Design and Simulation Study of A Microgrid System

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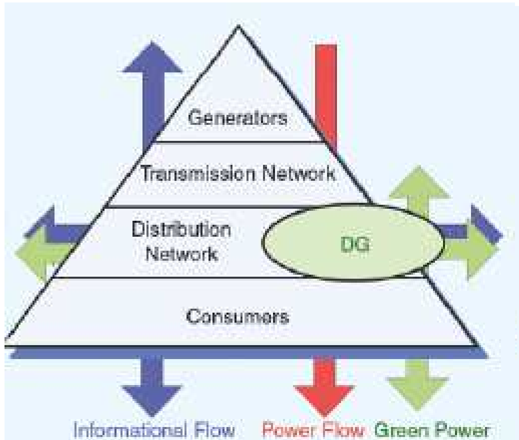
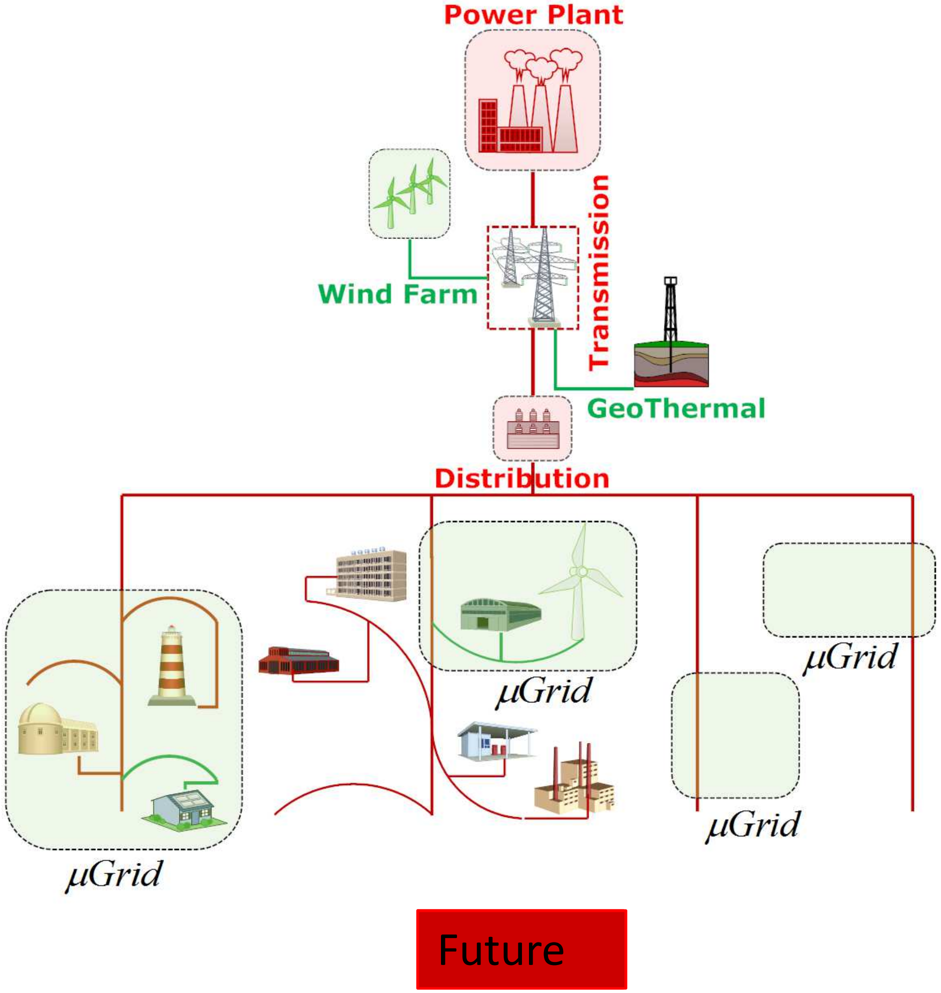
Evaluation of Electrical Power system Architecture

Future grid should be –

- ❑ Flexible
- ❑ Accessible
- ❑ Reliable
- ❑ Economic and
- ❑ Lower in Green House Gas emission





Basic Microgrid Architecture

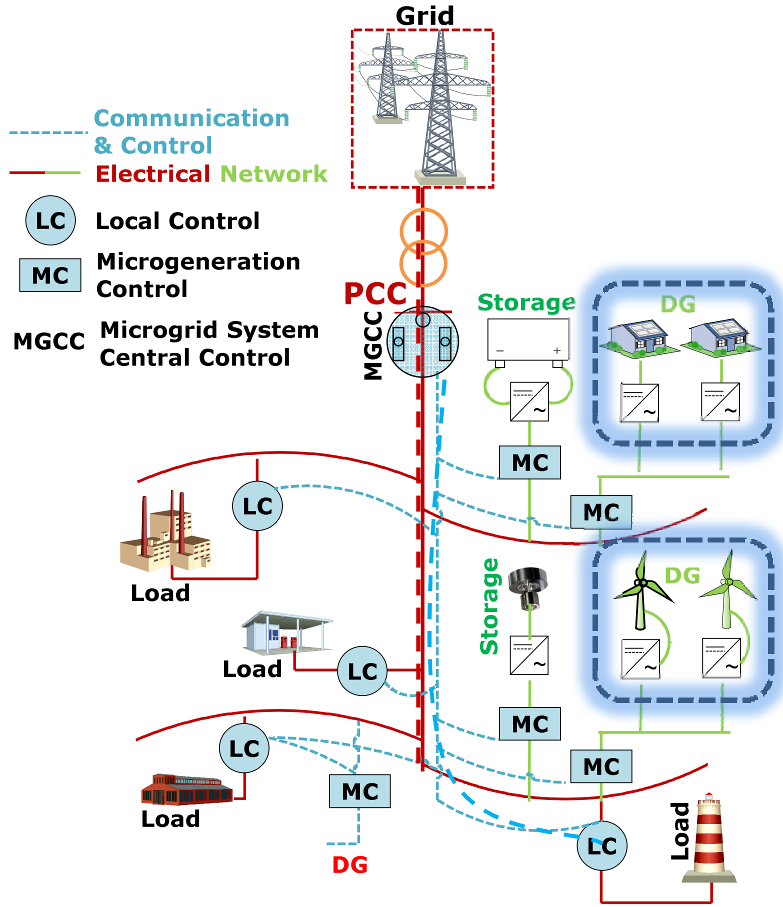
The basic Microgrid (MG) architecture is based on four different issues --

i) Distributed Generation (DG) resources

ii) Storage systems

iii) Distribution systems and

iv) Communication & control.



