

# MATLAB EXPO 2017

## KOREA

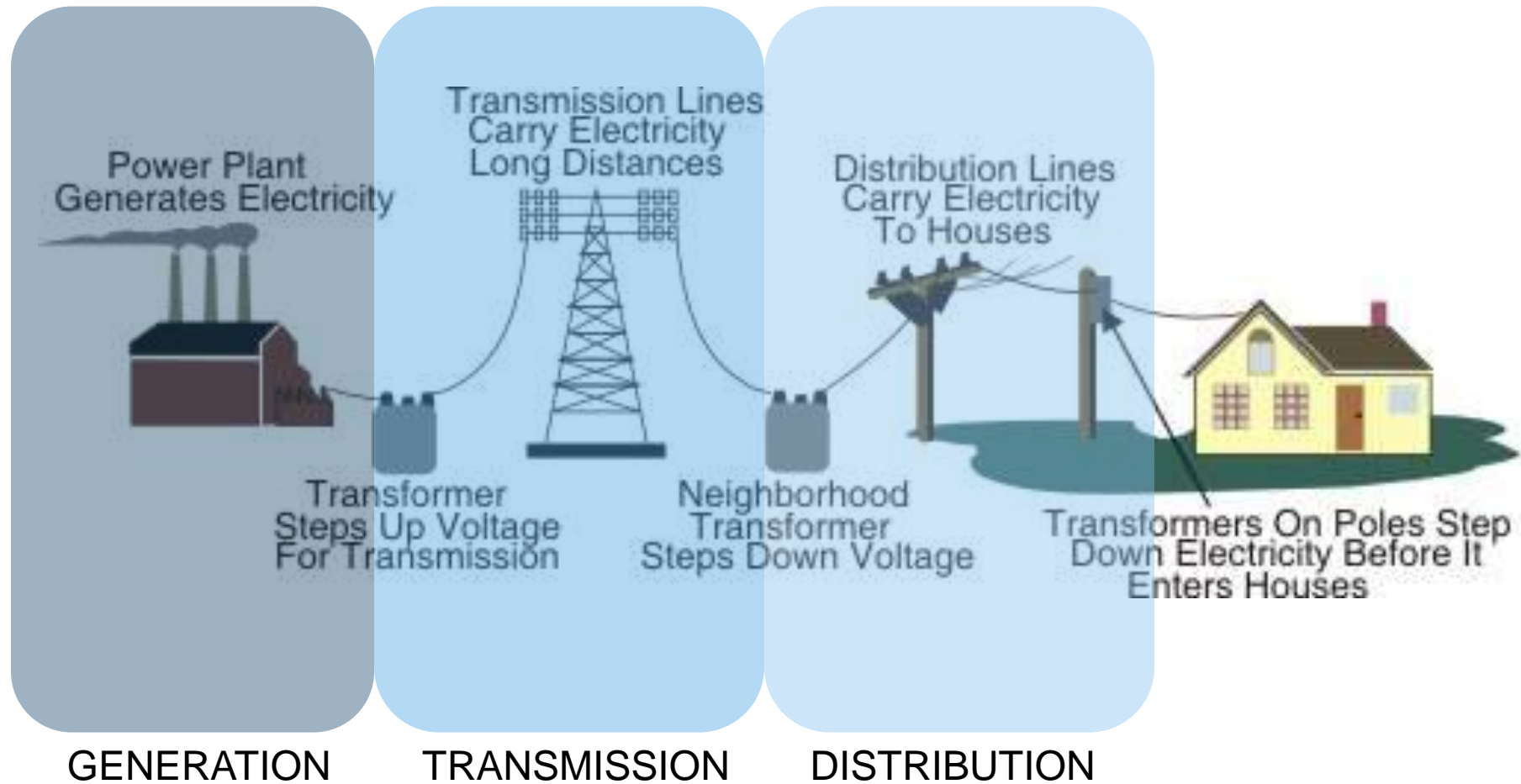
4월 27일, 서울

등록 하기 [matlabexpo.co.kr](http://matlabexpo.co.kr)

# Power Electronics Design and Simulation with Simscape Power Systems

강효석 과장 / Ph. D.  
Application Engineer  
MathWorks Korea

# Electrical Power System

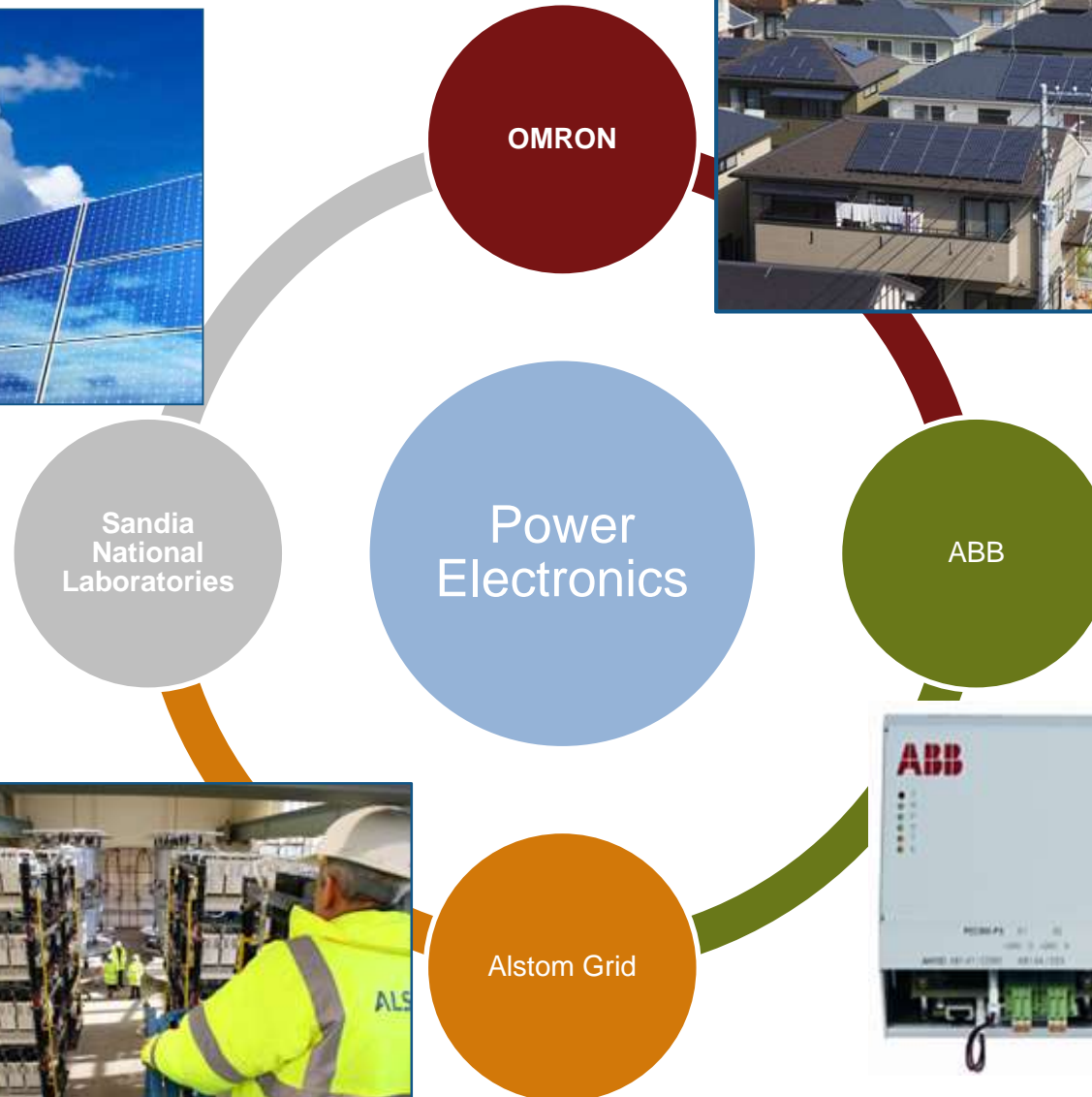


# Industry Needs of Power Electronics

- 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

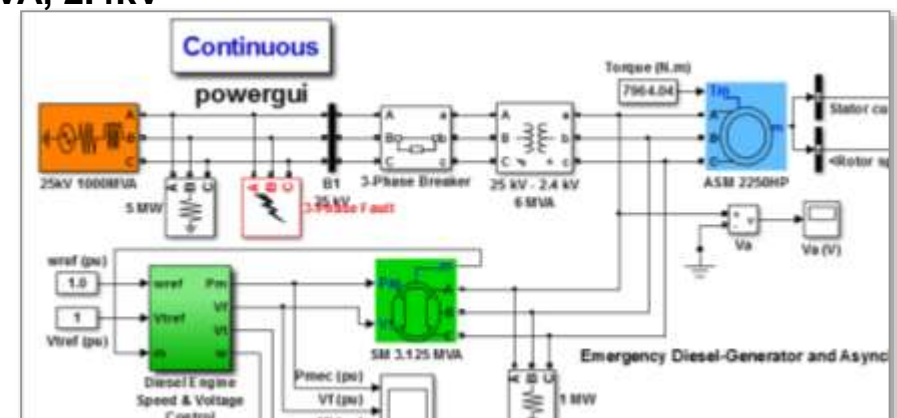
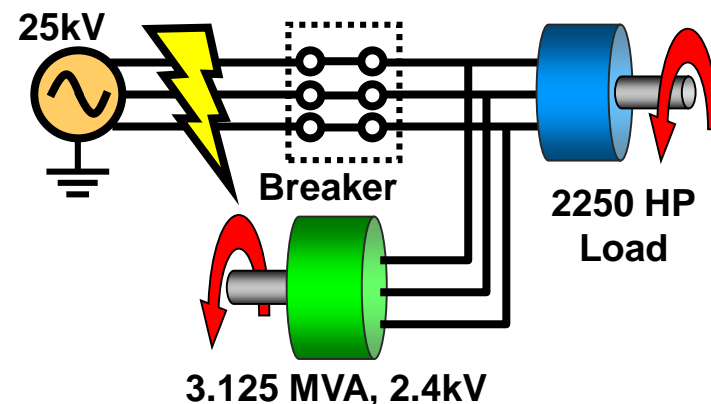
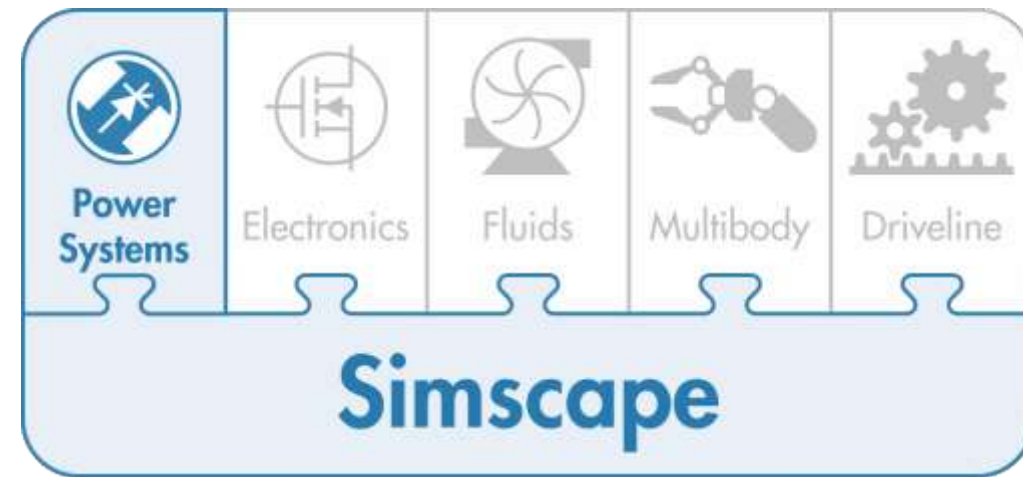


