



# Towards Efficient and Effective Smart Grid Control

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Less CO<sub>2</sub> emissions and a more reliable power system



# Outline



- Background Information
  - Method: PSO + Grid Search
  - Simulation and Results
  - Conclusion

A word cloud centered around the words "SMART GRID ENERGY". The words are arranged in a roughly circular pattern, with "SMART" at the top left, "GRID" in the center, and "ENERGY" at the bottom right. The words are in various sizes and colors, including shades of grey, black, green, and yellow. Some words have small arrows pointing to specific letters or parts of other words, indicating relationships or dependencies.

The word cloud includes the following words:

- SMART
- GRID
- ENERGY
- ADVANCED
- TECHNOLOGICAL
- GENERATORS
- LOAD
- METERS
- NETWORK
- SUPPORT
- INFRASTRUCTURE
- TIMES
- PEAK
- SEE
- COMMUNICATION
- INCLUDE
- CONSUMPTION
- POWER
- TECHNOLOGIES
- RESPONSE
- METER
- WAVE
- CURRENT
- ELECTRIC
- GENERATION
- DEMAND
- TRANSMISSION
- METING
- ALLOW
- REQUIRED
- MEASUREMENT
- PROVIDE
- DISTRIBUTED
- VIA STATIONS
- Possible
- MUCH
- USAGE
- AUTOMATION
- INFORMATION
- SYSTEMS
- LEVEL
- USED
- CONTROL
- MONITORING
- RAPID
- DEPLOYMENTS
- PERIODS
- MANAGEMENT
- DYNAMIC
- CONSUMERS
- DEVICES
- USE
- PLANTS
- ELECTRICAL
- VIA
- STATIONS
- POSSIBLE
- POSITIONS
- MEASUREMENT
- ALLOW
- REQUIRED
- TRANSMISSION
- METING
- ALLOW
- RELIABILITY
- NEEDED
- MAY
- HIGH DATA
- TIME
- LINES
- CALL
- EDS
- INTEGRATED
- DISTRIBUTION
- TURBINES
- VARYING
- DIGITAL
- EFFICIENCY
- REDUCE
- AREAS
- SYSTEM
- ABLE
- TIME
- RAPIDLY
- MULTIPLE
- USER
- SYSTEM
- EFFICIENCY
- REDUCE
- AREAS
- SYSTEM
- ABLE
- TIME
- RAPIDLY
- MULTIPLE
- USER

# Background of Smart Grid



## What is a Smart grid

“... an electricity supply network that uses digital communications technology to detect and react to local changes in usage...”

## Why do we need it

Decrease cost, waste, and response time:

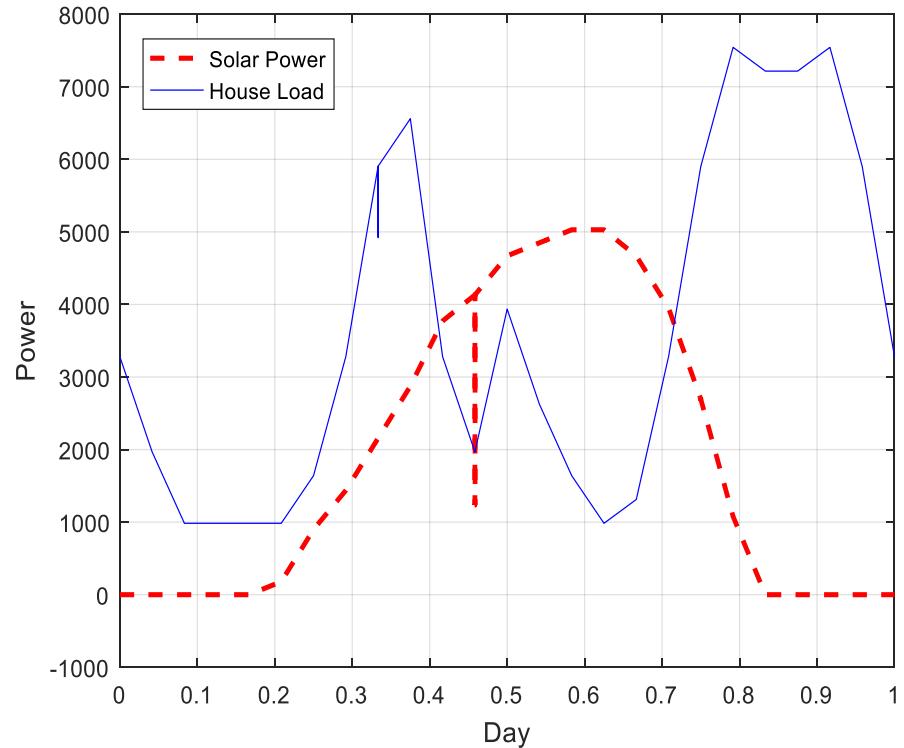
- Easier add distributed generation and storage
- Coordination and Communication
- Detect errors



