Energy research Centre of the Netherlands

VSYNC – The Virtual Synchronous Generator concept

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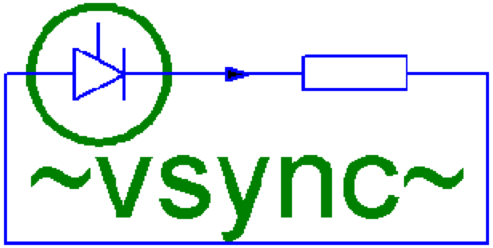

OVERVIEW

- The VSYNC project
- Future grid scenario
- Problem approach
- The VSG concept
- Operation principle of VSG's
    - Energy estimates
    - Case 1: primary balancing
    - Case 2: safety & security of supply
    - Case 3: reconnection of microgrid
- Many questions to be addressed
- A few project success factors

THE VSYNC PROJECT

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- 01 Oct 2007 – 30 Sept 2010
- Budget 3,25 MEuro
- Phase 1: Laboratory testing
  - 6 x 5 kW VSG
  - Energy stores (small & medium sized)
- Phase 2: Demonstration:
  - 10 x 5 kW VSG; The Netherlands (Continuon)
  - 1 x 100 kW VSG; Romania (Electrica)

Project partners

1 ECN	NL
Energy research Centre of the Netherlands	
2 TUE	NL
Technical University of Eindhoven	
3 TUD	NL
Delft University of Technology	
4 KUL	BE
Catholic University of Leuven	
5 UPB	RO
Universitatea Politehnica Bucuresti	
6 LABEIN	ES
Fundación LABEIN	
7 3E	BE
3E NV	
8 UfE	DE
UfE Umweltfreundliche Energieanlagen Handelsgesellschaft mbH	
9 Electrica	RO
Electrica SA	
10 Continuon	NL
Continuon NV	

FUTURE GRID SCENARIO

FUTURE CONDITIONS

- Large share of decentralised generation
- Central generation is diminished
- Partial near-islanding operation

CONSEQUENCES

- Less rotational mass in the system
  - Larger frequency variations
- Shorter response time to fault situations
  - for safety devices and for grid operators
- A less stable grid

PROBLEM APPROACH

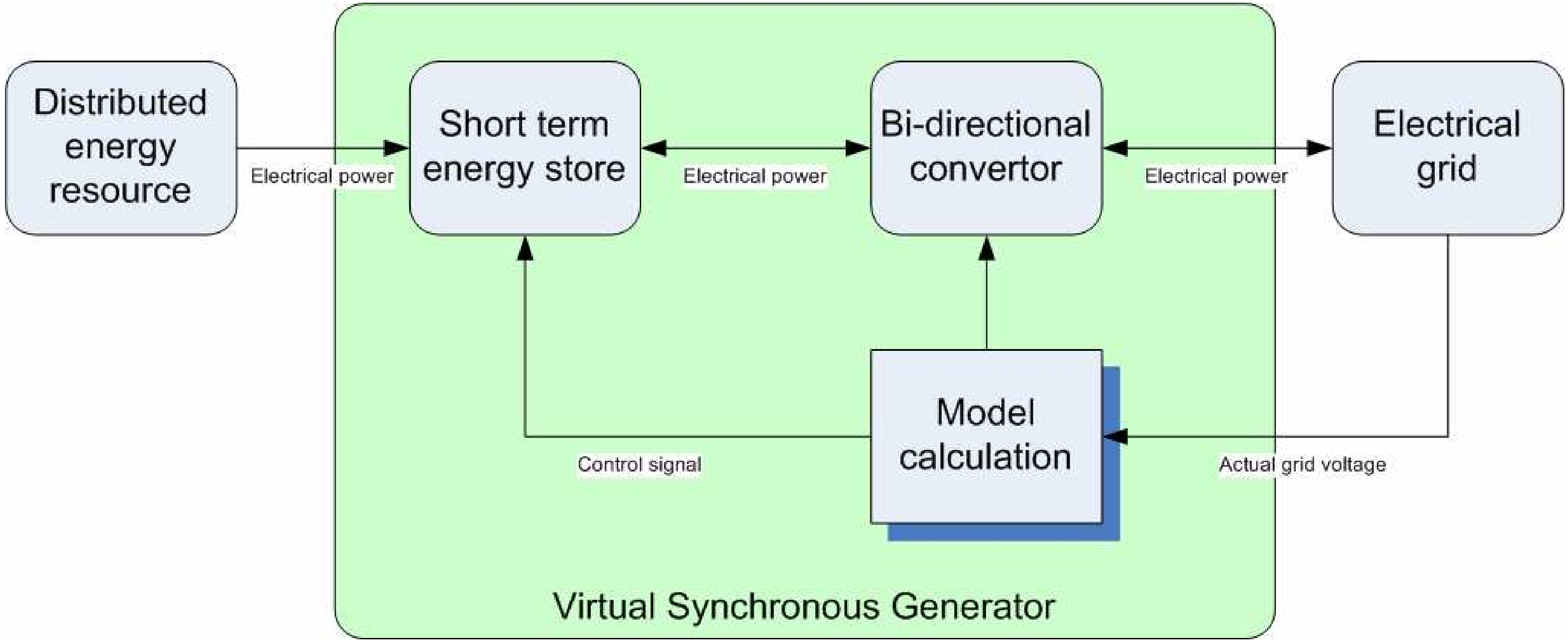
Add Virtual Synchronous Generators (VSG's)