# Diverse User in Power Electronics



# Introduction to Simscape Power Systems

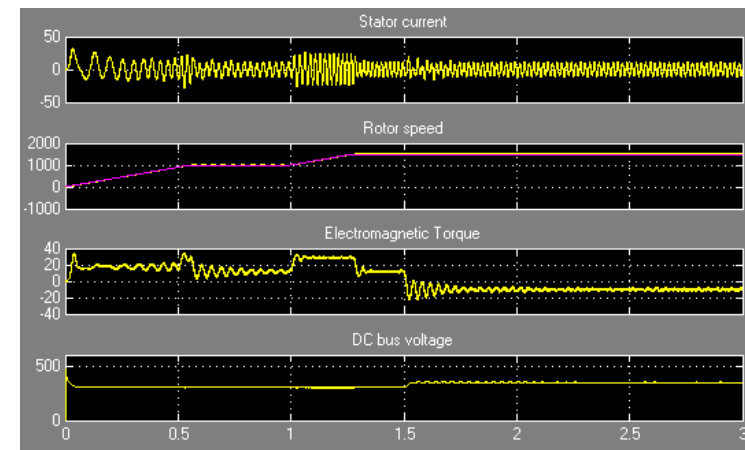
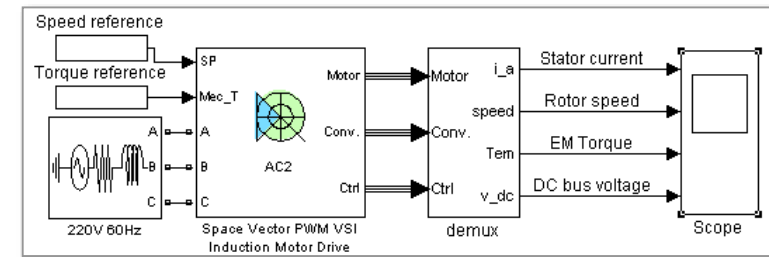
- Enables physical modeling (acausal) of electrical power systems and electric drives
- Electrical system topology represented by schematic circuit
- Used by electrical, system and control engineers to develop plant models and test control systems



# Working with Simscape Power Systems

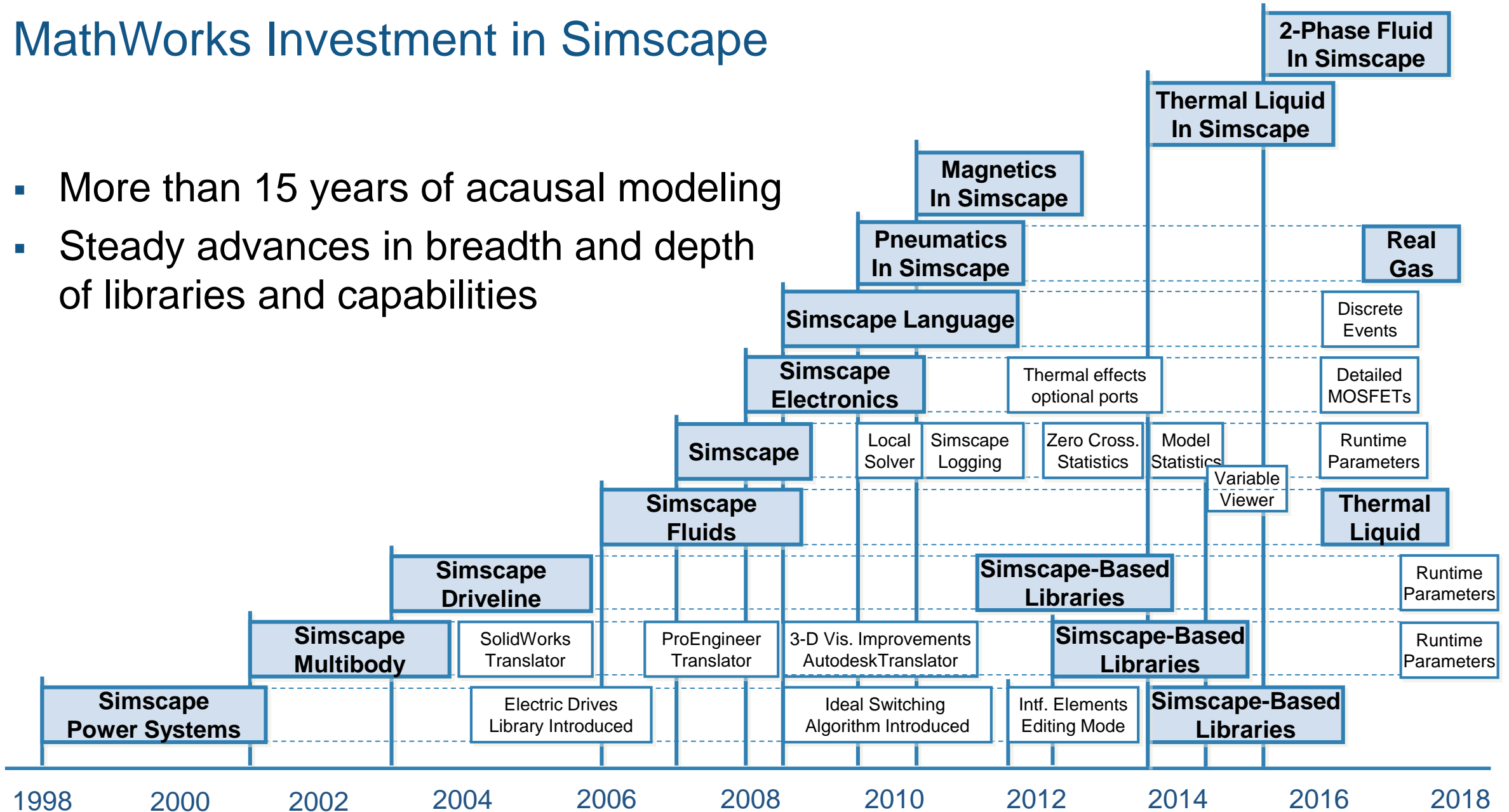
**Simscape Power Systems is a tool for modeling the generation, transmission, distribution, and consumption of electrical power**

- 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

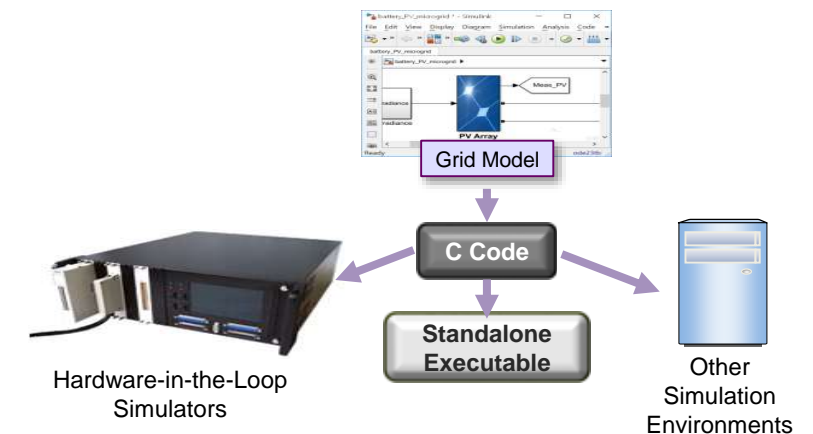
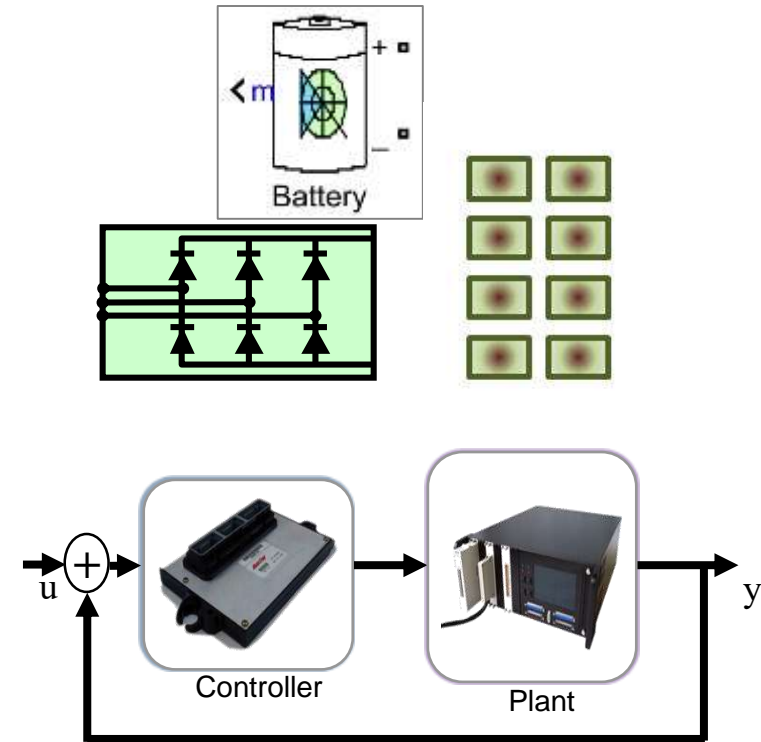
- More than 15 years of acausal modeling
- Steady advances in breadth and depth of libraries and capabilities