# Challenges of Smart grid Optimization



- Uncontrolled production and demand
- New generation sources need to be able to be introduced easily
- Transient surges of power



Need for smarter controllers

# What is: Particle Swarm Optimization



- A way of searching for an optimal point
- Originally based on a flock of birds
- Searches for best “food” location through communication

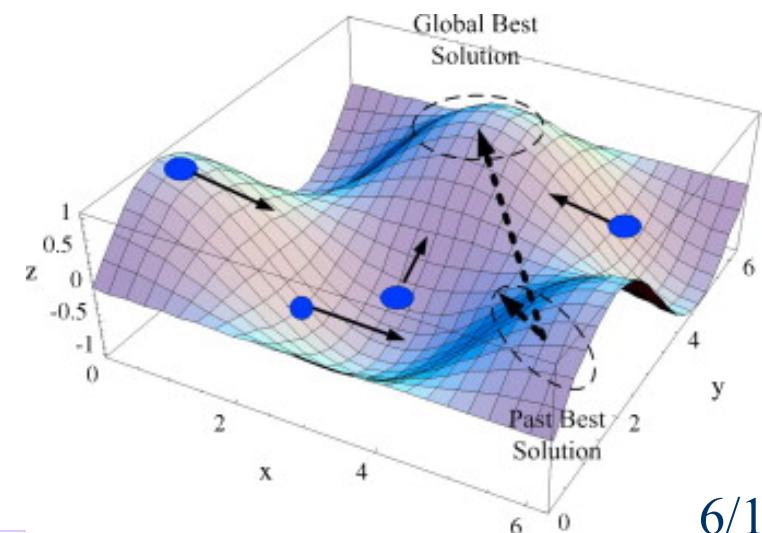
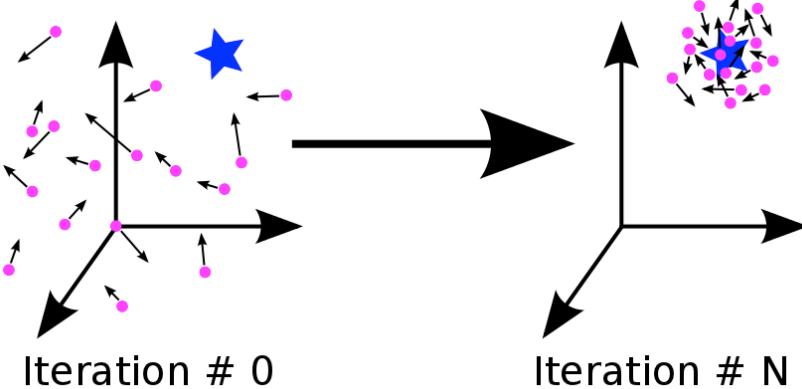


# How: Particle Swarm Optimization



- Starts randomly and compares particles location to personal and global best
- Moves toward best location at partially-random velocity, overshoots, repeats

