TECHNICAL UNIVERSITY OF CLUJ-NAPOCA ROMANIA

Modeling and Control of a Microgrid with Distributed Renewable Generators

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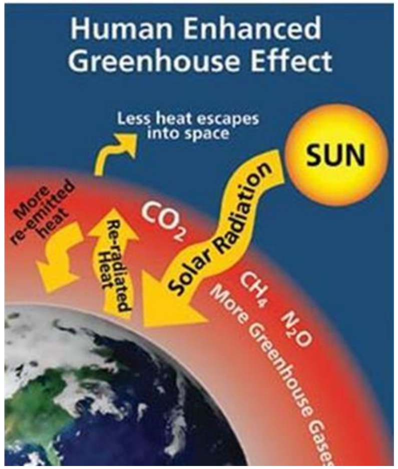
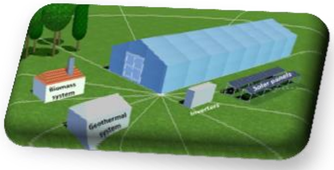
REMSIS

:: Introduction



- CO_2 – emissions
- Increase in the greenhouse effect
- Significant effects on water
- Can cause acid rains
- Environmental and landscape impacts

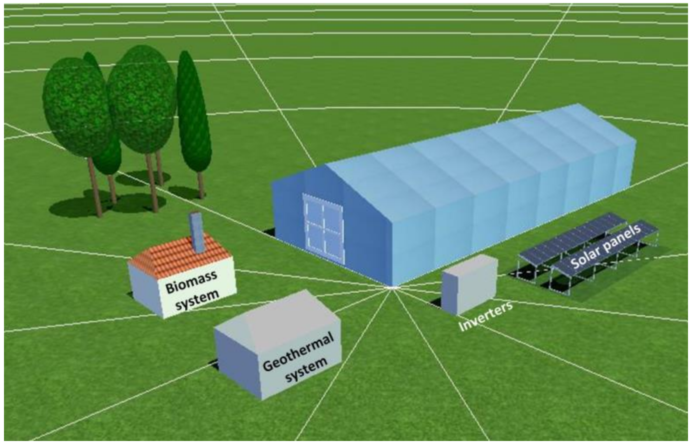


:: Objectives

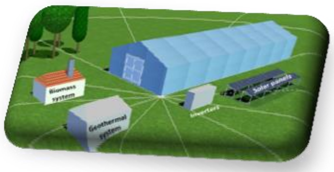
The main objective is to **supply a vegetable greenhouse** with renewable energies in the region of Oradea, Romania

- Propose a renewable energy microgrid based on: geothermal energy, biomass energy, photovoltaic panels, batteries
- Develop a microgrid control method
- Develop a microgrid energy management algorithm