# 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



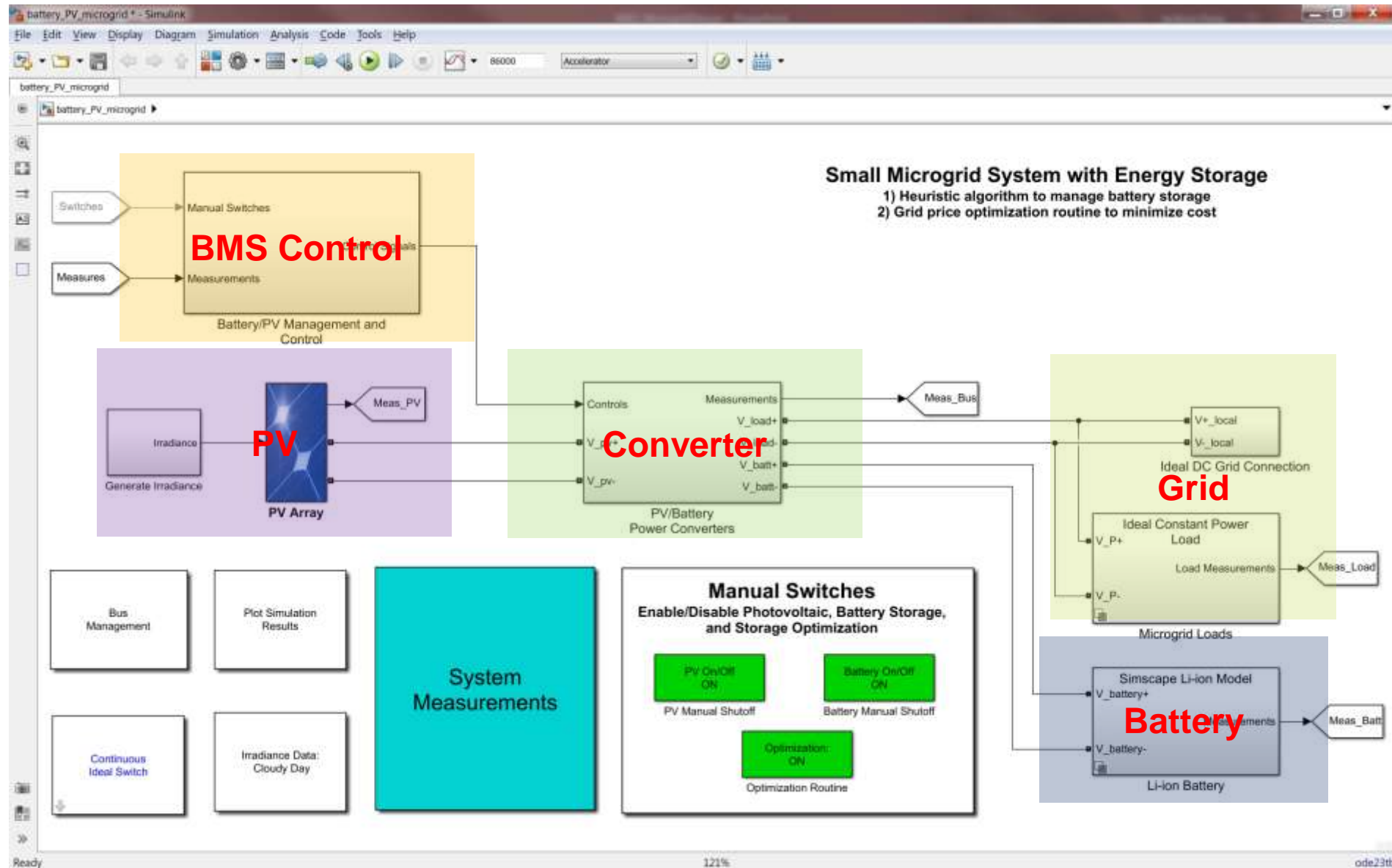
# Agenda

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

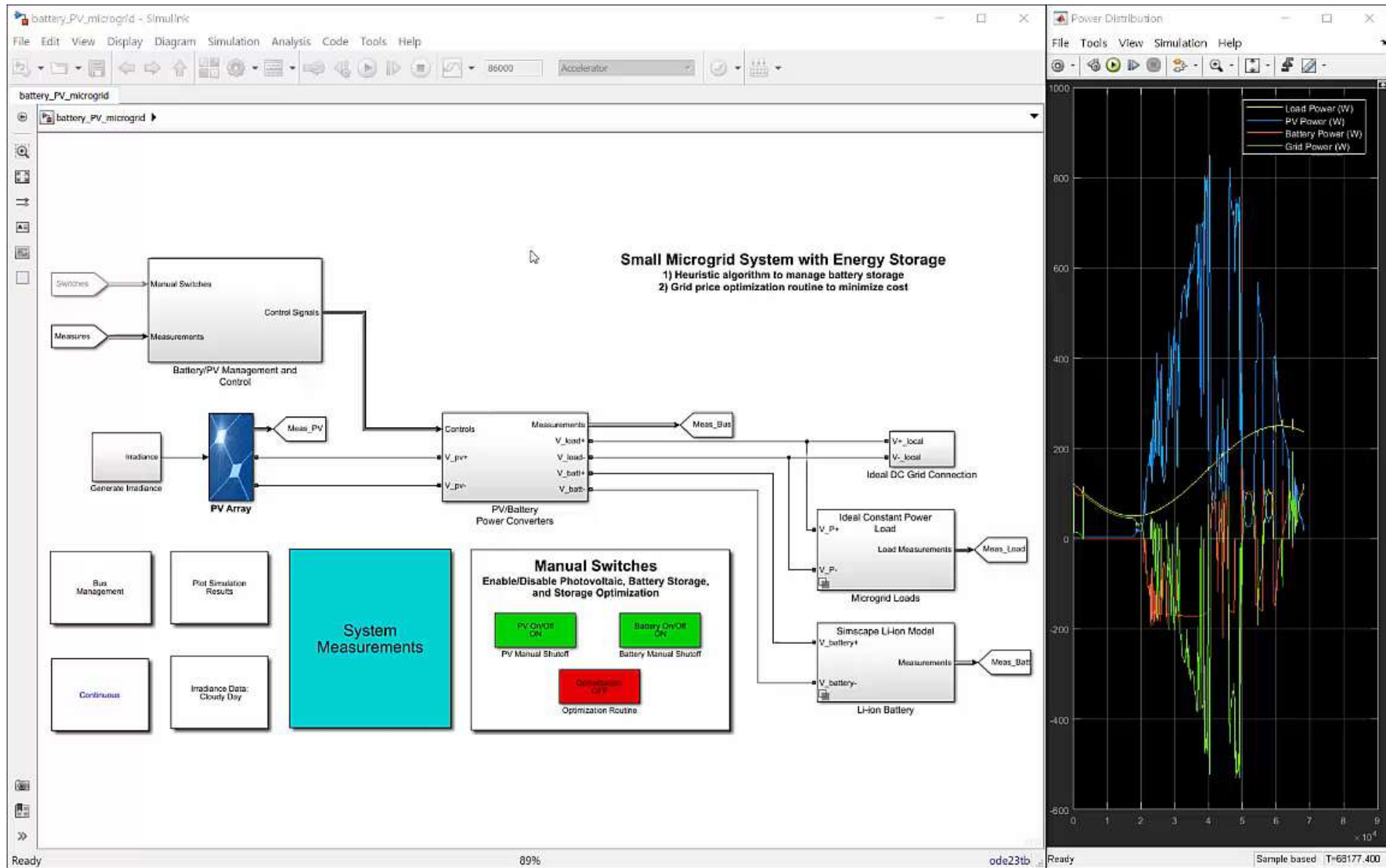
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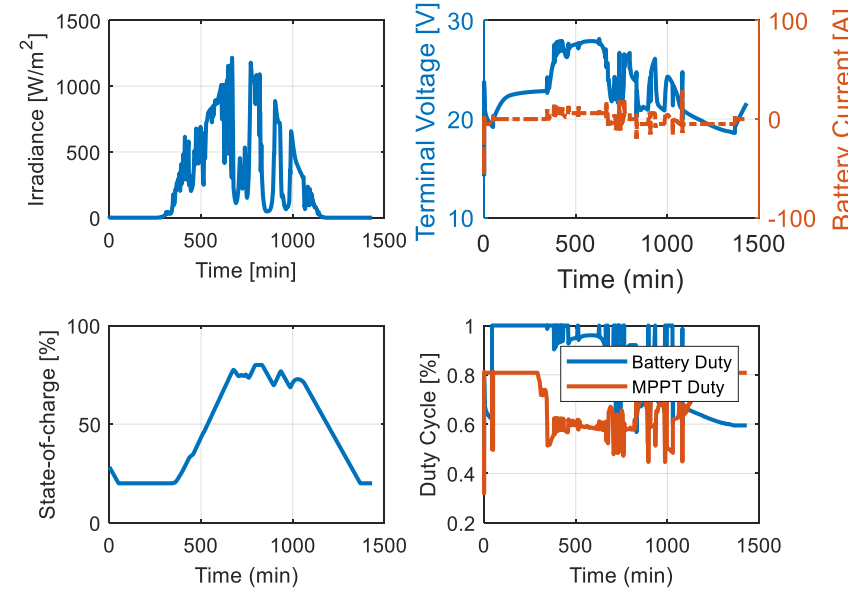
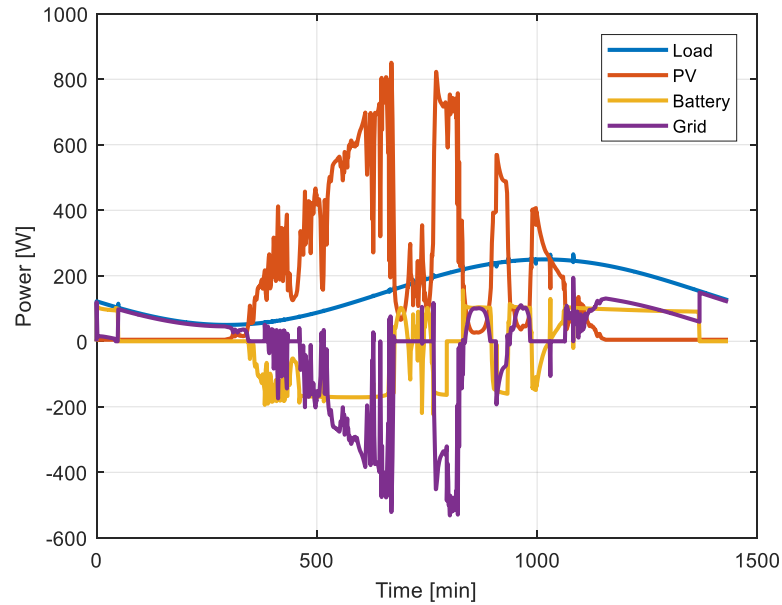
# Demo : Small Microgrid System with Energy Storage