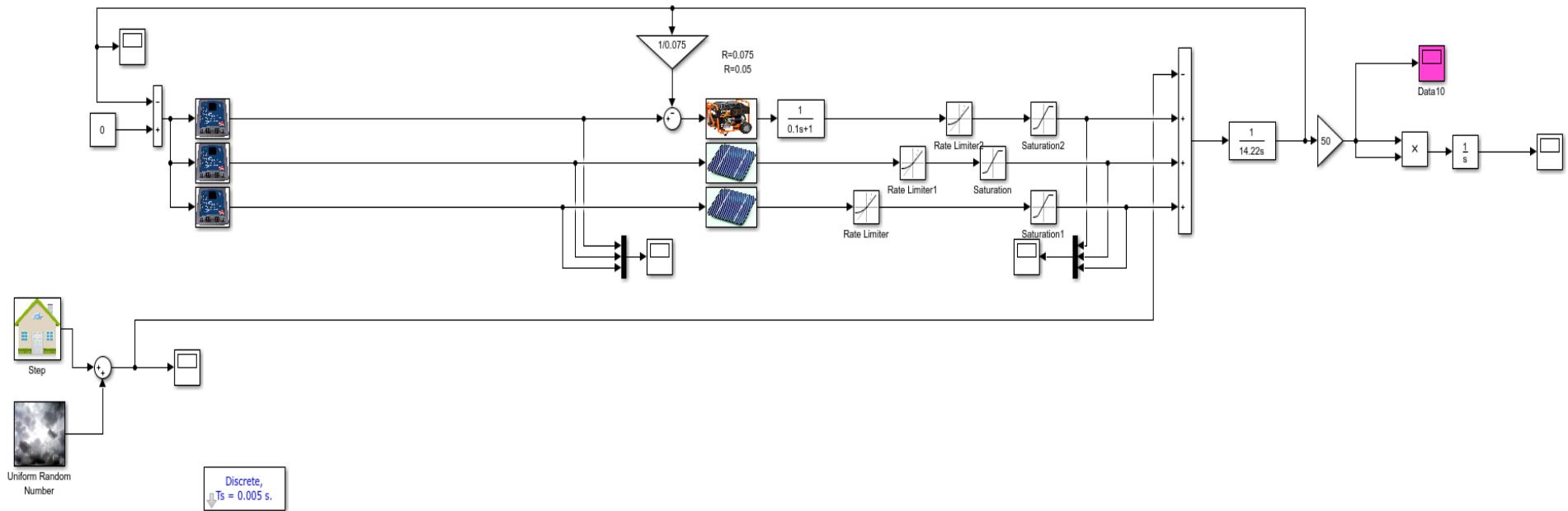
$$V^{k+1} = W * V^k + c_1 * \text{rand} * (P_{\text{best}} - x^k) + c_2 * \text{rand} * (G_{\text{best}} - x^k)$$
$$x^{k+1} = x^k + V^{k+1}$$



# Smart Grid Simulation Model



Home Load, Cloud Shading and Solar Panels, Generator, Controllers...