Microgrid Architecture

Objective

1. Techno-economic analysis of grid connected **Community Based µGrid (C-µGrid)** system integrated with storage.

2. Simulation model of grid connected **Community Based µGrid (C-µGrid)** system by Matlab Simulink

➢ ***C-µGrid system*** based on

- ✓Micro Wind energy system
- ✓Location - Dublin, Ireland
- ✓Wind based µGen system is not yet very popular with the present REFIT (Renewable Energy Feed-in-Tariff) policy.
- ✓**Considered same REFIT policy for µGen and C-µGrid system**

Feed-in-tariff policy in Ireland

- Irish Government has introduced incentive for **Micro-generation (μGen)** systems from early 2009
- According to the REFIT policy, **μGen** users receive 0.09€/kWh for all exported electricity to the grid, which is much lower than the importing grid electricity cost (0.22 €/kWh)
- Wind energy based μGen system is not yet economically feasible in Ireland
- There is no existing policy for **Microgrid (μGrid)** system in Ireland

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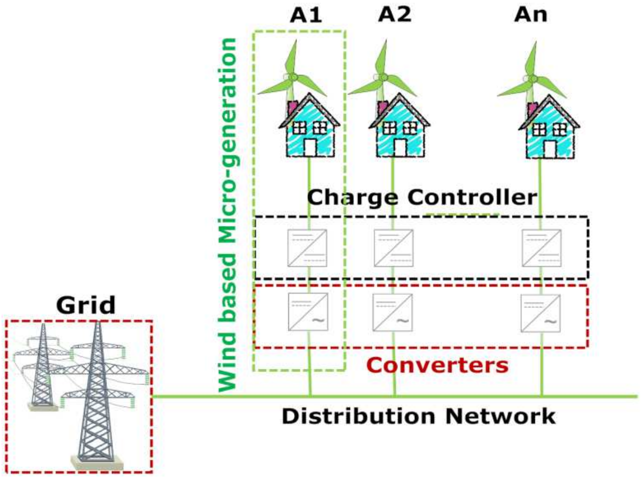
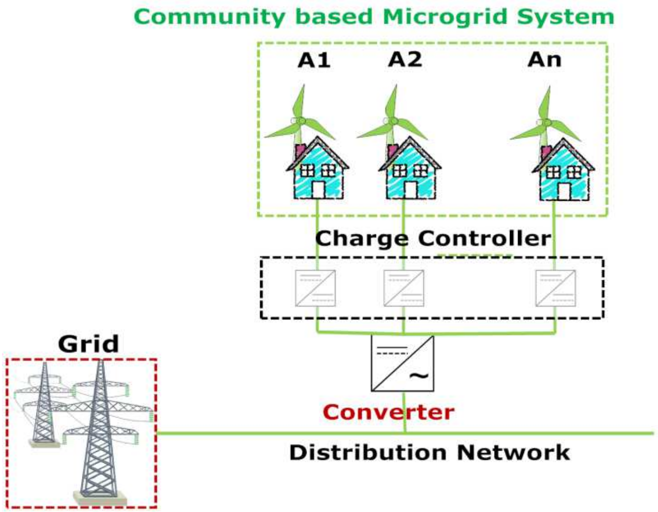
Proposed Community μGrid system

- A cluster of ***μGen*** systems forms ***C-μGrid*** system in distribution network
- Simple modification in ***μGen*** systems: Instead of having separate converter, they will share a central converter to connect to the grid