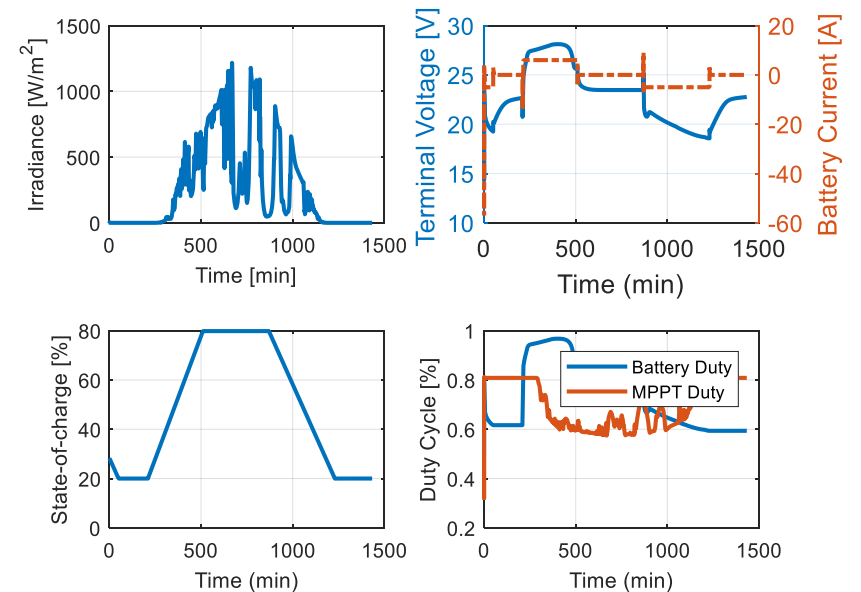
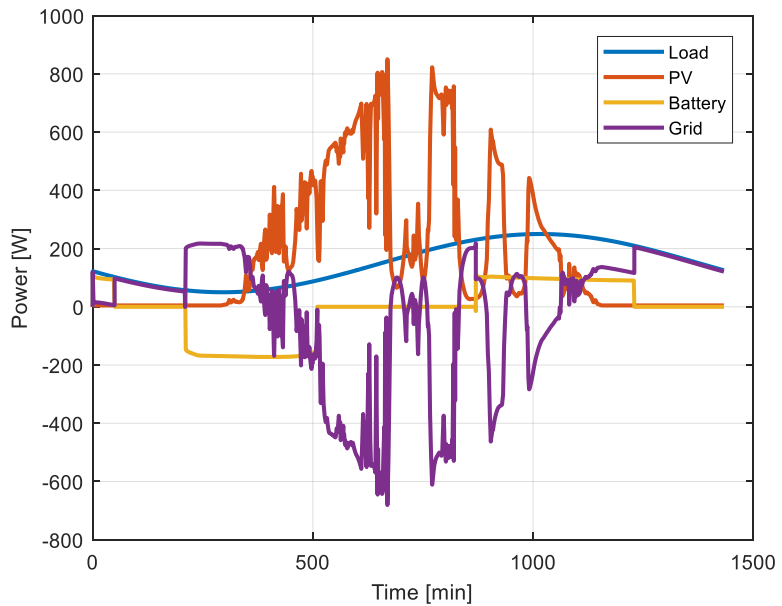
# Small Microgrid System with Energy Storage



## Heuristic Logic



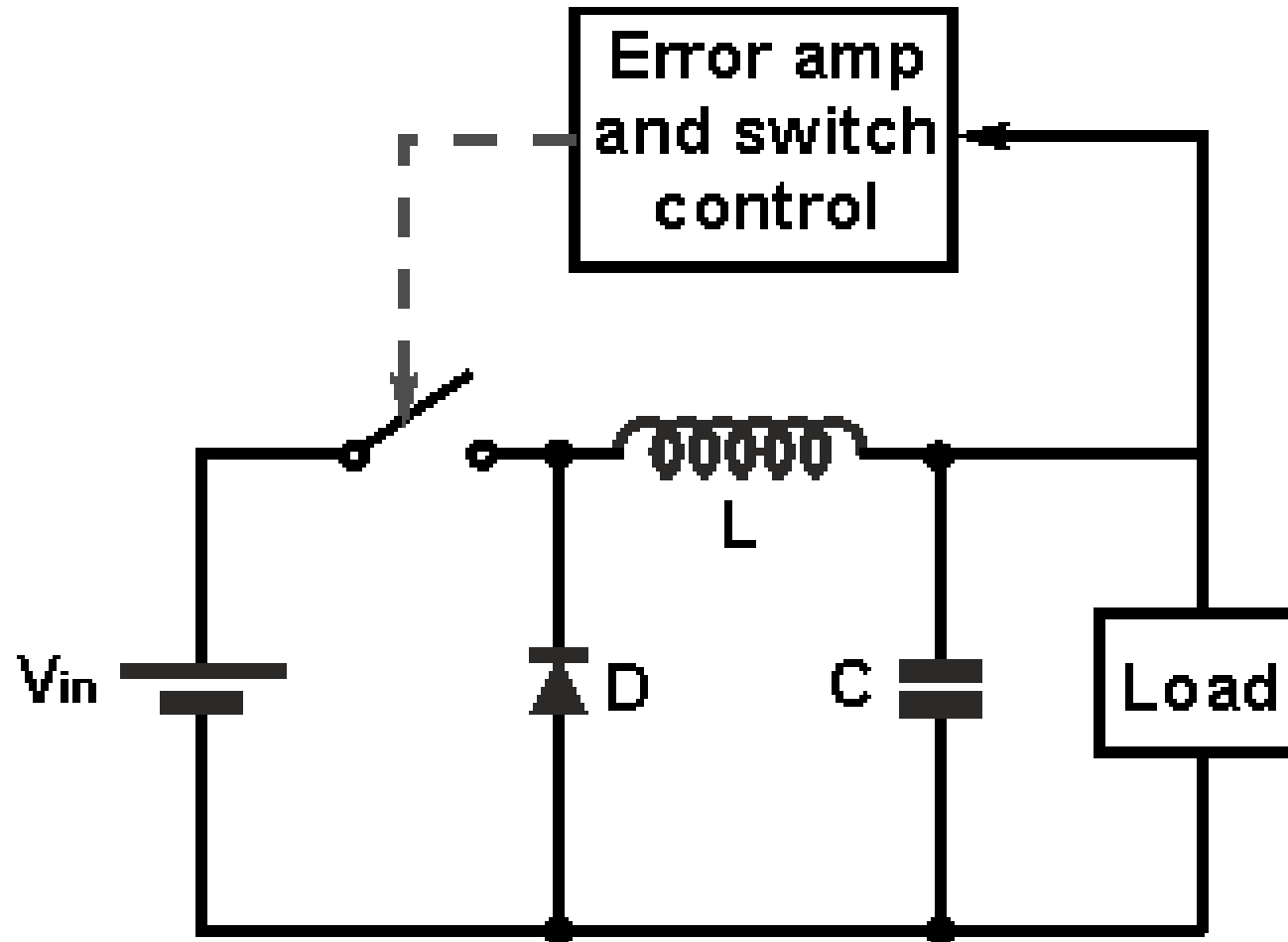
## Optimization Logic



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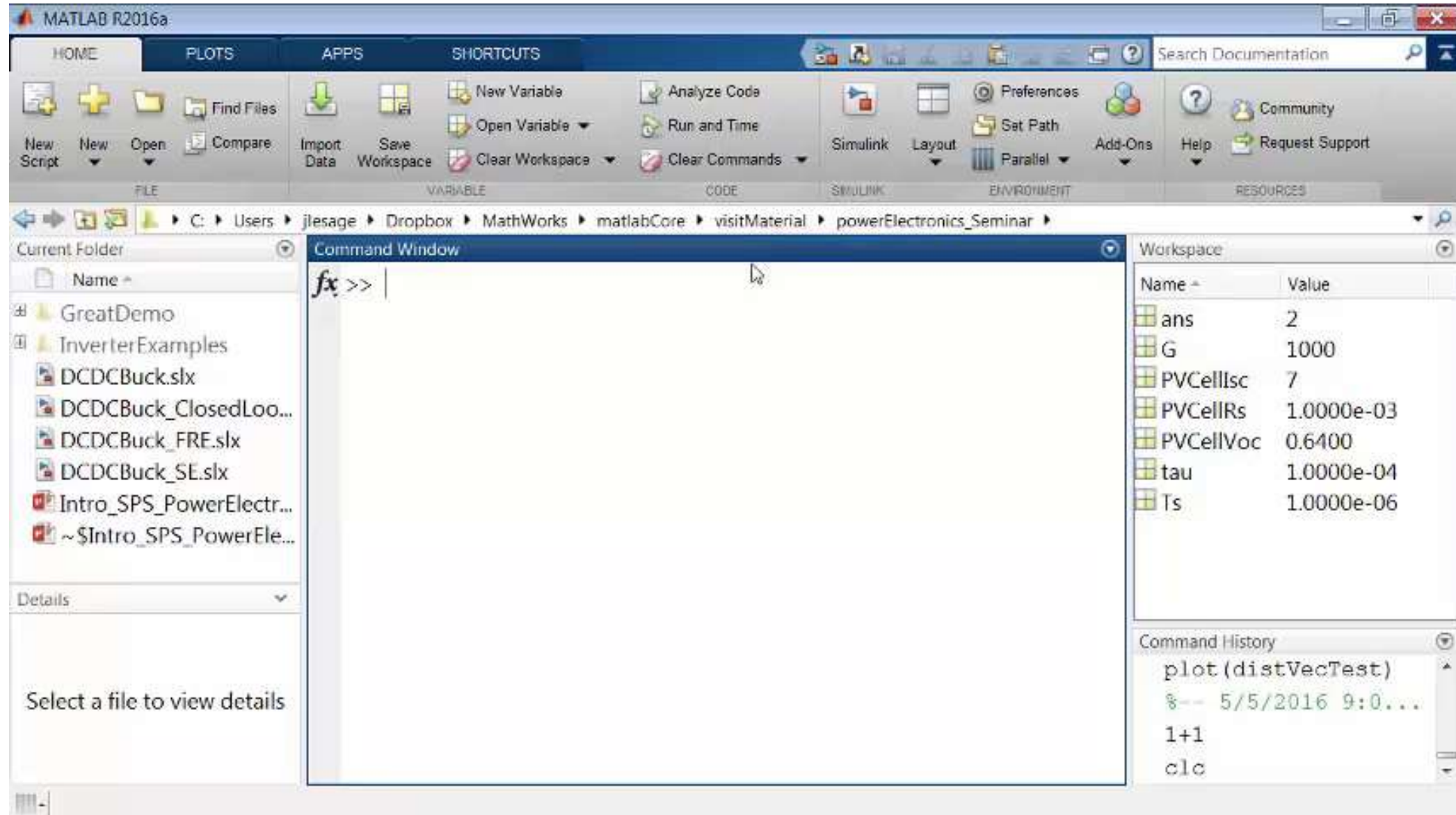
# DC-DC Converter (Buck Converter)