Geothermal potential area



Greenhouse



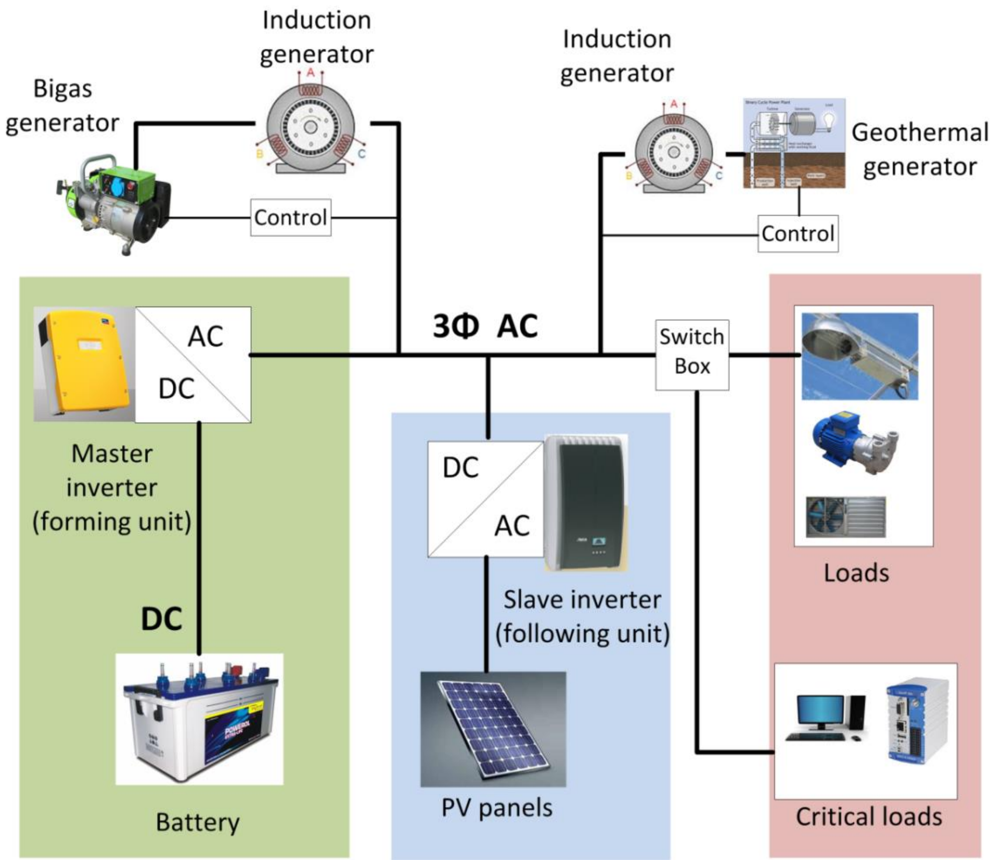
:: Proposed microgrid

Components

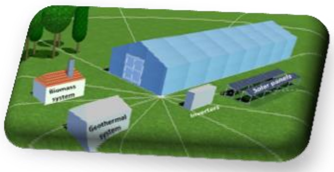
- Battery storage - ***master***
- Geothermal generator - ***slave***
- Biogas generator - ***slave***
- Photovoltaic generator - ***slave***

Loads

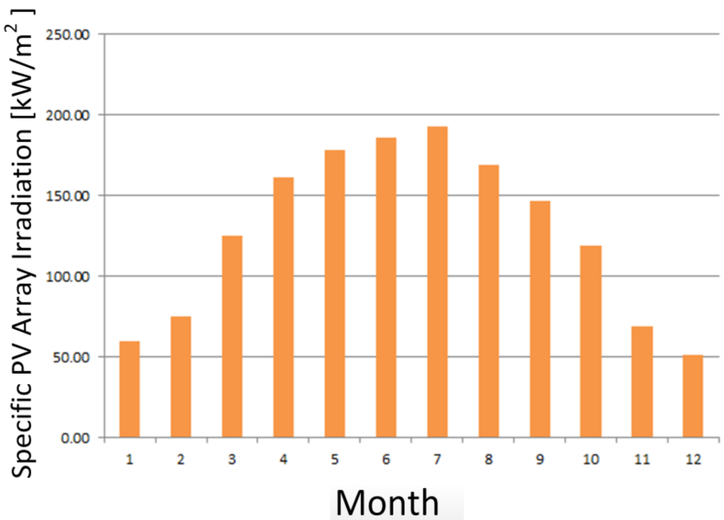
- Standard Loads
- Critical loads



Proposed microgrid



:: Size of the microgrid

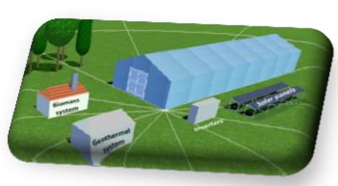


Climatic conditions

Load	Nr.	Rated power		Maximum power	
Fans	4	600	W	2400	W
Special Lamps	7	700	W	4900	W
Window opening system	1	2400	W	2400	W
Electric drives	1	100	W	100	W
Management system	1	100	W	100	W
Lighting	1	100	W	100	W
Water Pumps	8	600	W	4800	W
Maximum total power				**14800**	kW

Greenhouse loads

Component	Characteristic	Value
Biogas generator	Rated power(kW)	7kW
Geothermal generator	Rated power(kW)	7kW
Solar panels	Rated power(kW)	5kW
Solar inverter	Rated power(kW)	5kW
Batteries	Capacity(Ah)	500Ah/48V
Battery inverter	Maximum power(kW)	10kW



:: Control Method

Two level control structure:

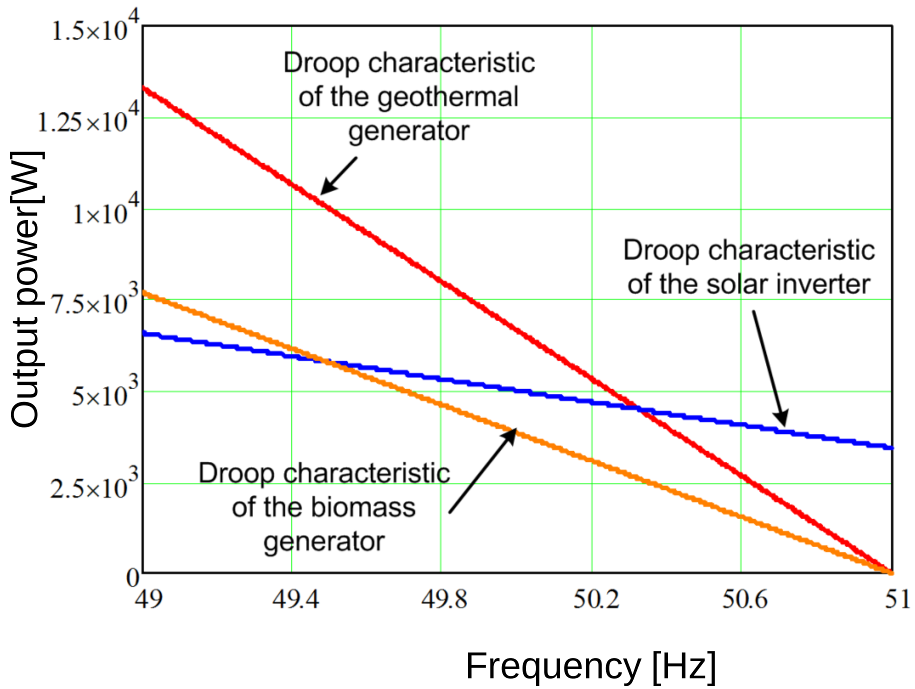
- *Primary level control* - Droop control
- *Secondary level control* - Communication based control – RS485