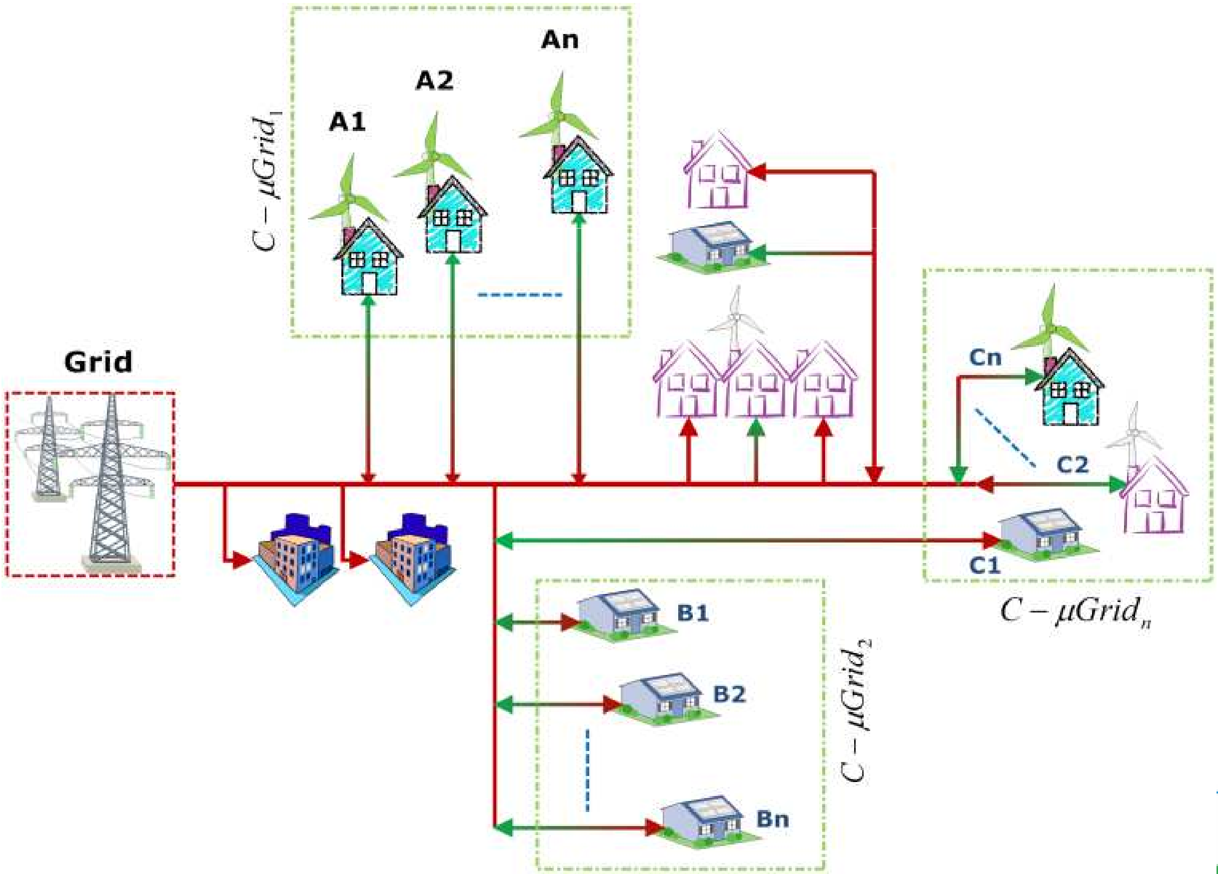


Basic features of **C-μGrid** system:

- The system can be more stable.
- Maintenance can be done professionally and the cost could be shared.
- Central converter and storage.
- Can minimize environmental pollution.
- Can reduce the operating cost and COE.
- Can be implemented under the μGen policy.



Concept of C-μGrid system in distribution network



Techno-economic analysis of a C-μGrid system

- 100 houses have been virtually considered
- Three case studies have been performed --

Off-grid μGen system

Off-grid C-μGrid system

Grid connected C-μGrid system

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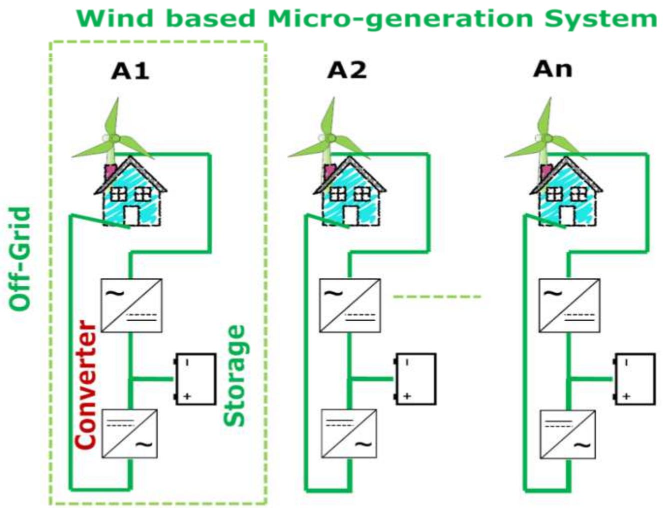

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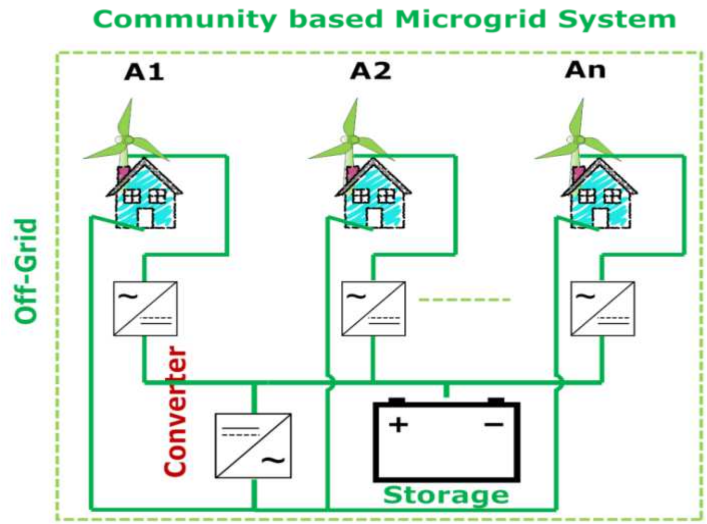

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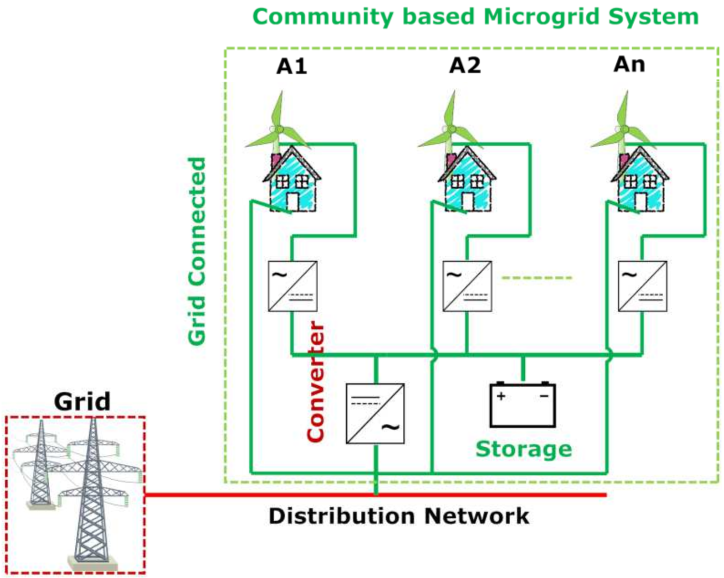