High DC Voltage  $\rightarrow$  Low DC Voltage



# Modeling Electrical Circuit – Buck Converter



The image shows the MATLAB R2016a interface. The top menu bar includes HOME, PLOTS, APPS, and SHORTCUTS. The ribbon contains various toolboxes and functions. The current folder is `C:\Users\jlesage\Dropbox\MathWorks\matlabCore\visitMaterial\powerElectronics_Seminar`. The file explorer shows a list of files, including `GreatDemo`, `InverterExamples`, and several `DCDCBuck` files. The Command Window shows the prompt `fx >> |`. The Workspace window displays the following variables and 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

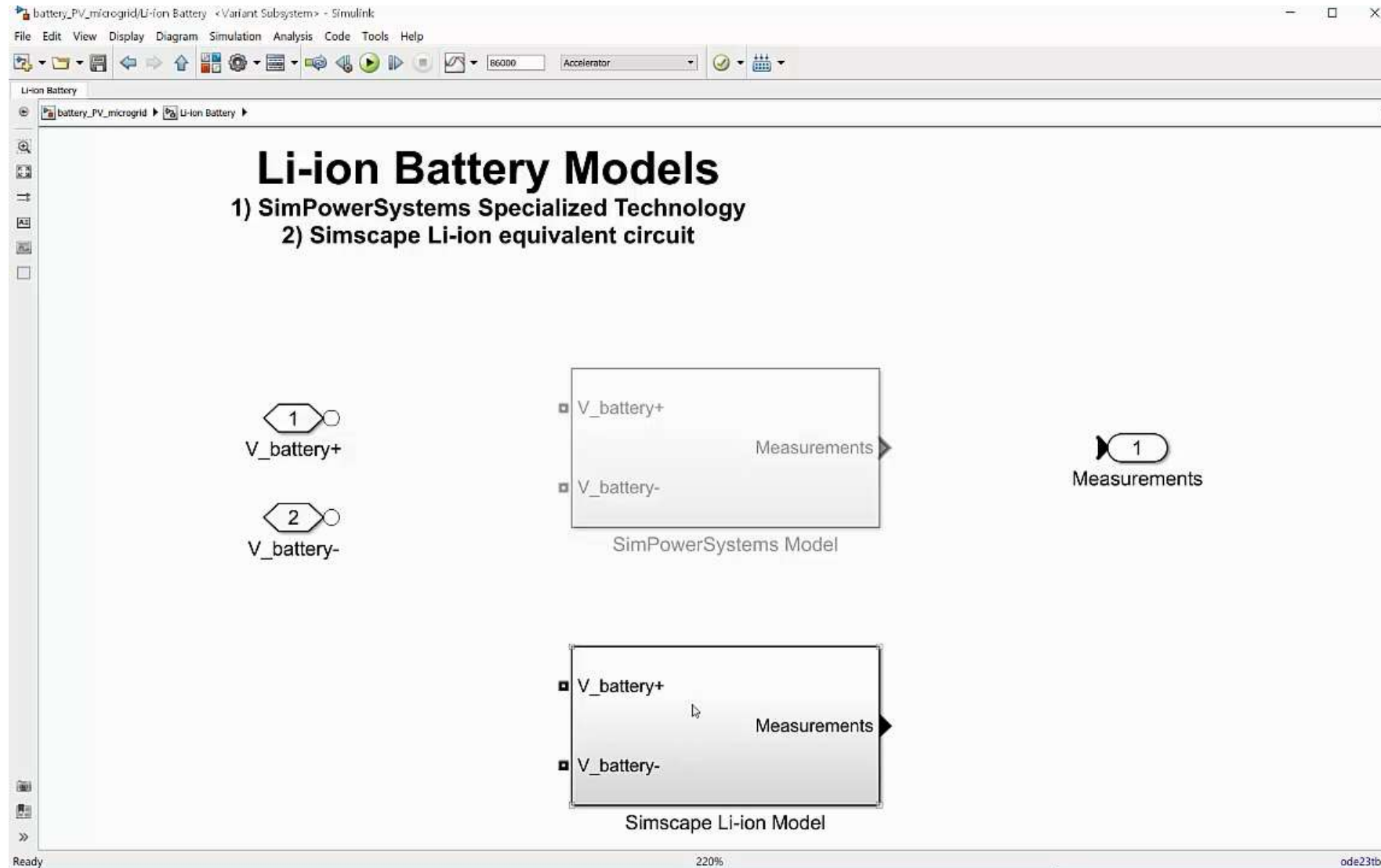
The Command History window shows the following commands:

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

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# Battery Modeling using Simscape Power Systems

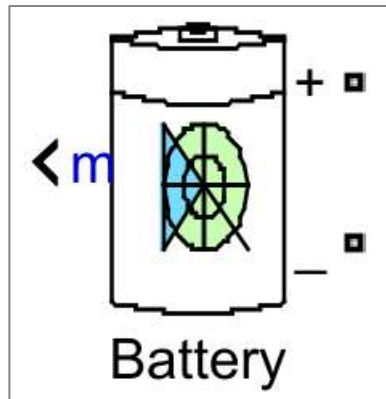


# Simscape Power Systems **ST**

## 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



Block Parameters: Battery

Battery (mask) (link)

Implements a generic battery model for aging (due to cycling) effects can be spe

Parameters Discharge Aging

Type:

Lithium-Ion

Temperature

Simulate temperature effects

Aging

Simulate aging effects

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

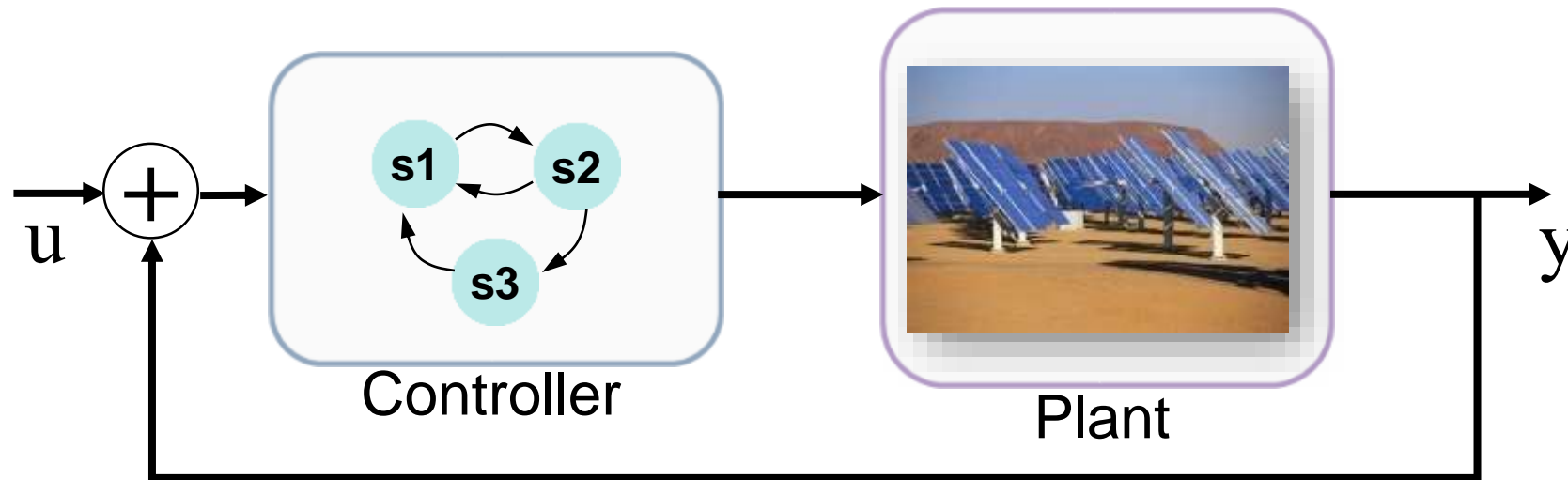
Ambient temperature Ta2 (deg. C) 45

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

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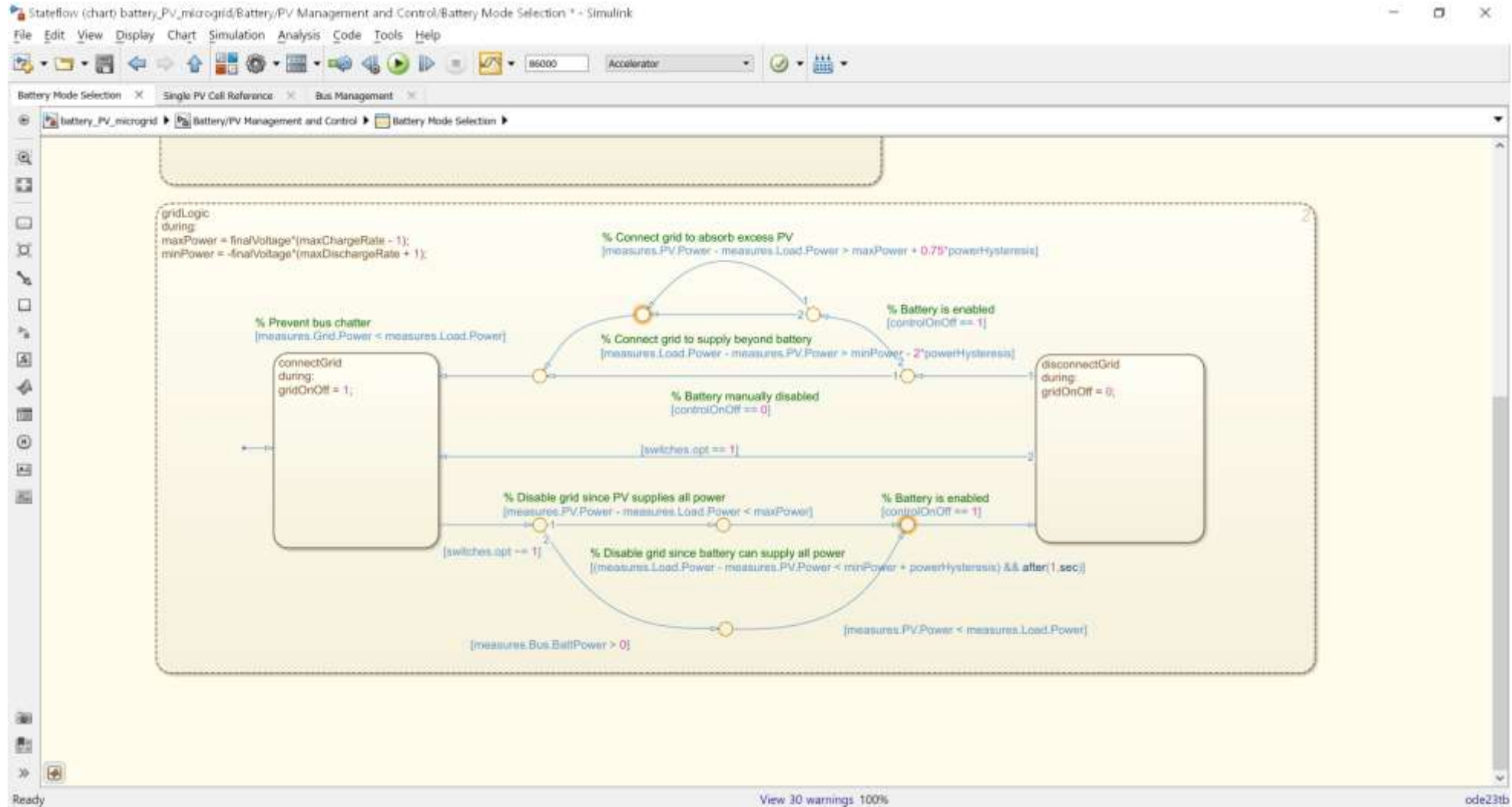
# Designing control algorithms