Induction generator droop

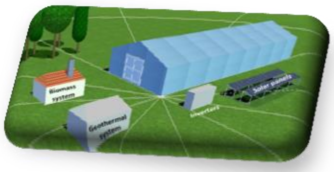
$$P_m(f) = k_m \cdot (f_0 - f)$$

Solar inverter droop

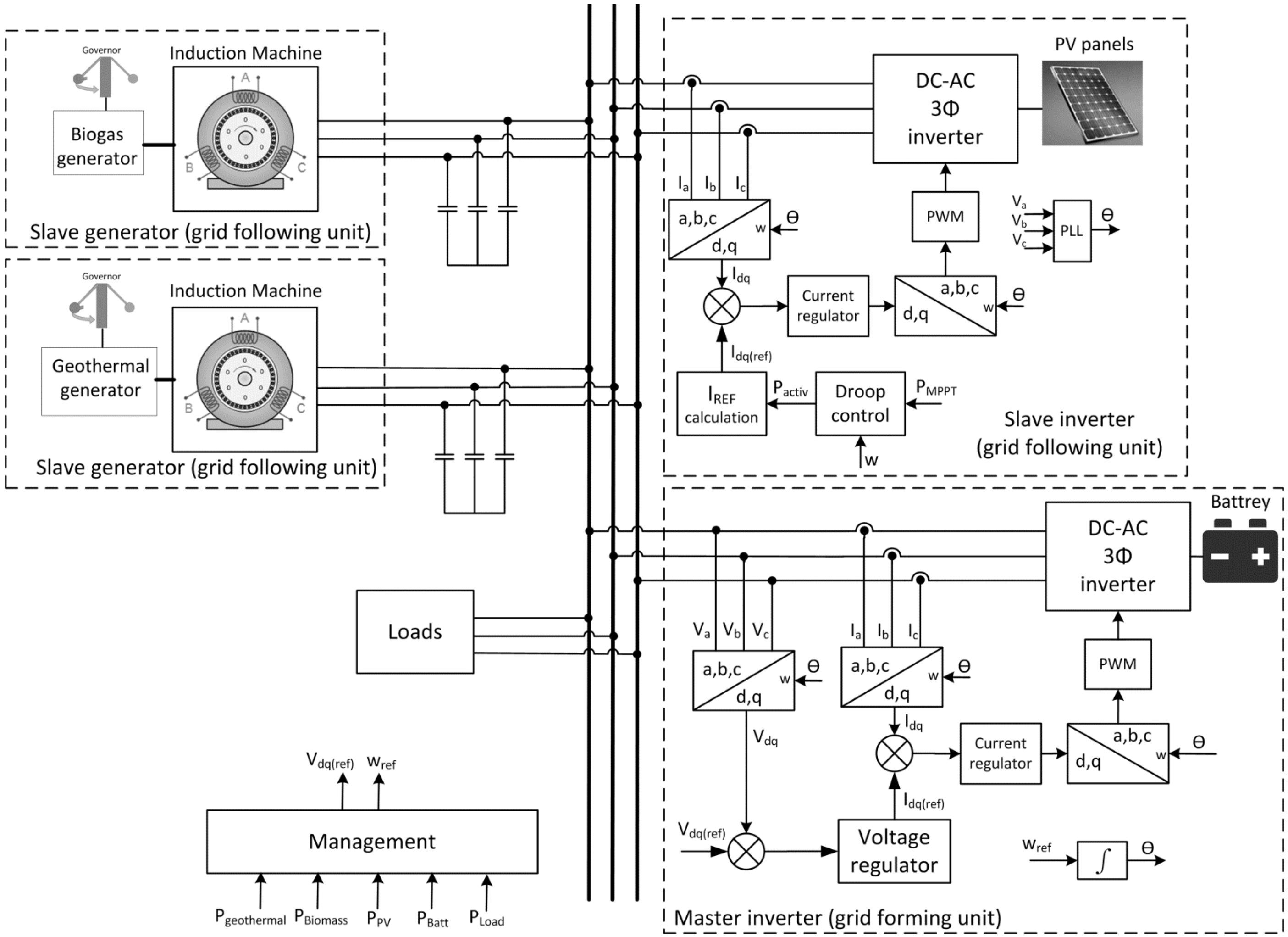
$$P(f) = P_o + k \cdot (f_0 - f)$$

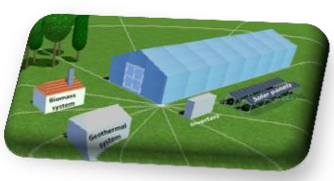


Droop control method

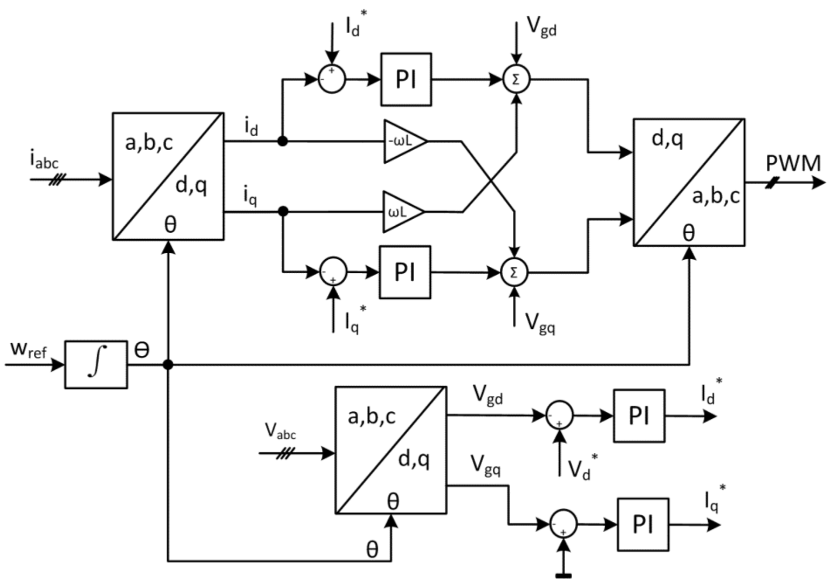


:: Microgrid control

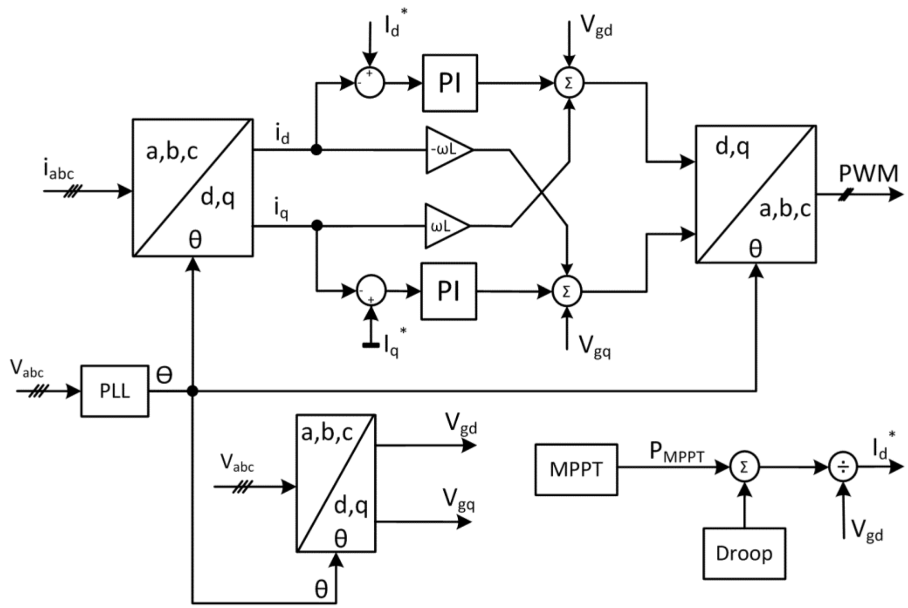