Grid connected C-μGrid system

Techno-economic analysis

Technical information of the systems

Grid integration		Off-grid		On-grid
Aspect	System	µGen System	Community µGrid System	Community µGrid System
		100 Houses (100 unit)	1 Microgrid (1 unit = 100 houses)	1 Microgrid (1 unit = 100 houses)
Technical aspect	Wind Turbine	6*100 = 600 kW	6*100 = 600 kW	6*100 = 600 kW
	Converter	6*100 = 600 kW	600 kW	600 kW
	Storage			
	Battery Capacity	28.8*100 = 2880 kWh	1870 kWh	14.4 kWh to 1870 kWh
	Autonomy	24 hr	23 hr	1 hr to 23 hr
	Expected life	20 yr	20 yr	20 yr
	Project life	20 yr	20 yr	20 yr

consumers of the community would agree to share the investment and benefits of the system equally

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Result and discussion

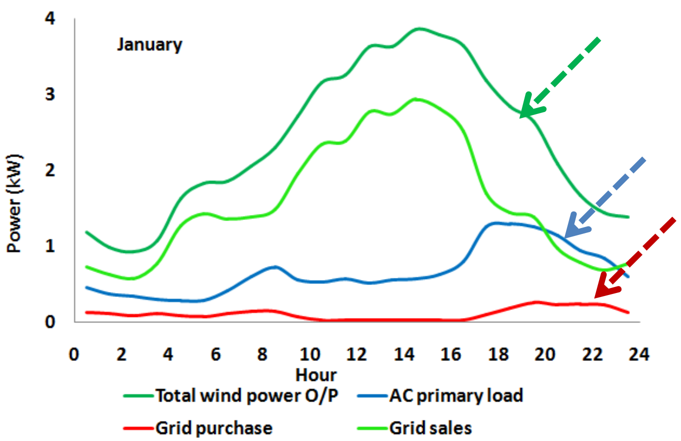
Technical performance of wind based **μGen** system

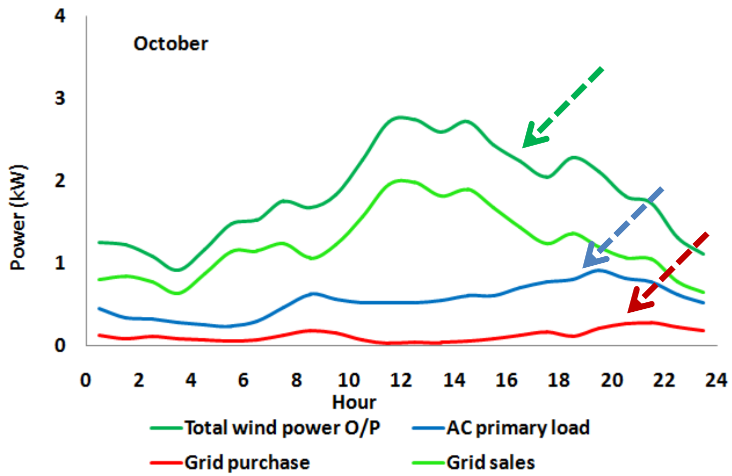
Winter months --

✓ wind power is always higher than the load demand

✓wind profile follows the load profile for most of the hours

✓at peak load demand consumers purchase less electricity from the grid





Result and discussion

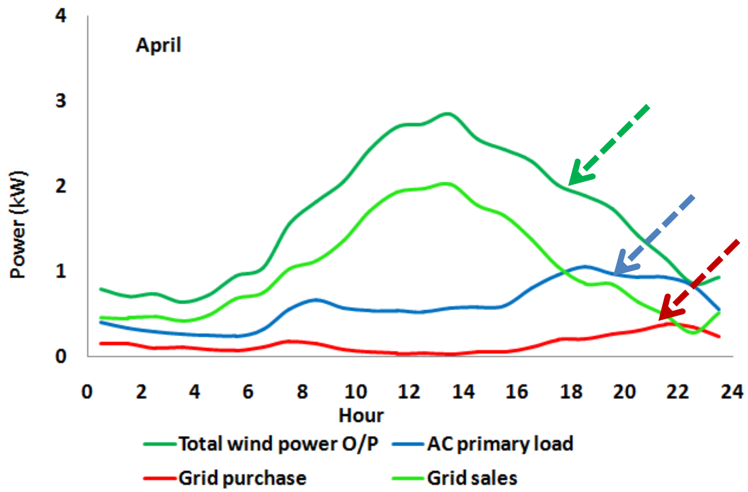
Technical performance of wind based *µGen* system