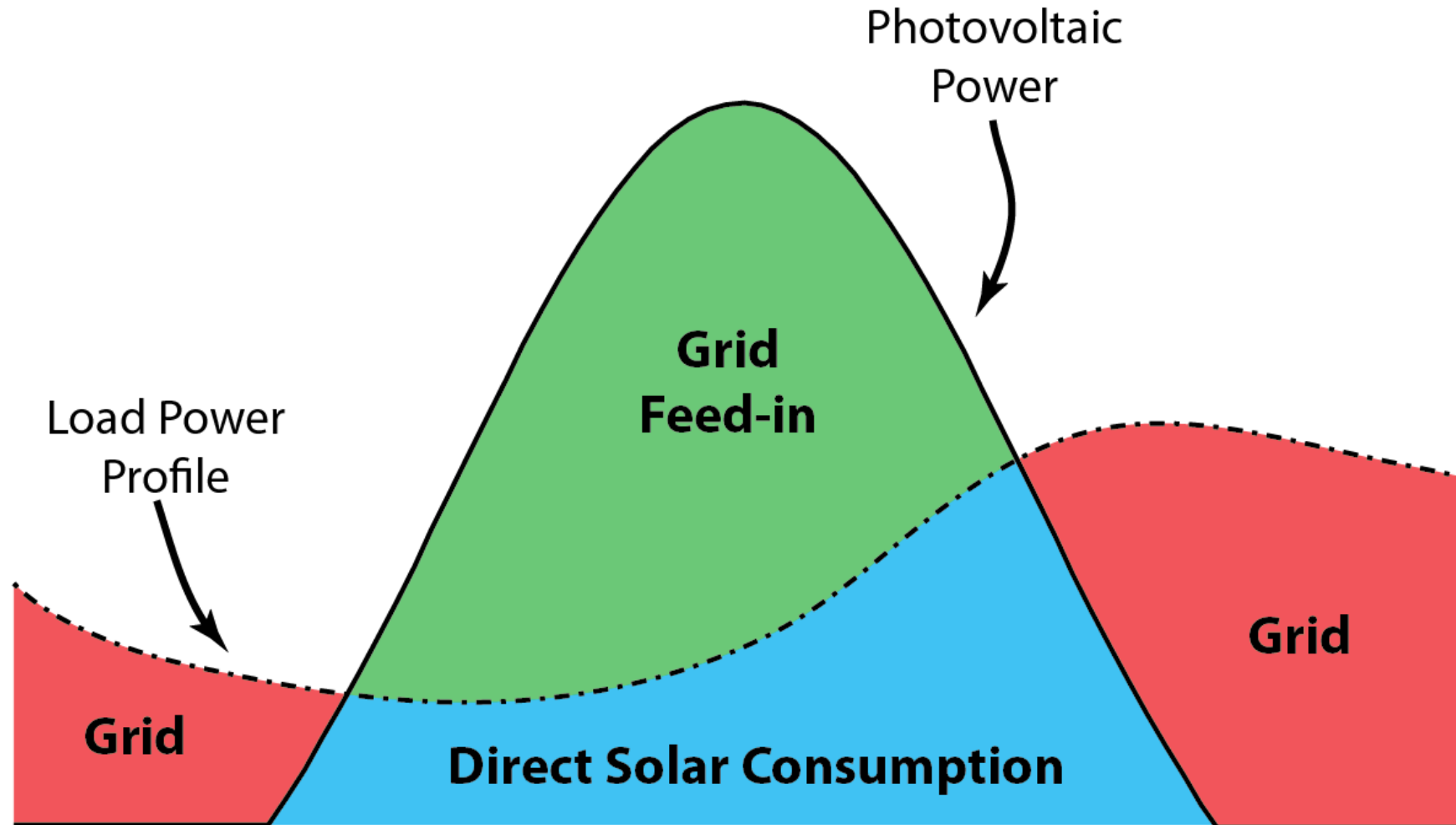
Simulating plant and controller **in one environment** allows you to **optimize system-level performance**

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

# Defining Control Logic for Battery Management System



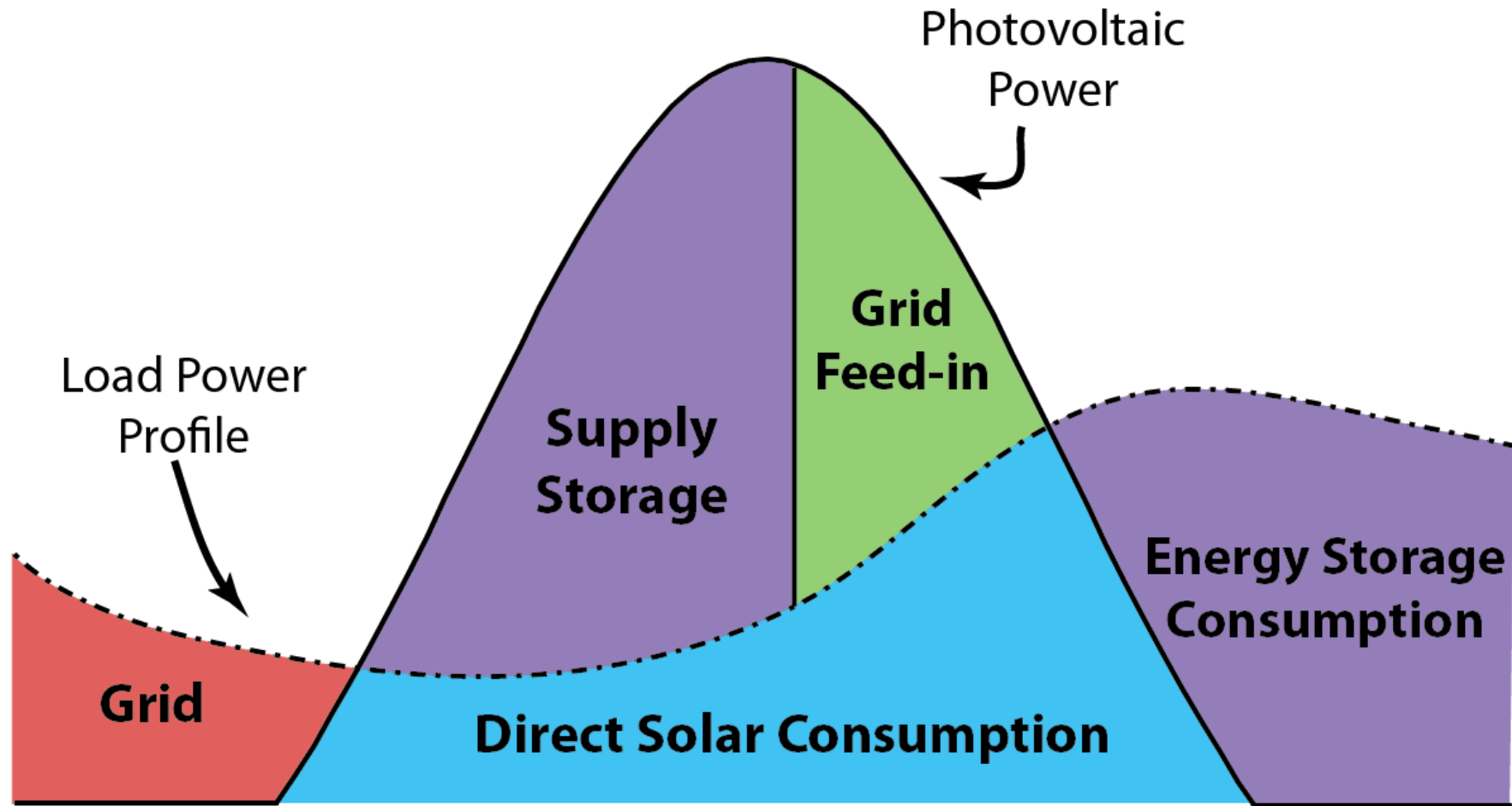
# Defining Control Logic for Battery Management System