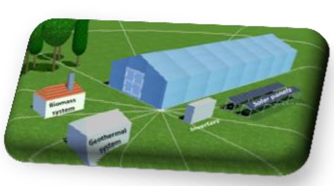
:: Inverter control



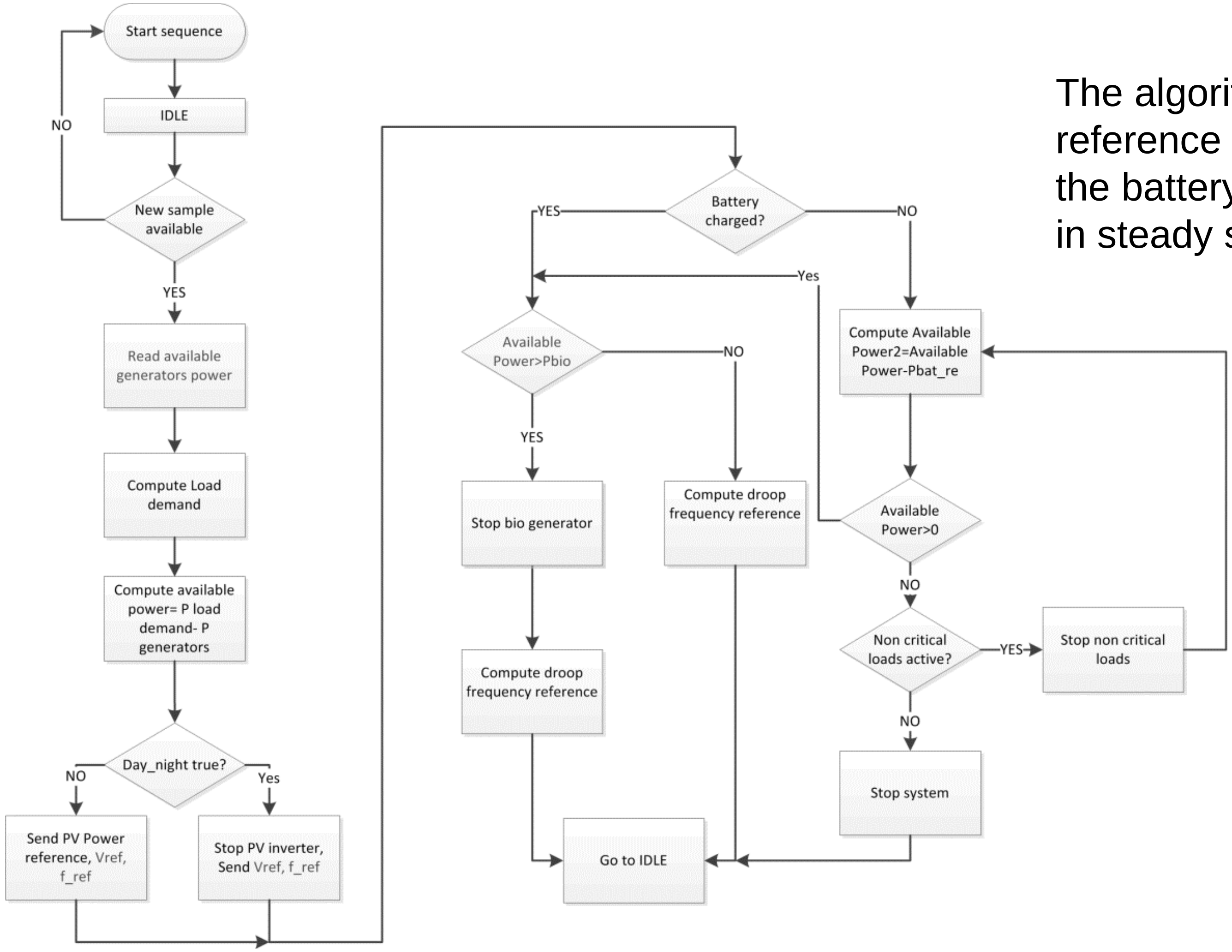
Battery inverter control



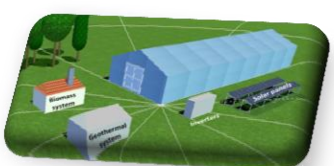
Solar inverter control



:: Energy management algorithm



The algorithm gives the frequency reference value in such a way that the battery inverter supplies 0 energy in steady state