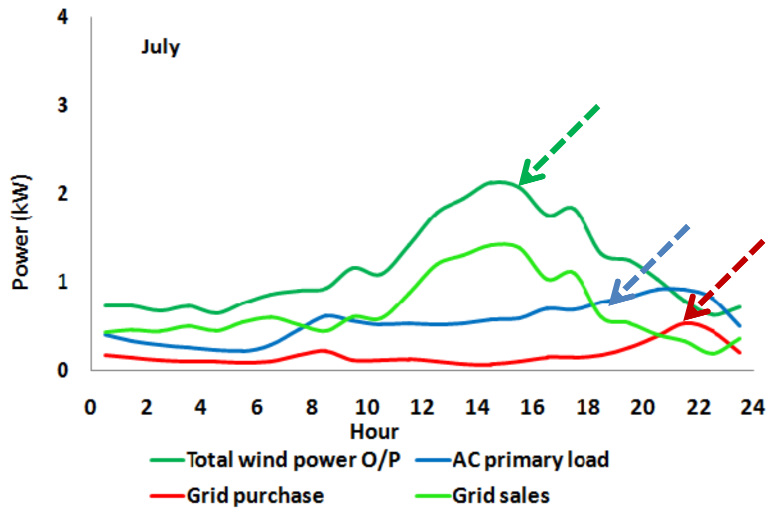
Summer months –

✓ wind power is not always higher than the load demand

✓ wind profile does not follow the load profile for few hours

✓ at peak load demand consumers purchase more electricity from the grid

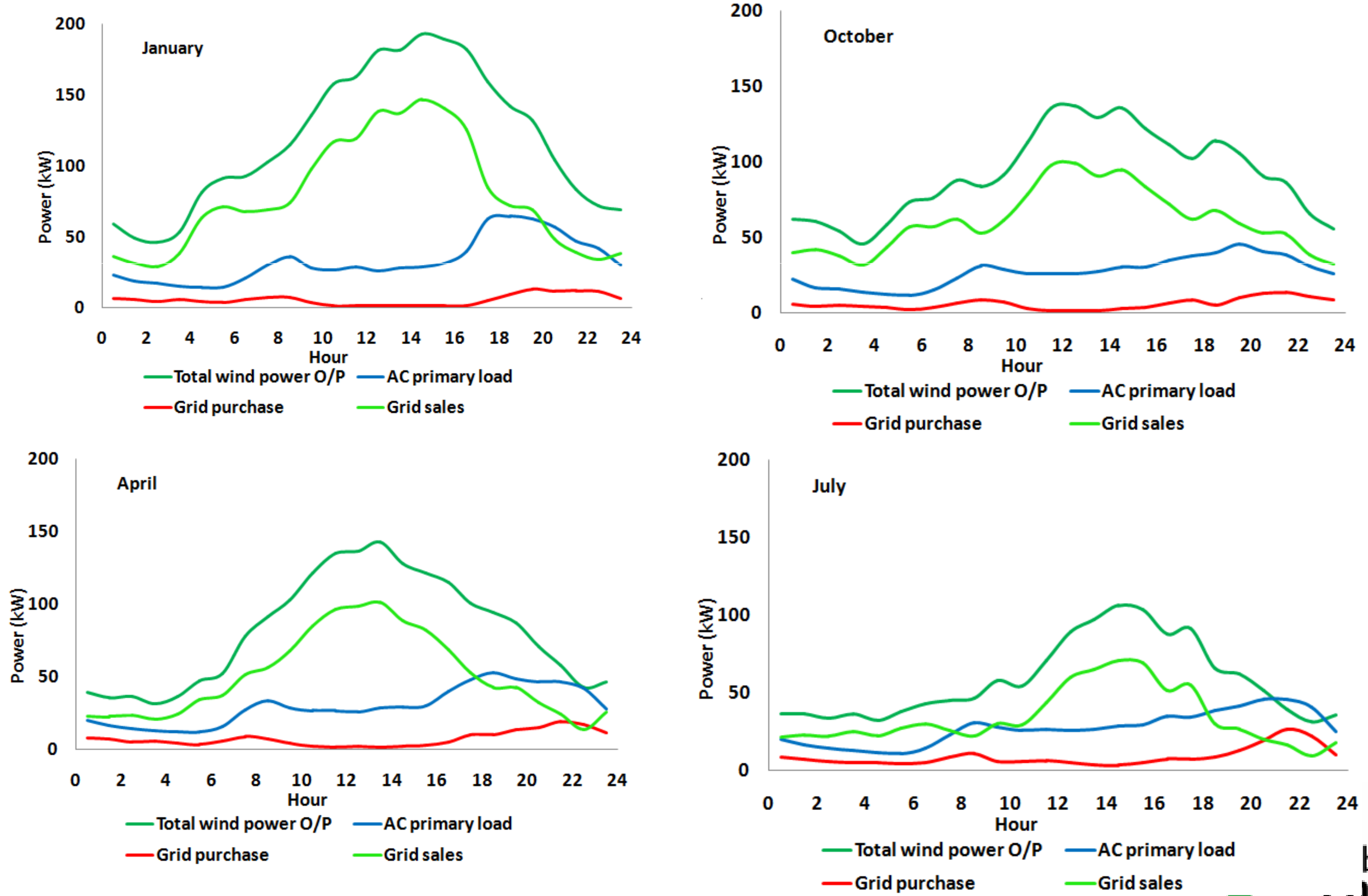




Result and discussion

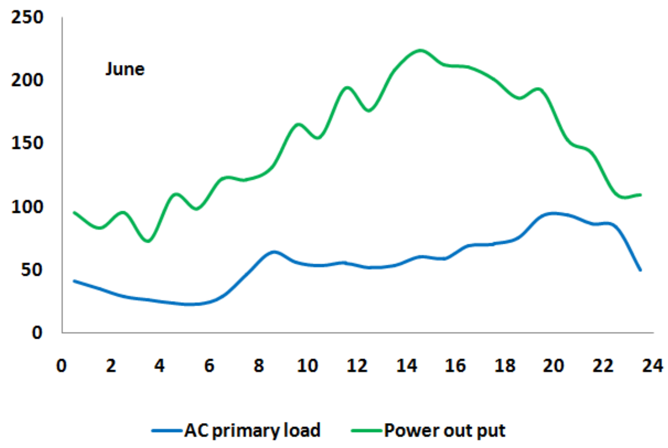
Technical performance of *C-µGrid* System

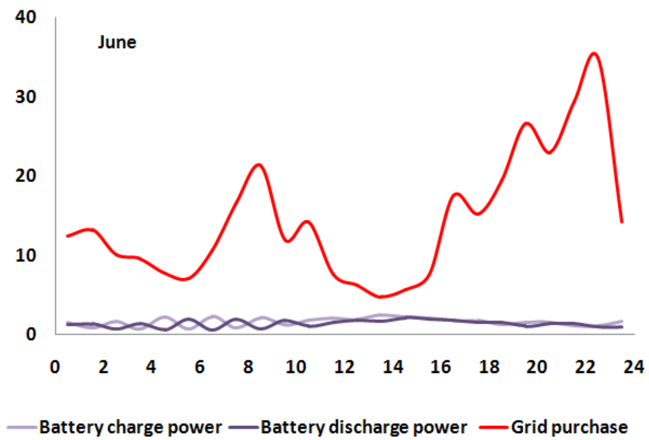
Similar results/technical performance is obtained