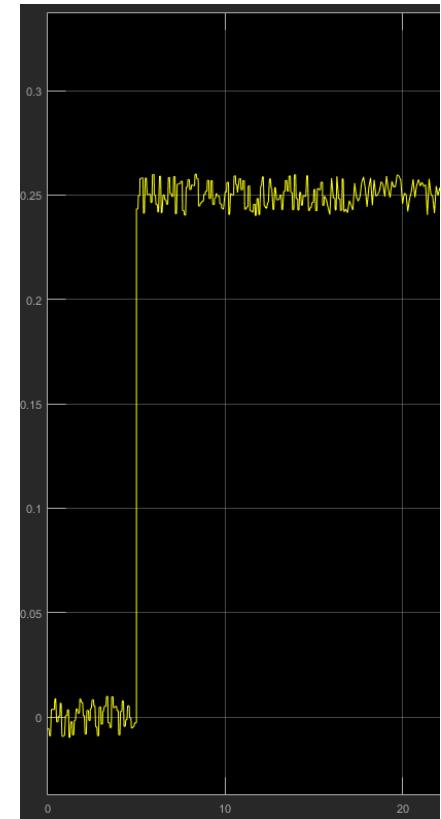
# Simplified vs Realistic Models



Simple:  
Load put on  
the system



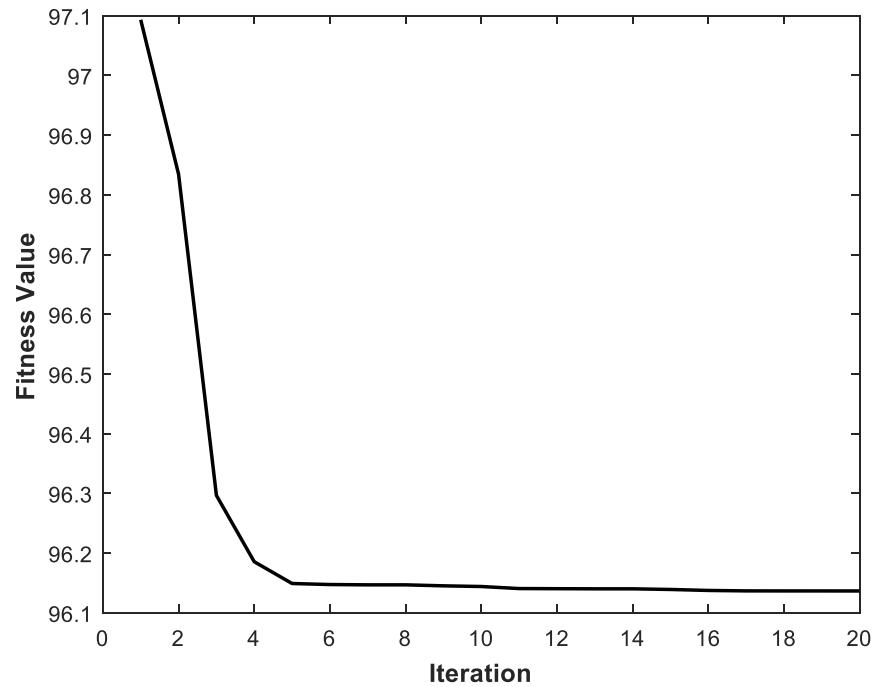
Realistic:  
Load put on the  
system, with the  
noise from  
distributed  
generation