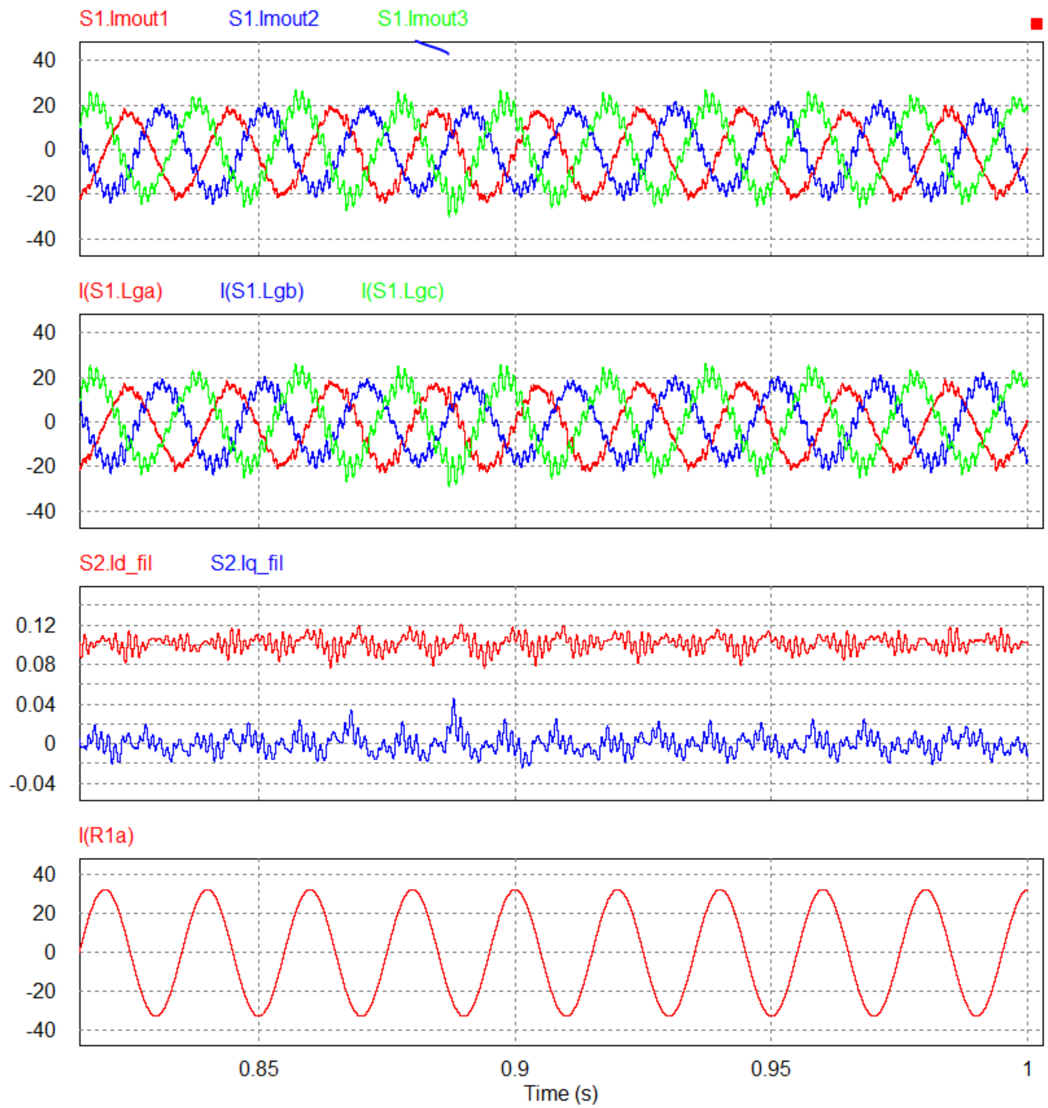
::Inverter operation

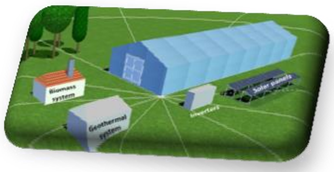
Master inverter output currents

Solar inverter output currents

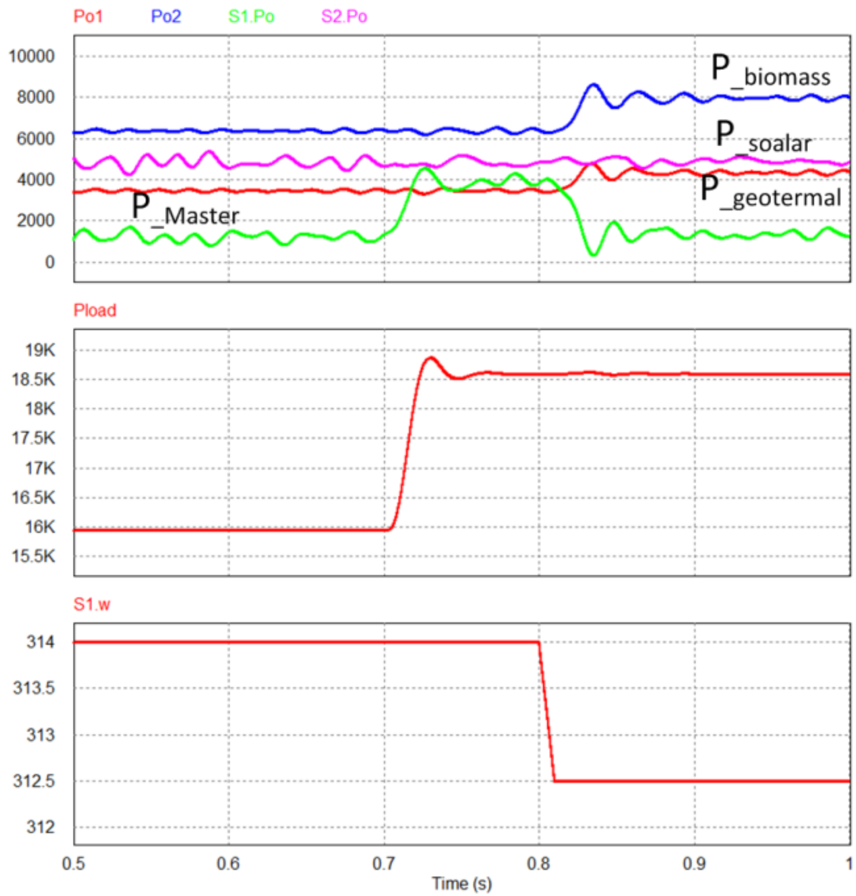
I_d and I_q master inverter currents

One phase load current



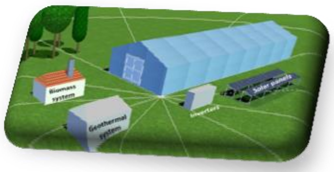


:: Case studies