Result and discussion

Technical performance of battery in ***C-μGrid*** System





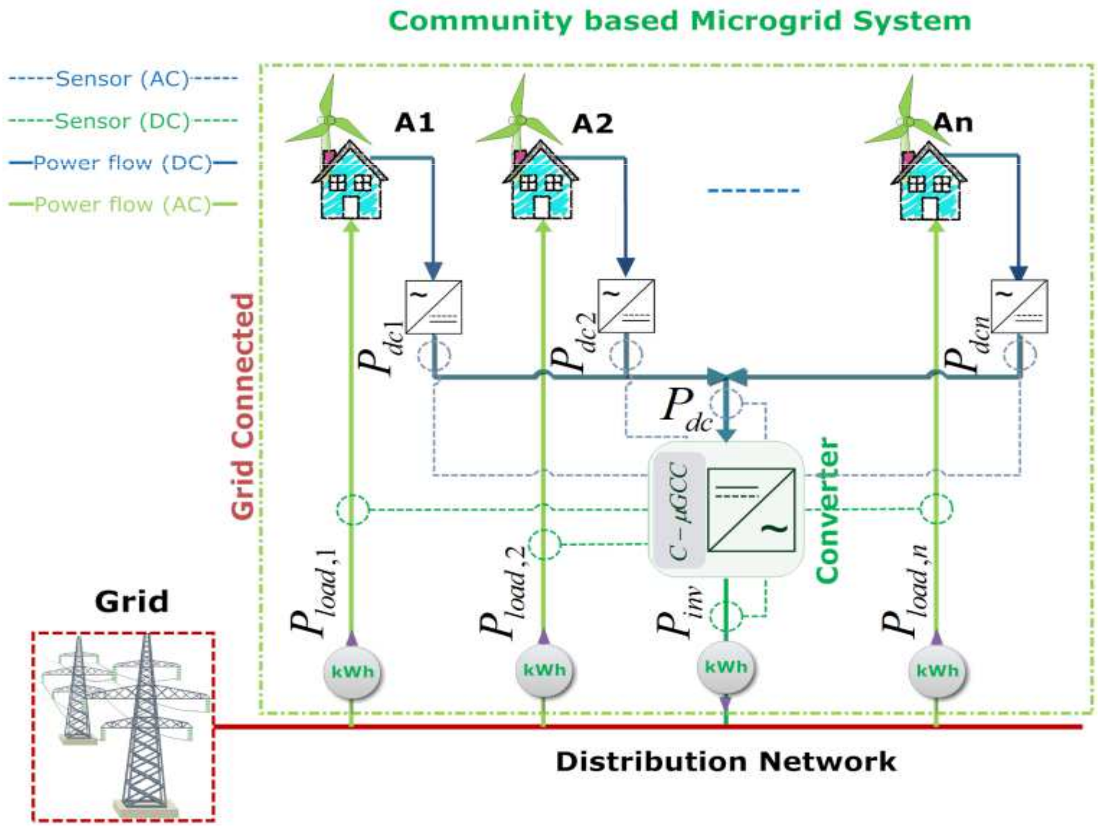
Result and discussion

Economic aspects of grid connected *C- µGrid* system with **STORAGE**

Grid integration		Off-grid		On-grid
Aspect	System	µGen System	Community µGrid System	Community µGrid System
Economic aspect (€)	Initial investment	€19430*100	€1514520	€1324920
	Total system cost	€26064*100	€1766710	€1605133
	Cost of energy (COE) €/kWh	€0.22	€0.16	€0.10