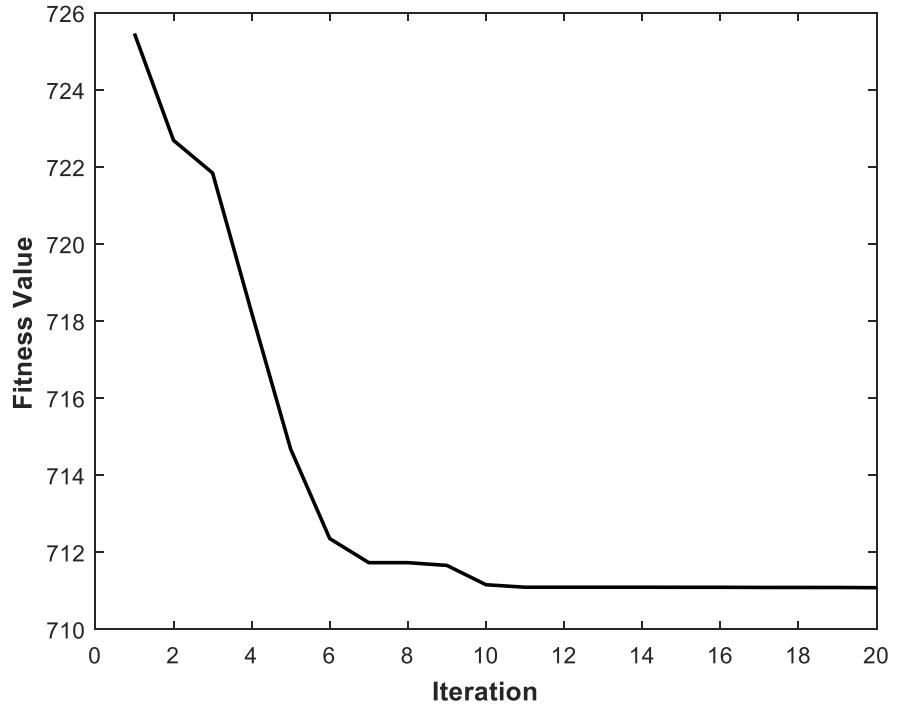
# PSO fitness vs. iteration



Simplified Model



Realistic Model



# PSO vs Grid Search: Simplified Model



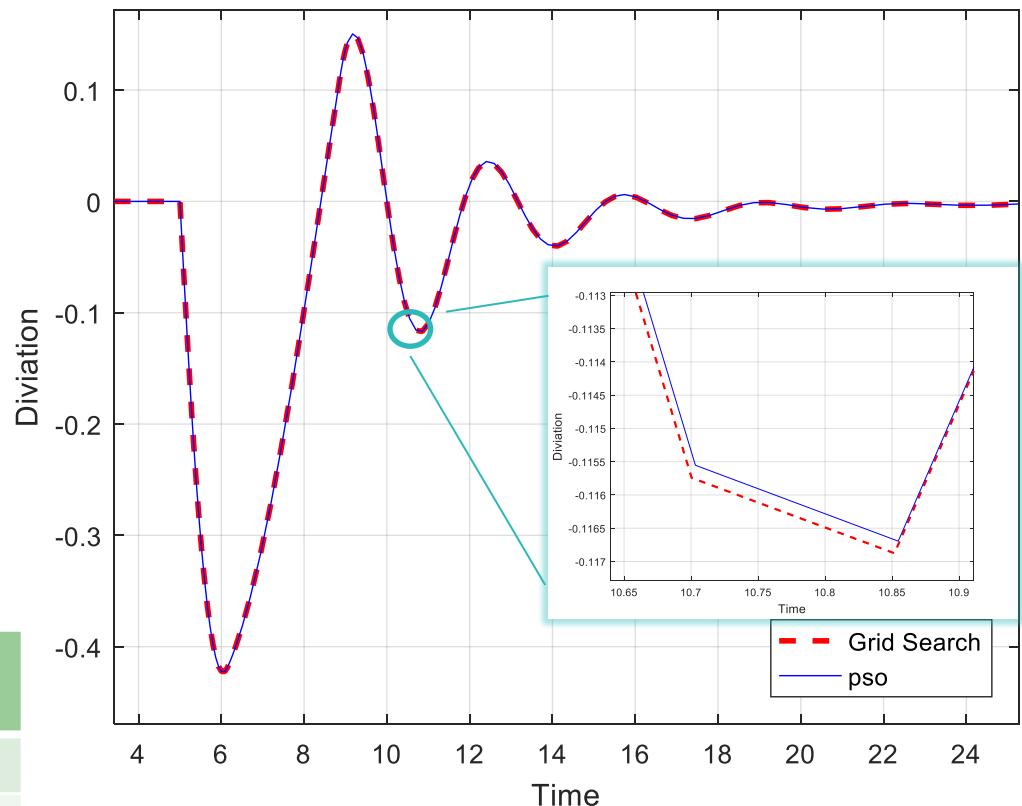
-Grid Search

525.5 min

-PSO

20.9 min ( Over 26 times faster)

	Time (min)	P	I	Fitness
PSO	20.86	27.287	3.5184	96.098
Grid Search	525.5	27.3	3.5	96.1185