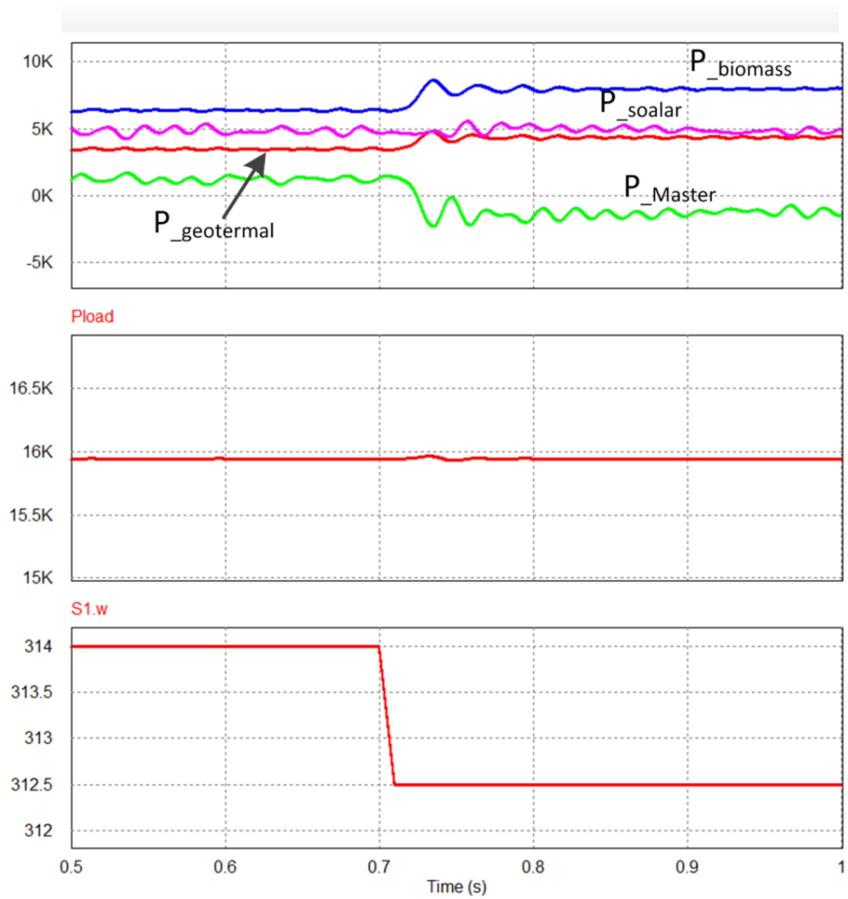


Case I

- ✓ The load increases from 16kW to 18kW
- ✓ The master inverter supply the needed energy to the load from batteries
- ✓ The energy management controller detects the change in the power balance and decreases the frequency
- ✓ Every generator adjust its output power according to its droop characteristic