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

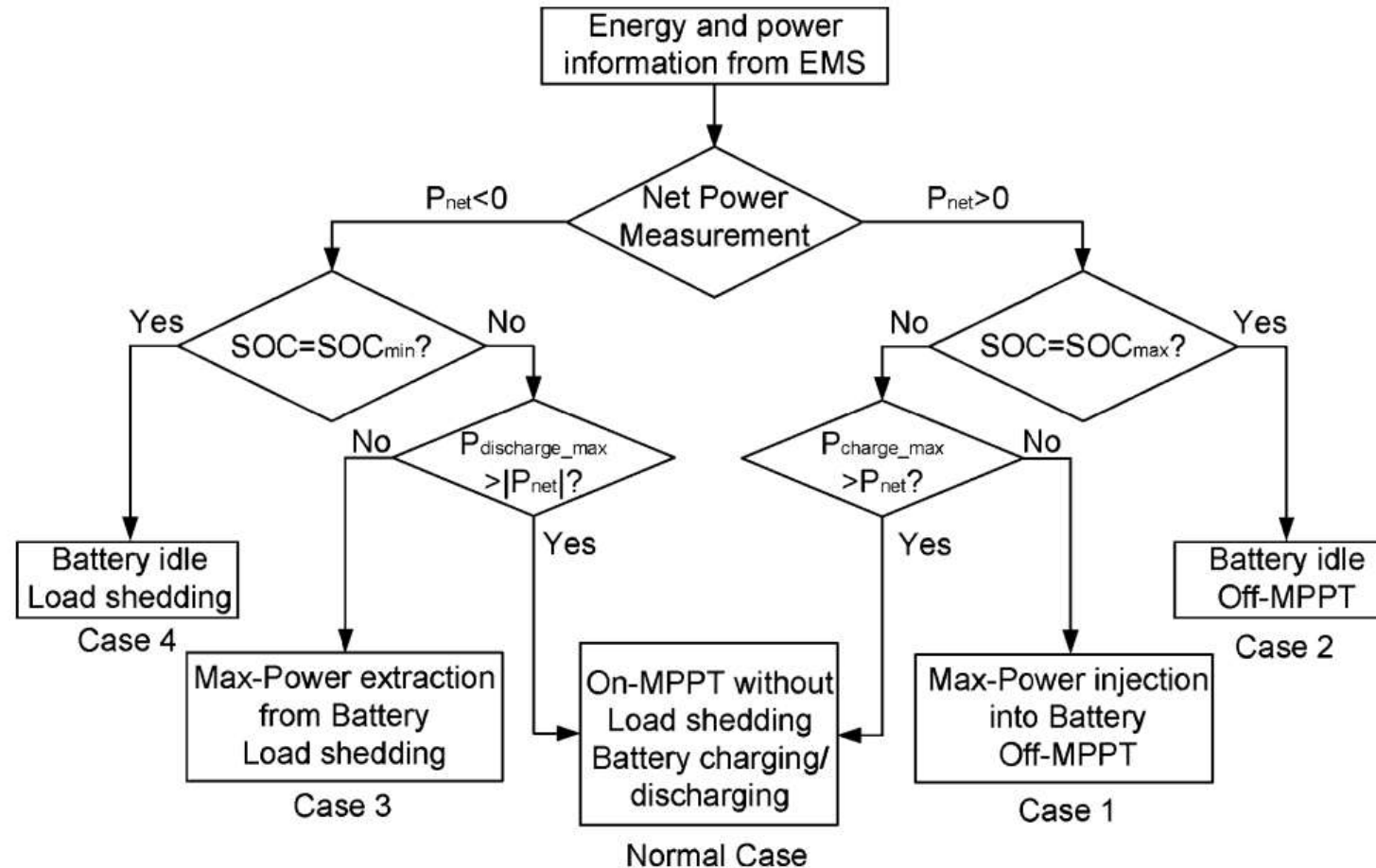


# Peak Demand Shift using Energy Storage

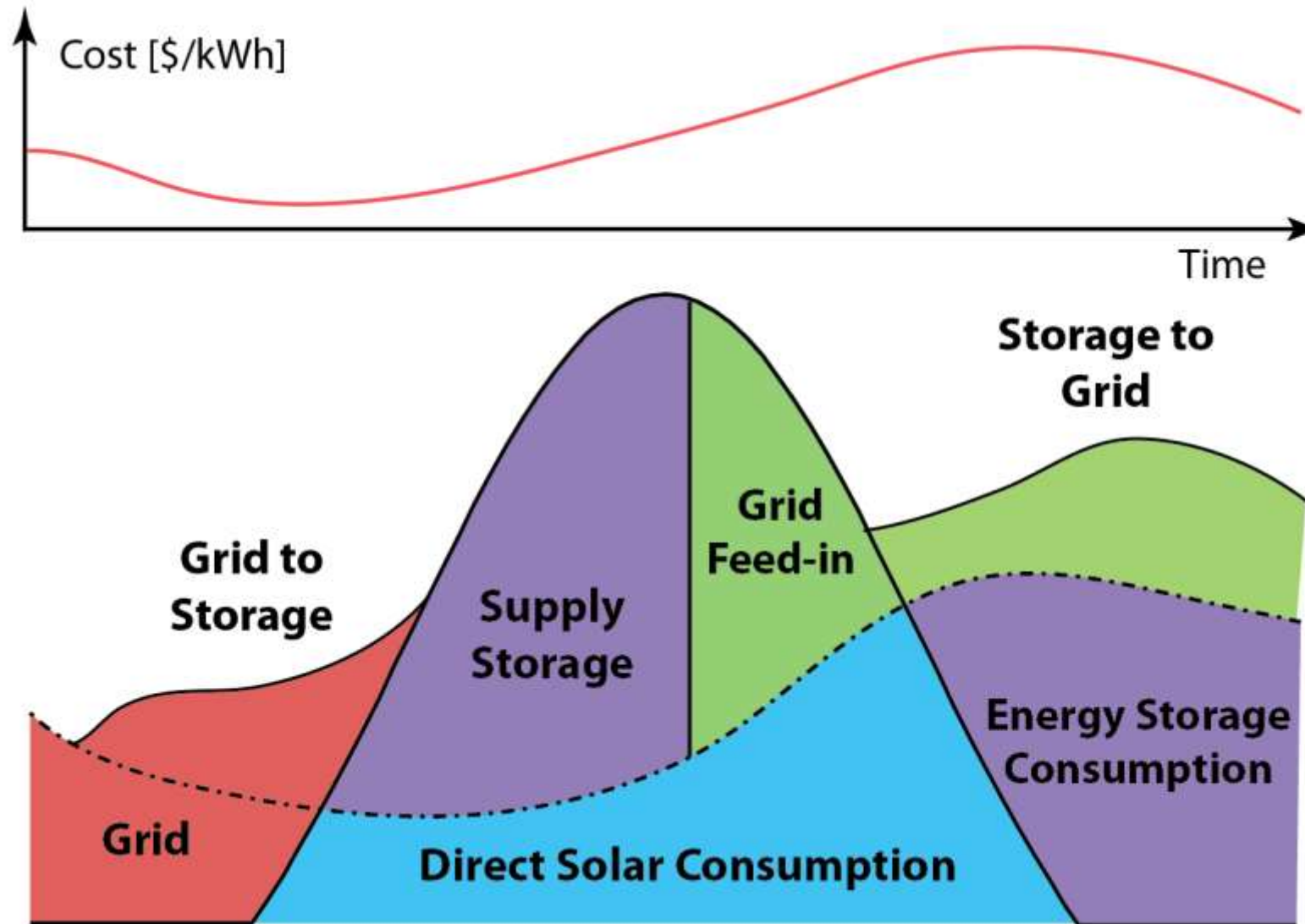


Adapted from: Smart EnergySystems Website  
<http://www.smart-energy.ag/products/ac-gekoppelte-speicherlosung-smartenergy-ac/?lang=en>

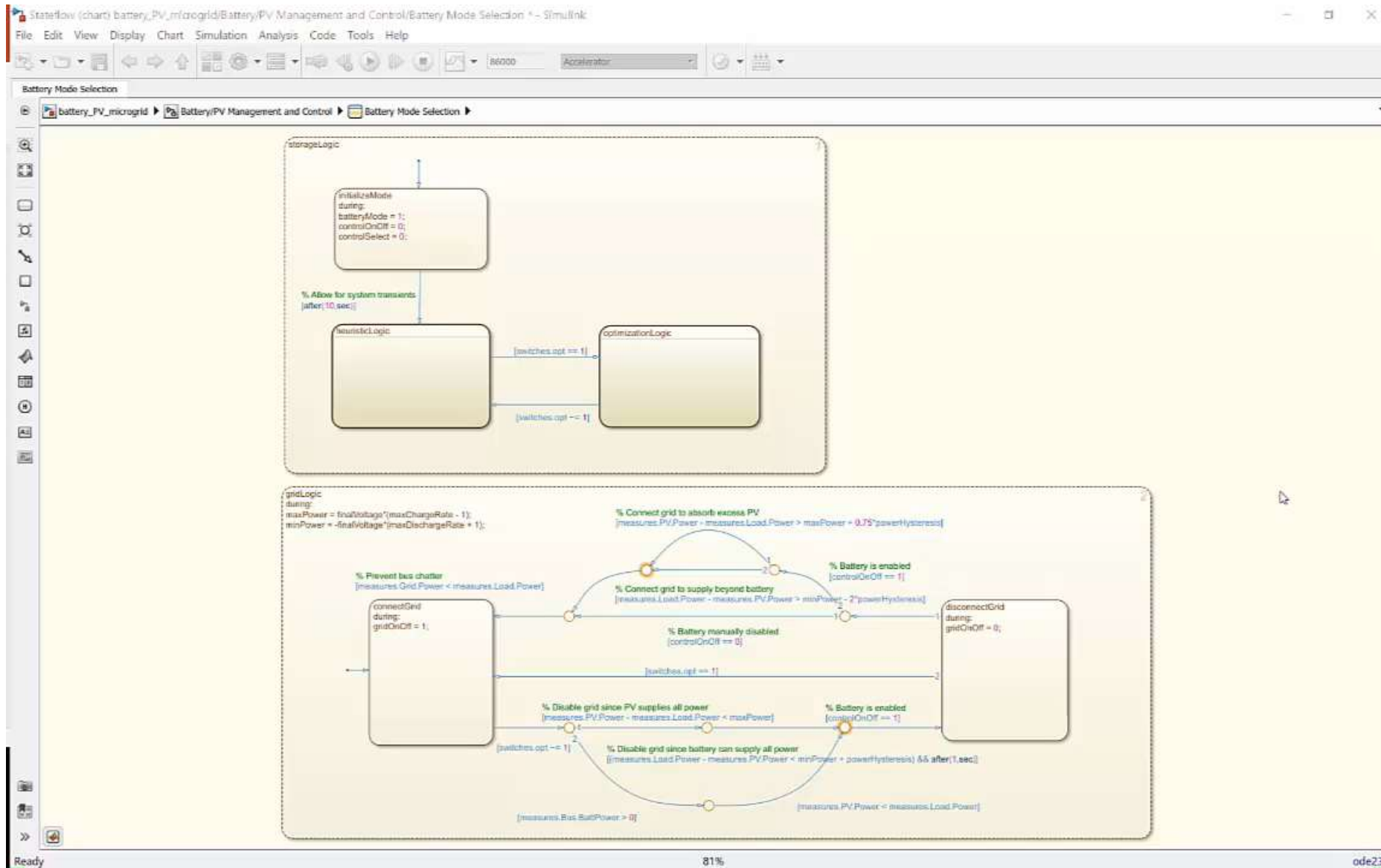
# Implementation of Energy Management Logic