# PSO vs Grid Search: Realistic



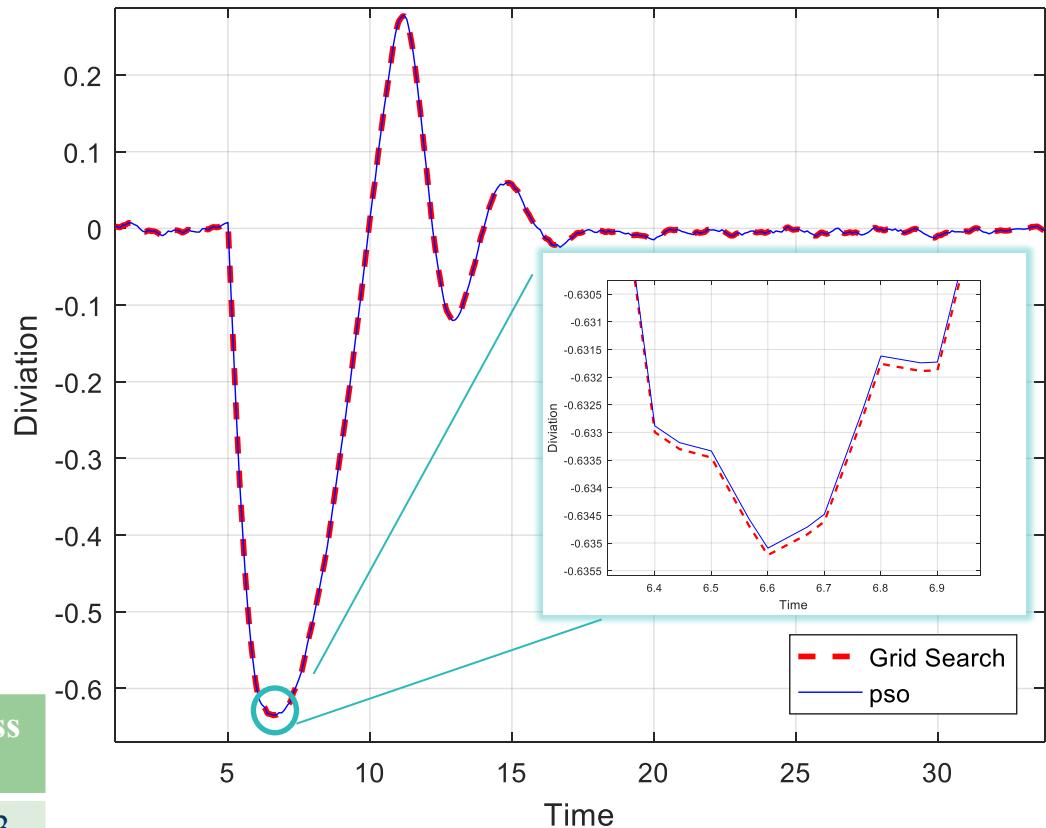
-Grid Search

487.7 min

-PSO

21.1 min (23 times faster)

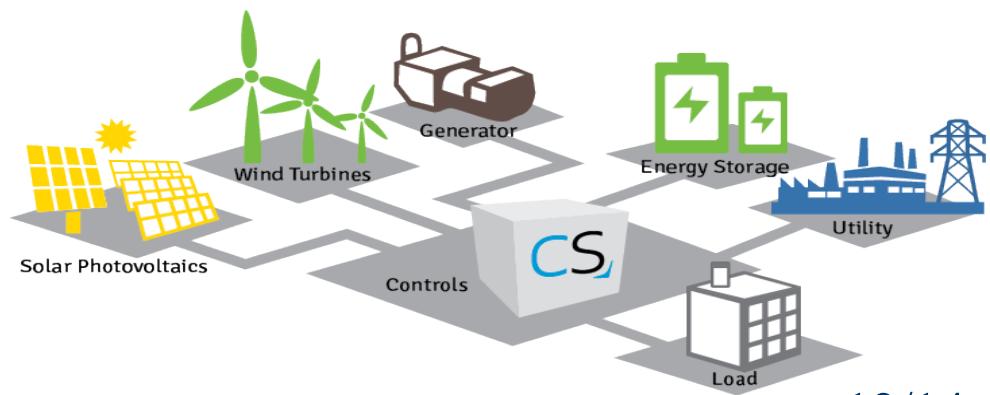
	Time (min)	P	I	Fitness
PSO	21.12	22.019	2.152	710.83
Grid Search	487.72	22	2.15	710.91



# Conclusion



- Smart grid is the future of power systems
- It brings new challenges, such as frequency fluctuations
- Smart controllers can deal with these challenges through use of Particle Swarm Optimization



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