Control Strategies for Hybrid AC/DC Grids

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Outline

1. Motivation and thesis objectives
2. Methodology
3. Preliminary results
4. Working plan

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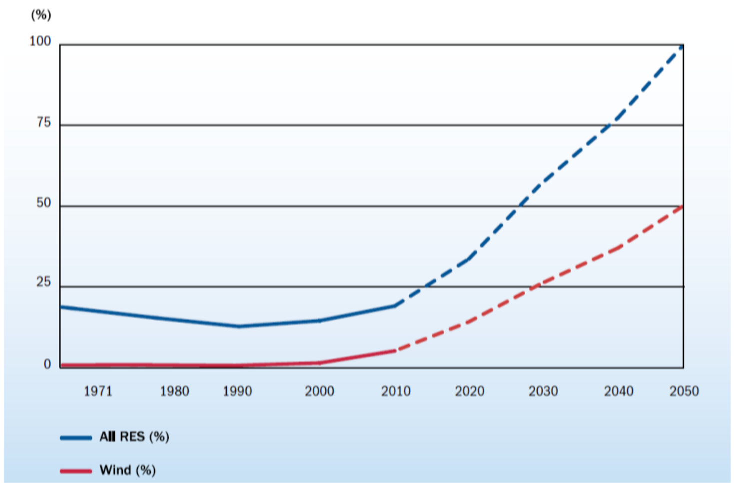
Motivations



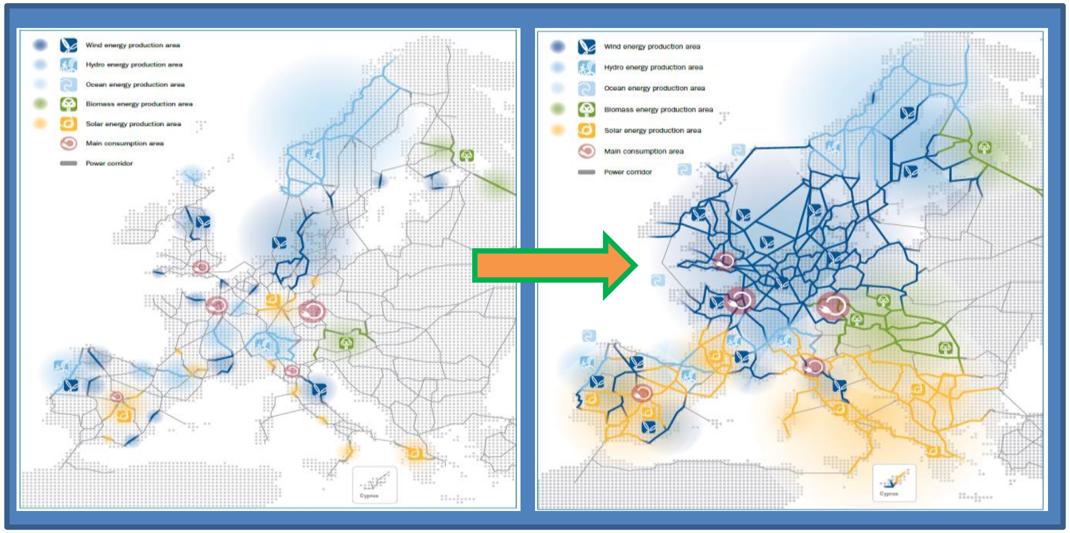


Fig. 1 Contribution of Renewable energy to electricity consumption and expected contribution up till 2050
Source: EWEA EU Energy Policy to 2050

Fig. 2 New Interconnections expected to be HVdc and for technical reasons Meshed HVdc will be the end goal

Challenge

- System is dynamics is changing and will continue to change for the worse.
- There is need to identify new phenomena and put control in place to mitigate undesirable responses.

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Focus of the work

- Voltage source converter (VSC) dominated hybrid ac/dc grids.
- System-level approach:
  - High voltage level,
  - Meshed grids.
- Identify and understand new phenomena as regards to converter penetration for different case studies.
  - **Dynamic studies.**
- Control strategies for mitigation of undesirable responses, which includes:
  - Improvement of dynamic responses,
  - Control under harsh conditions, such as weak grids,
  - Coordinated control.
- Advanced control for ancilliary services

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Methodology

1 Impedance modelling paradigm:

- Each subsystem is modelled with its impedance equivalent,
- all input devices are modelled with their equivalent impedance+control,
- that is, converters, controlled devices, synchronous generators, etc.