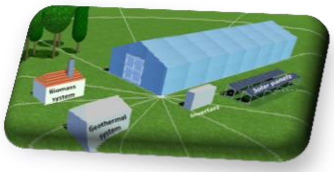


:: Case studies

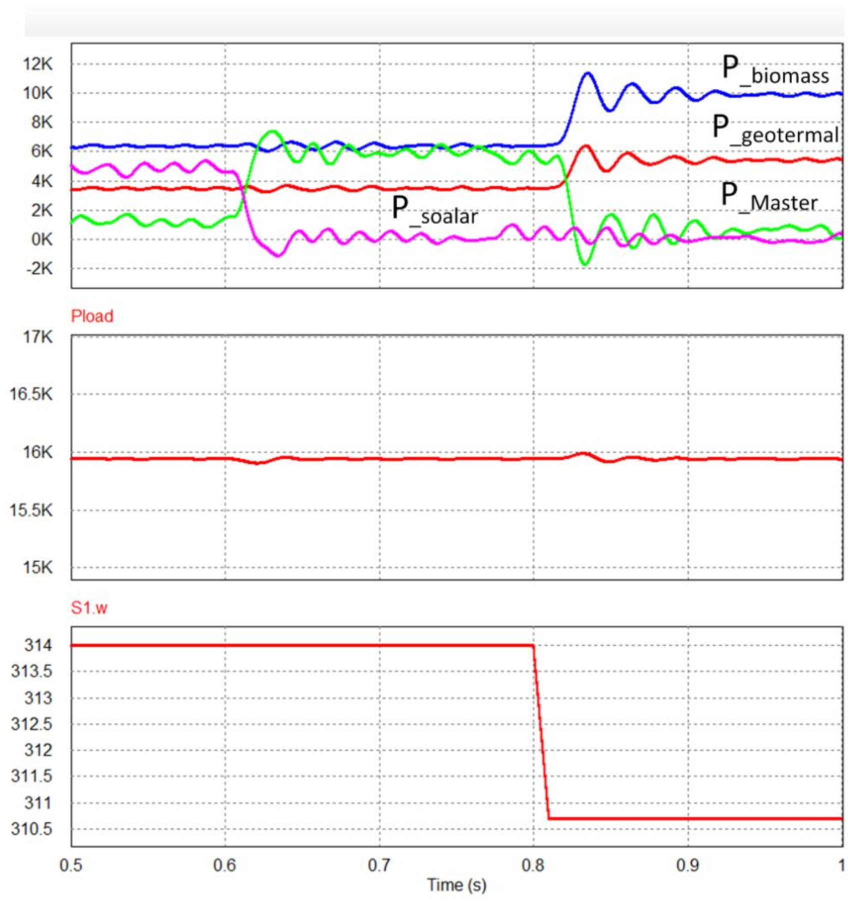


Case II

- ✓ Batteries need charging
- ✓ Energy management controller reduces the frequency
- ✓ The other generators increase their output power

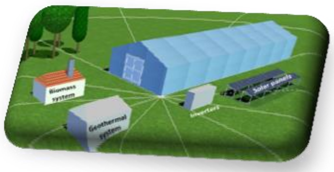


:: Case studies



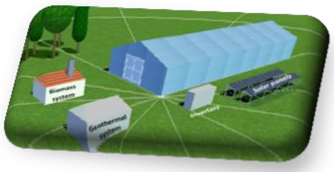
Case III

- ✓ Solar power is lost
- ✓ The master inverter supply the needed energy to the load from batteries first
- ✓ The energy management controller detects the change in the power balance and decreases the frequency
- ✓ Every generator adjust its output power according to its droop characteristic



:: Conclusions

- ✓ This paper presented the modeling and control of a renewable energy microgrid that supply a vegetable greenhouse.
- ✓ The power flow between the generators and the load in the microgrid is controlled using a two level hierarchical structure: a primary level based P-f droop control and a secondary level based on communication.
- ✓ The main goal of the proposed control method is to maintain the energy consumption from batteries as low as possible.
- ✓ The simulation show that when a perturbation appear (load variation, solar energy variation) the master inverter acts as a buffer supplying the load from batteries for a short period of time until the power management system brings the operation of the microgrid to a new steady state operation point where the master inverter power is close to zero.
- ✓ The simulations prove the proper steady state operation of the microgrid for different load and climatic conditions.



::Thank you

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