# Factoring in Variable Electricity Cost



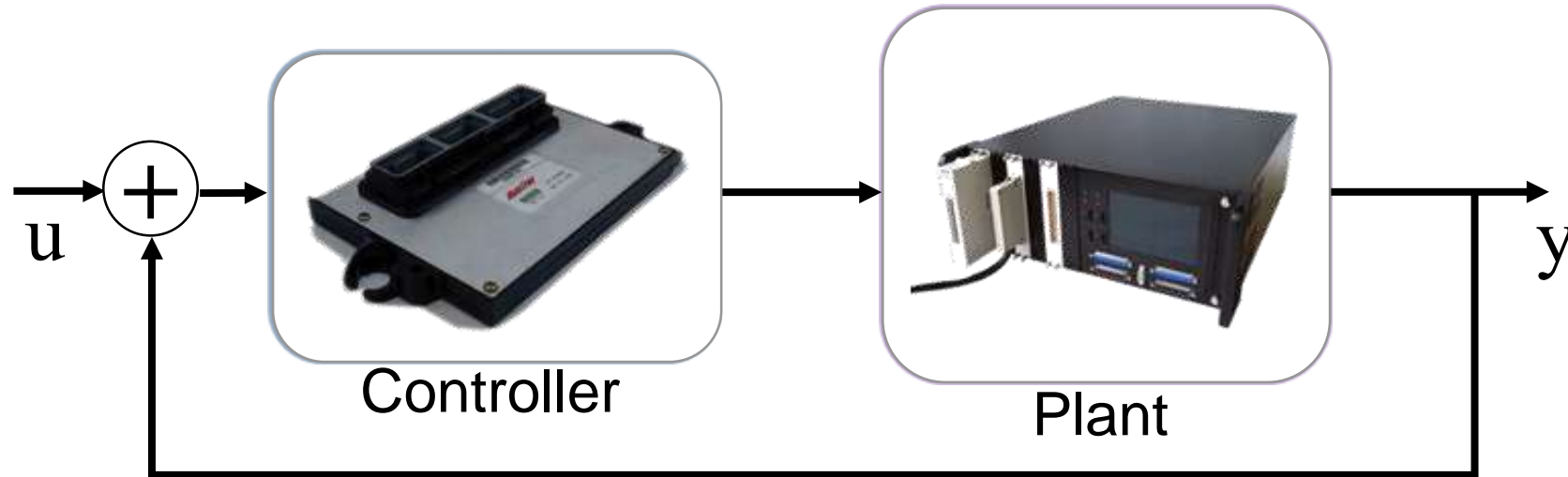
# Defining Control Logic for Battery Management System



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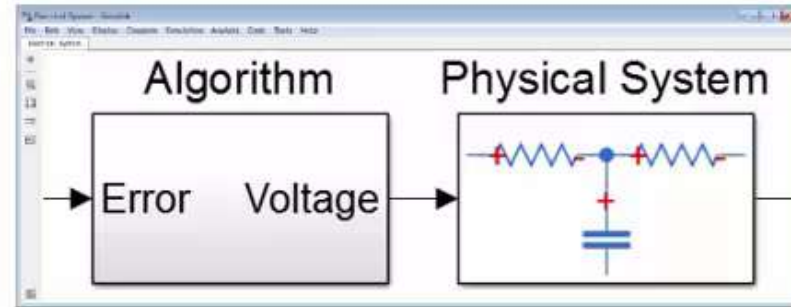
## Detect Integration Issues Earlier



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

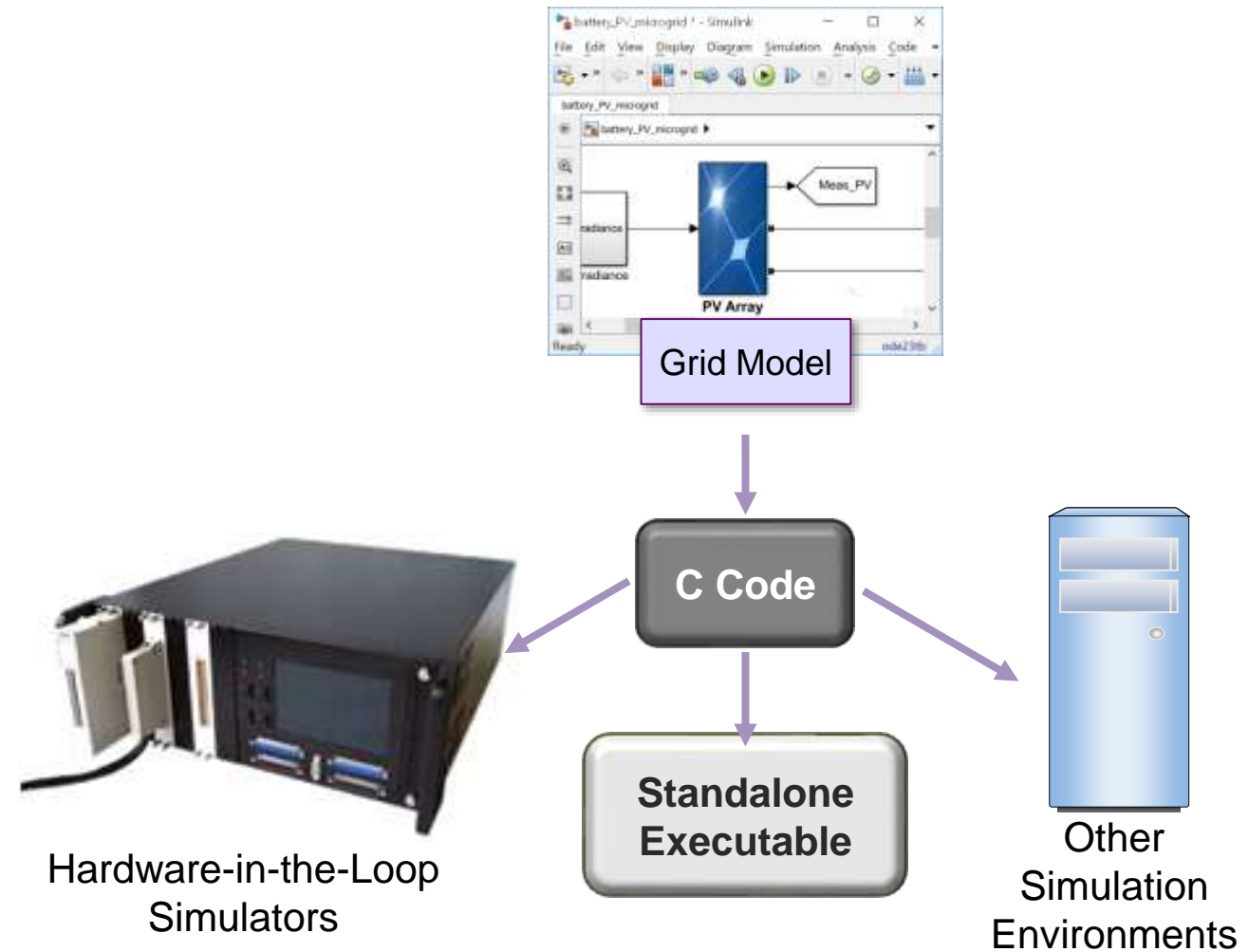
- Convert models to C code for HIL tests
- Share with internal users with fewer licenses
- Share with external users while protecting IP

# 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

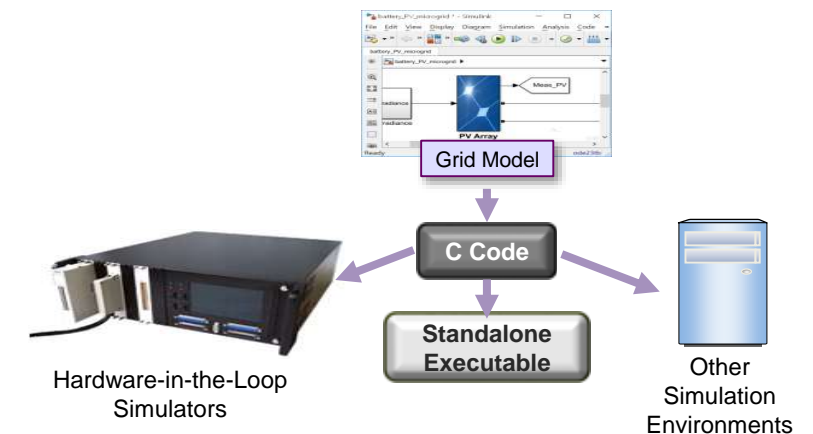
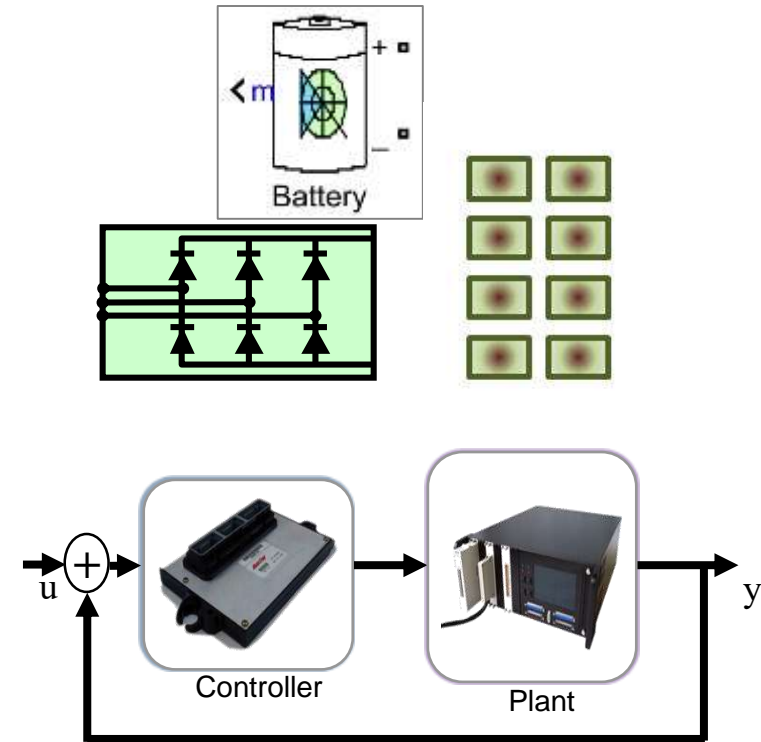


*Deploy the model as C code to other simulation environments, or use it as a standalone executable*



# Summary

- Physical component models at various levels of fidelity are necessary for Power Electronics
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# Q&A