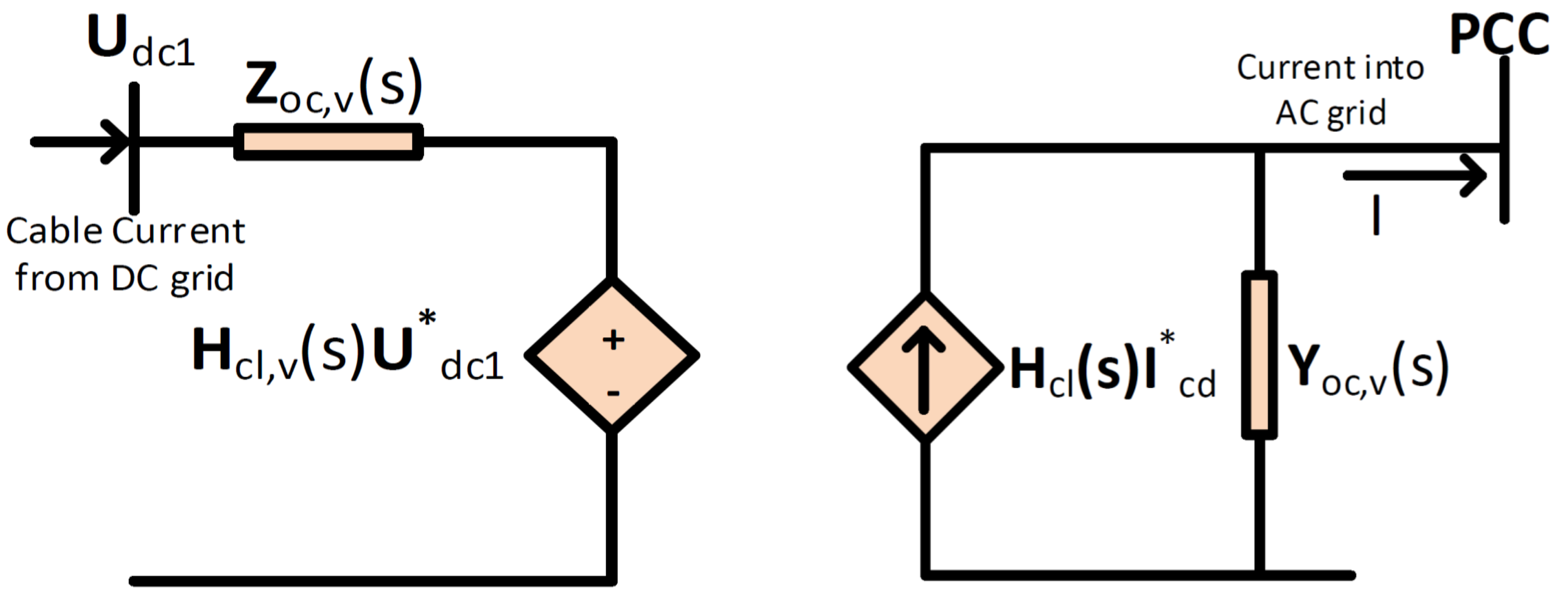

Fig. 3 Subsystem Approach to impedance modelling of hybrid grids

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Methodology

2 System level aggregation:

- Thevenin equivalents,
- Norton equivalents.
- Multivariable Systems theory.

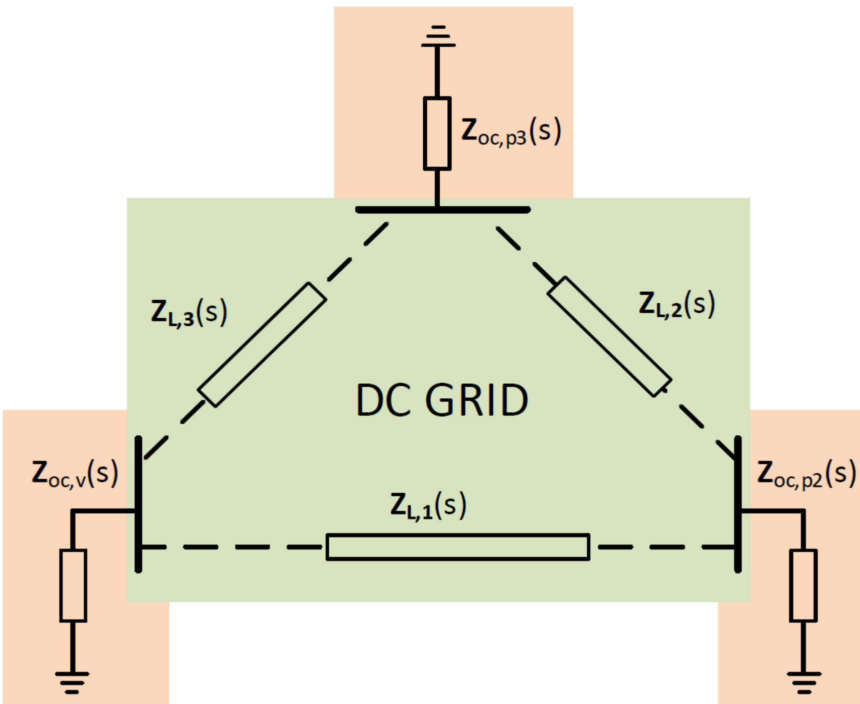

Fig. 4 System aggregation

$$\begin{bmatrix} Z_{11}^{dc} & Z_{12}^{dc} & \cdots & Z_{1n}^{dc} \\ Z_{21}^{dc} & Z_{22}^{dc} & \cdots & Z_{2n}^{dc} \\ \vdots & \vdots & \ddots & \vdots \\ Z_{n1}^{dc} & Z_{n2}^{dc} & \cdots & Z_{nn}^{dc} \end{bmatrix}$$

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Methodology

3 Analysis (Frequency, time domains):

- Nyquist,
- Root locus,
- Bode for SISO, SVD for MIMO, amongst others,
- **Multivariable system analysis.**

4 Controller design:

- H_{∞}, H_2 robust controllers for resonance mitigation and improving dynamic responses,
- Diagonal controller for decoupling,
- SVD analysis.

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Next Steps

- Robust control formulation,
- H_{∞}, H_2 robust controllers for resonance mitigation and improving dynamic responses.
- Multivariable system approach, output channel damping,
- Controller strategies and design,
- Active damping design,
- **Detailed modelling (EMT)**

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Future Case Studies

Influence of Power Direction on Grid Stability of (Hybrid AC/DC Grids) Considering Fixed Control Architectures

Impact of SCR on Hybrid AC/DC Grid Stability: An Impedance Approach

Interactions between Synchronous Generation and Embedded MTdc Grids

Understanding the Influence of Operating point on the Stability and Resonances in VSC-HVdc Systems

Influence of different DC Capacitance Values on resonances in AC systems Connected via MTdc Grid

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Thank you!

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