- Many decentralised generators behave synchronously for small time intervals
  - PV, mCHP, Windturbines, etc
  - tens of milliseconds through minutes

- Group VSG-action must last longer than fault clearance times

Expected Result: A more stable grid

THE VSG CONCEPT



OPERATION PRINCIPLE OF VSG's

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- Many VSG's together behave like one large rotating mass
- Short lasting power exchanges between grid and energy stores counteracting changes in
  - Frequency
  - Voltage

EXPECTED RESULTS:

- Reduction of variations in frequency and voltage
- Improved fault clearance due to slower response of power system

ENERGY ESTIMATES

$$\delta t = (1 \quad 5 \quad 15)\ \mathrm{min}$$

$$P_{nom} = \begin{pmatrix} 5 \\ 50 \\ 100 \end{pmatrix} \mathrm{kW} \qquad E = \begin{pmatrix} 0.1 & 0.4 & 1.3 \\ 0.8 & 4.2 & 12.5 \\ 1.7 & 8.3 & 25 \end{pmatrix} \mathrm{kWh}$$

CASE 1: Primary balancing

Wind turbine and one central generator

1. Wind catches up
2. Power balance disturbed
3. Generator speeds up (frequency increases)
4. Operator takes measures (load increase or power decrease)

Scenario 1: No VSG

5. System goes into critical condition
6. Generator trips

Scenario 2: VSG added to the wind turbine

5. VSG buffers the excess wind power for a short time period
6. Balance restored

CASE 2: Safety & Security of supply

Solar array with inverter

1. Normal operation
2. Nearby short circuit fault
3. Voltage drops

Scenario 1: No VSG

4. Inverter trips
5. Safety device kicks in, and fault is cleared

Scenario 2: VSG added to the inverter

4. VSG empties its buffer to slow down the voltage drop
5. Safety device kicks in, and fault is cleared

CASE 3: Reconnection of microgrid

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Micro grid with decentralised generators

1. Normal operation
2. Main grid voltage drops for a short time interval (minutes)

<u>Scenario 1: No VSG</u>

1. Decentralised generators trip
2. Main grid voltage restored

<u>Scenario 2: VSG’s added to the generators</u>

1. Main grid connection broken (islanding mode)
2. VSG’s balance the micro grid (active & reactive power)
3. Main grid voltage restored
4. VSG’s synchronise to main grid (UCTE sync/ grid voltage)
5. Micro grid reconnection

MANY QUESTIONS TO BE ADDRESSED

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1. To what extent will VSG's improve the stability of future grids?
2. What are the limitations of VSG's?
3. What are good laboratory test cases for a VSG?
4. How to measure the effect of one VSG in a field test?
5. To what extent doe the use of VSG's increase the amount of DG allowed in the grid?
6. Is a VSG a cost effective solution?
7. (….)

A FEW PROJECT SUCCESS FACTORS

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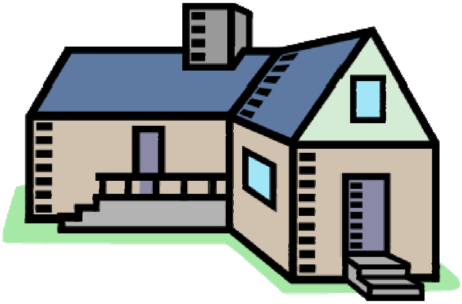
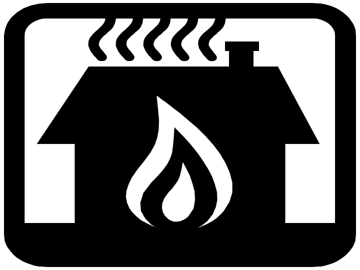
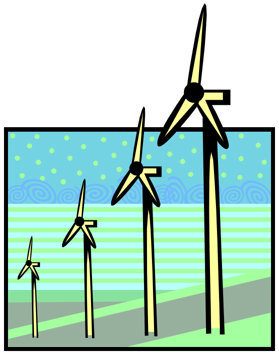
1. Use your time only for key technologies
   - Choice of short term energy stores
   - VSG model calculations and simulations
   - Laboratory test cases
   - Field test cases
2. Money saves time, but time does not save money
   - Buy readily available equipment (turn-key)
     (E.g. TriPhase test environment- KUL)
3. Do not use your time to invent a square wheel
   - Learn from other successful parties







Thank you for your attention