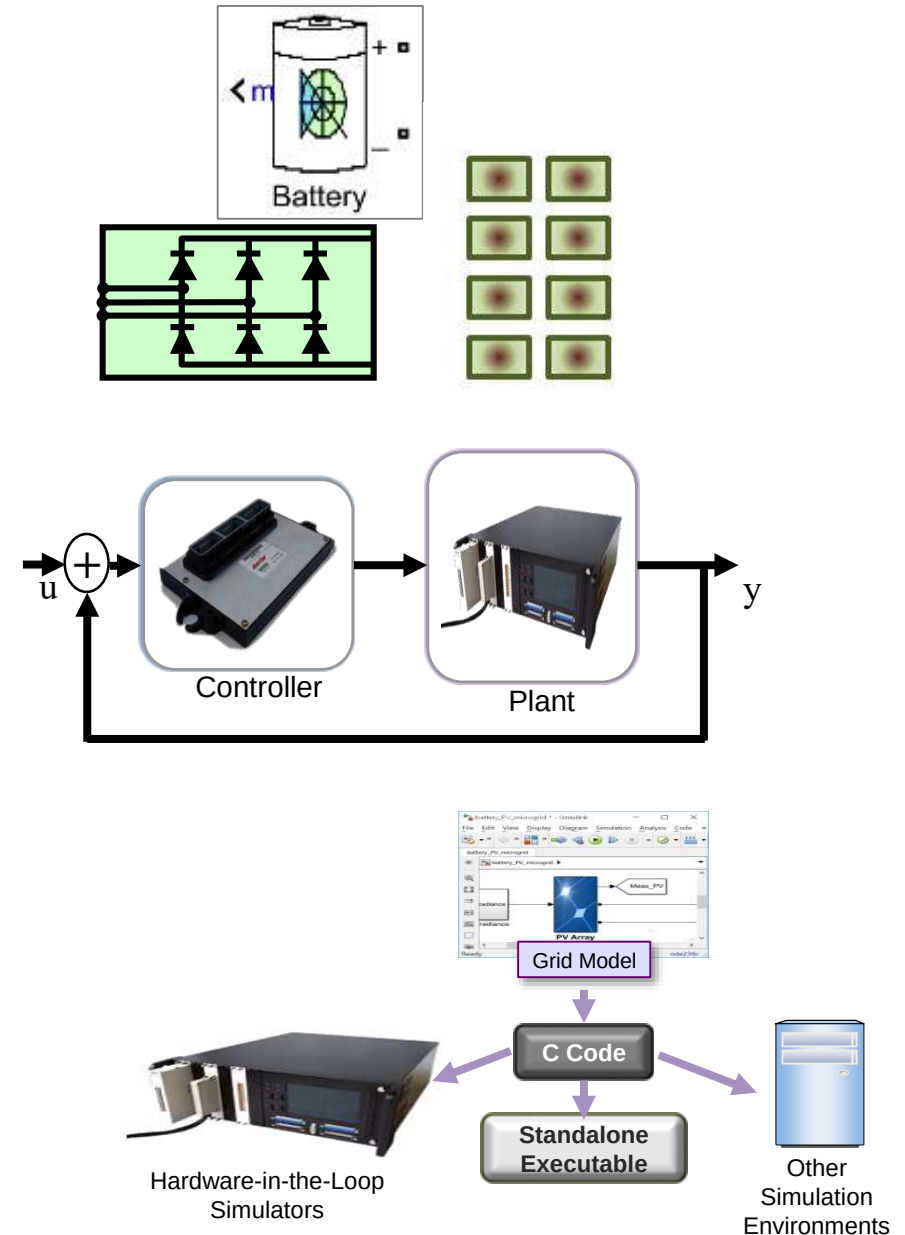
- Model can be converted to C code
 - Run in real-time to test controller hardware (HIL)
 - Standalone executable (parameter sweeps)
 - Integration with other simulation tools



Deploy the model as C code to other simulation environments, or use it as a standalone executable

Summary

- Physical component models at various levels of fidelity are necessary for Power Electronics
- Modeling the plant and controller in a single environment enables system level optimization
- Deploy the model as C code to other simulation environments, or use it as a standalone executable





Q&A