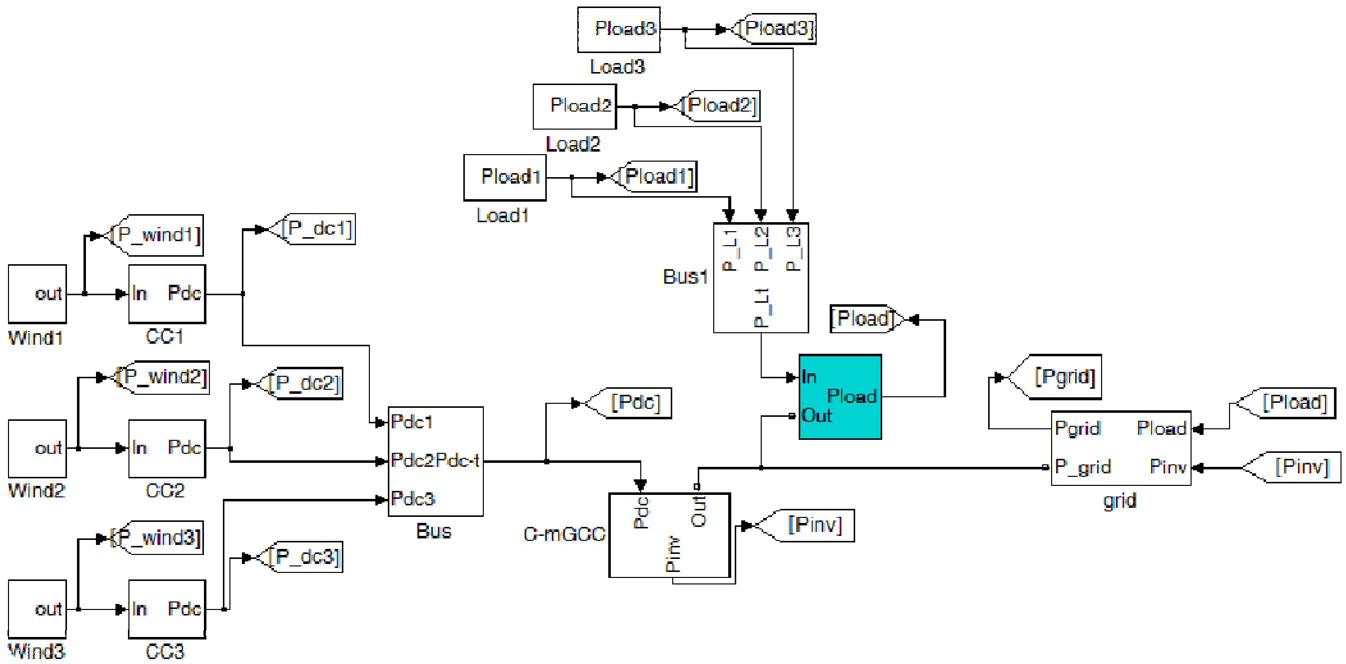
Simulation model of a C-μGrid system

- All μGens with Charge Controller are connected in parallel to a common DC bus
- DC bus is connected to the central converter
- ***C-μGrid central controller*** (***C-μGCC***) manages the power sharing between the prosumers (producer and consumer) based on its control strategy

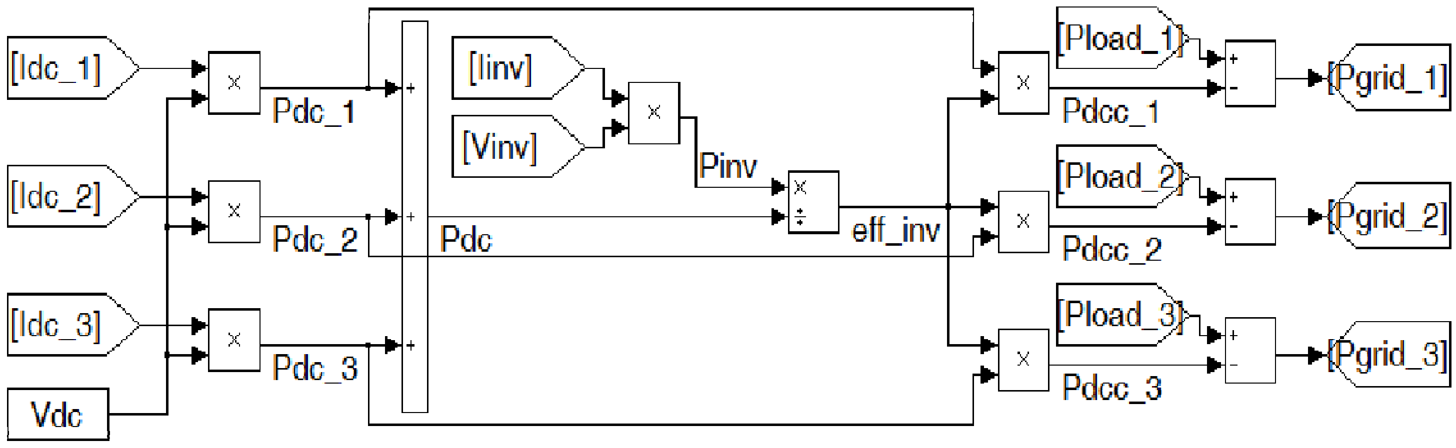


Simulation model of C-μGrid system

➢ Three wind turbines with a rated output of 6kW each is used in this simulation model.
➢ Simulation has been performed for a typical day to understand the power sharing mechanism.



Power sharing by C-μGCC



Real Inverter Efficiency

$$\eta_{inv} = {P_{dc}}/{P_{inv}}$$

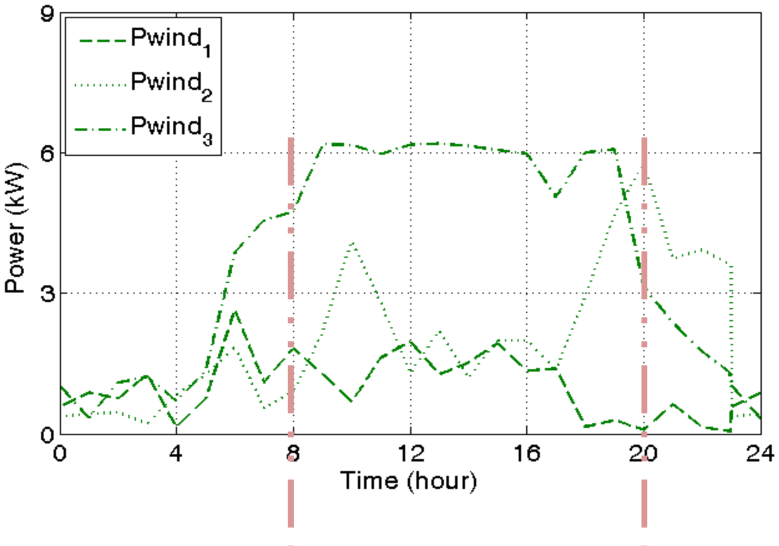
Power Contribution by prosumer

$$P_{dcc,n} = \eta_{inv} P_{dc,n}$$

Power Transfer to Grid by prosumer

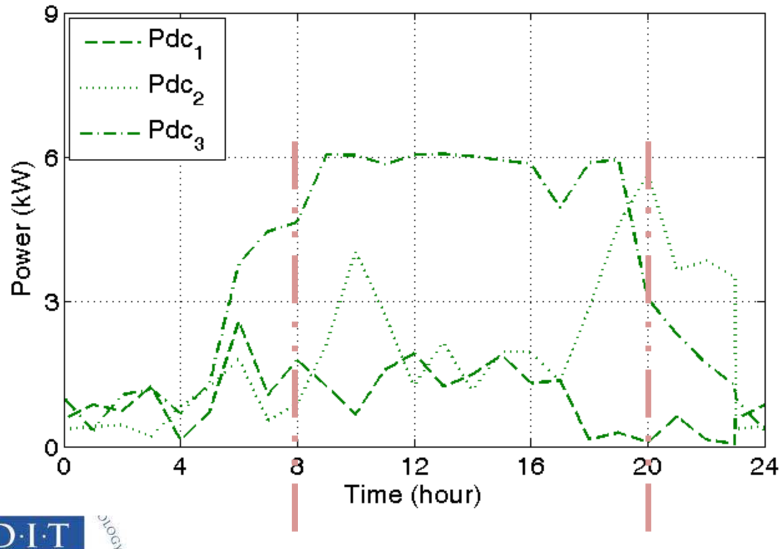
$$P_{grid} = P_{load} - P_{dcc}$$

Results and discussion



Output power from wind turbines

Time	Turbine 1	Turbine 2	Turbine 3
8:00am	1.8	1.0	4.7
8:00pm	0.3	5.7	3.1



Power after charge controller (CC)

Time	Turbine 1	Turbine 2	Turbine 3
8:00am	1.76	0.98	4.6
8:00pm	0.29	5.57	3.03

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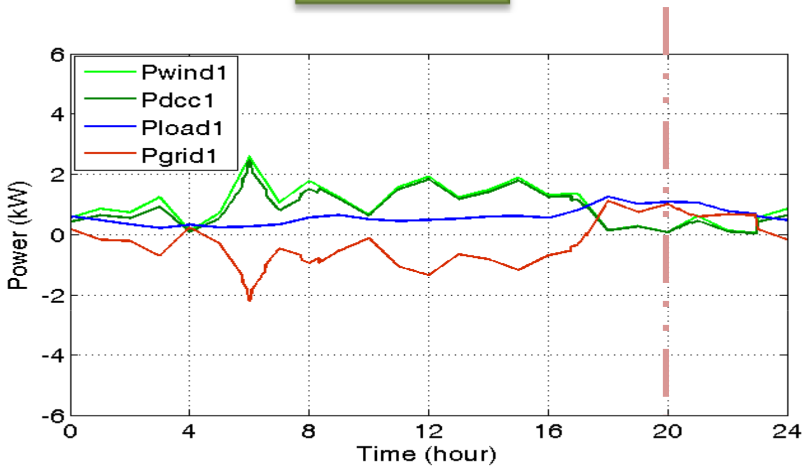
Results and discussion

House 1



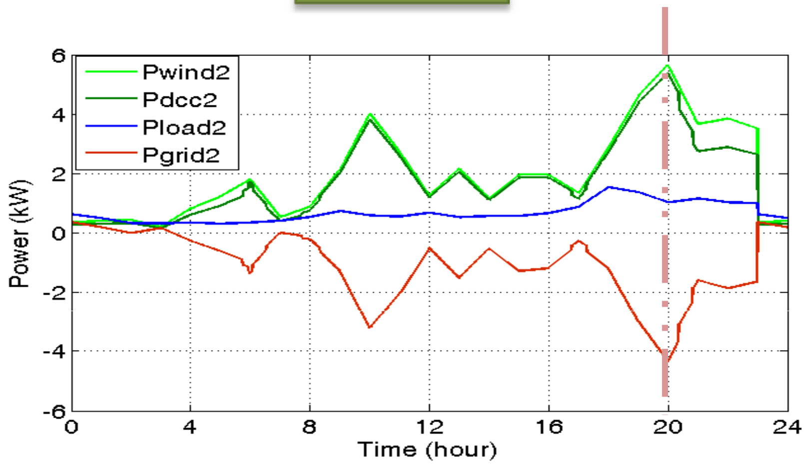
Power consumption from grid (at 8:00pm)

Power sharing information

- Output Power from Turbine1
- Contributed Power by Prosumer1
- Load Demand of House1
- Power Transfer to Grid by House1

Results and discussion

House 2



Power consumption from grid (at 8:00pm)

Power sharing information

Output Power from Turbine2

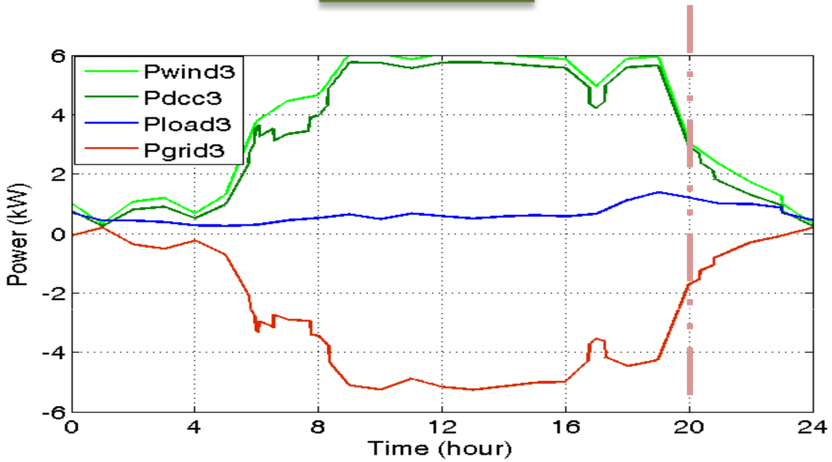
Contributed Power by Prosumer2

Load Demand of House2

Power Transfer to Grid by House2

Results and discussion

House 3



Power consume from grid (at 8:00pm)

Power sharing information

Output Power from Turbine3

Contributed Power by Prosumer3

Load Demand of House3

Power Transfer to Grid by House3

Conclusion

✓In case of *C-μGrid* system COE is equal to the REFIT price.

✓ Without changing the policy, community users can convert their *μGen* in to *C-μGrid* system and economic benefit can be assessed.

✓ Depending on the scenario, some modification can be done in the present policy, such as:

(i) VAT reduction

(ii) increase electricity export rate

(iii) provide incentives for GHG reduction

✓The simulation model in Matlab shows the power sharing mechanism to understand at a technical level the practical implementation of such a system where ***μGrid* policy does not exist but *μGen* policy exists.**

✓ The analysis can set some grounds for policy change to make the ***C-μGrid*** system more lucrative towards the development of ***μGrid*** system.

✓The results with performance study show the effectiveness of the system.

Thank You

Questions ???