



Control of Hybrid AC/DC Grids

Adedotun J. Agbemuko

INCITE Fellow

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Marie Skłodowska-Curie grant agreement No 675318



Personal Introduction

- Adedotun Jeremiah Agbemuko (Ade).
- Nigerian.
- B. Eng. Electrical Engineering (FUT, Minna), 2012.
- MSc. Electrical Power Systems (Delft), 2016.
- PhD (UPC, 2016-?).



Project Information

Title: Control of Hybrid (High Voltage**) AC/DC Grids**

Main Location:

IREC, Barcelona, Spain

Supervisors:

José Luis Domínguez-García (IREC)

Oriol Gomis-Bellmunt (UPC)



Journey so Far...

Review Paper on State-of-Art

- Framework for modelling (including modelling philosophy, software, benchmark, tools).
- Software acclimatization.
- Multivariable Control Review.

Literature review:

- AC-DC Grid Interaction.
- Stability
- Oscillation (and damping)
- Harmonic interaction
- Ancillary services
- Controller interaction
- ...among others.

- Administration
- Documentation
- Enrolment at UPC

Extra-curricular Courses

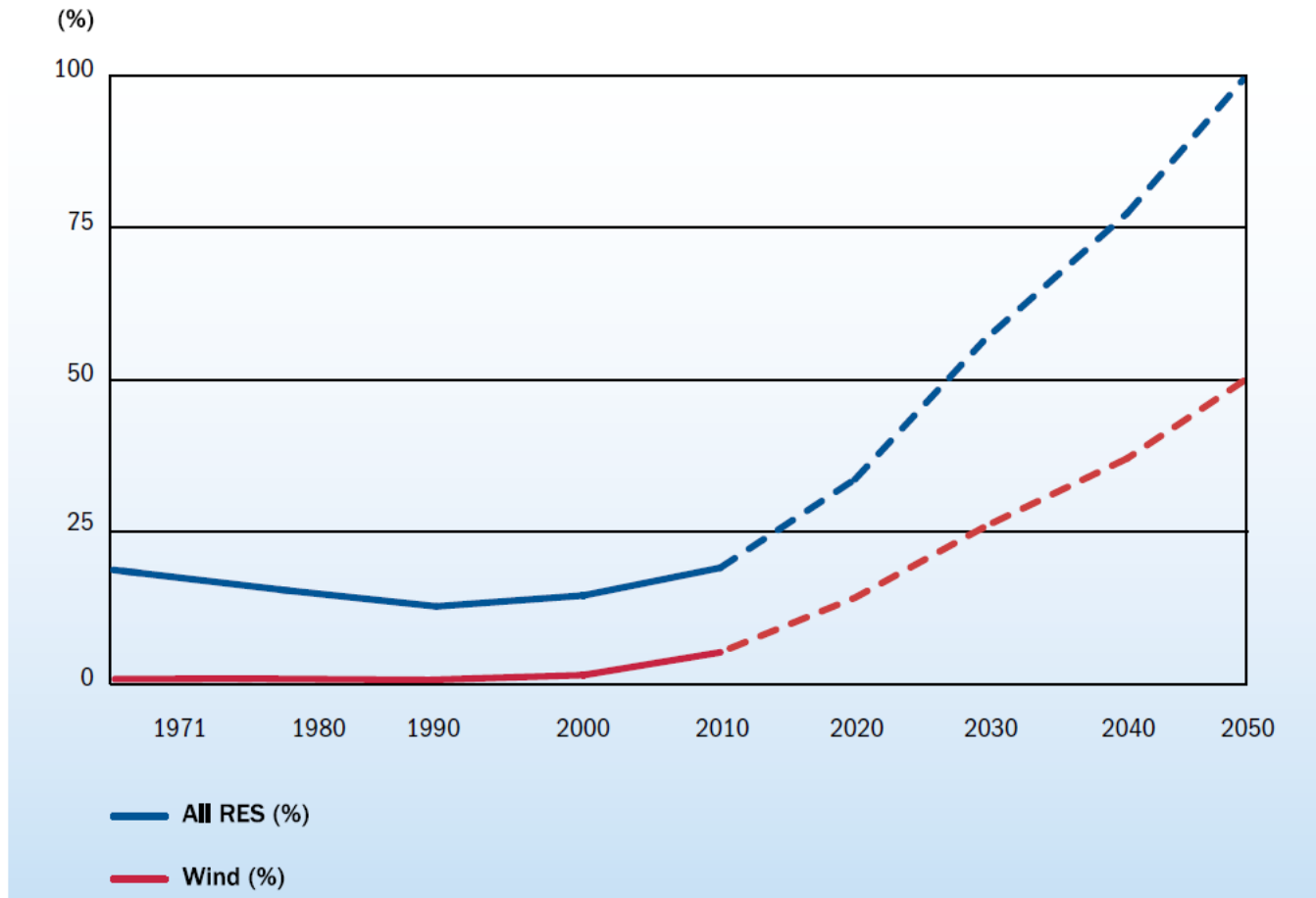
- Course on Research Ethics.
- Spanish language for beginners

December

October-November

September

Motivation for Project (1)

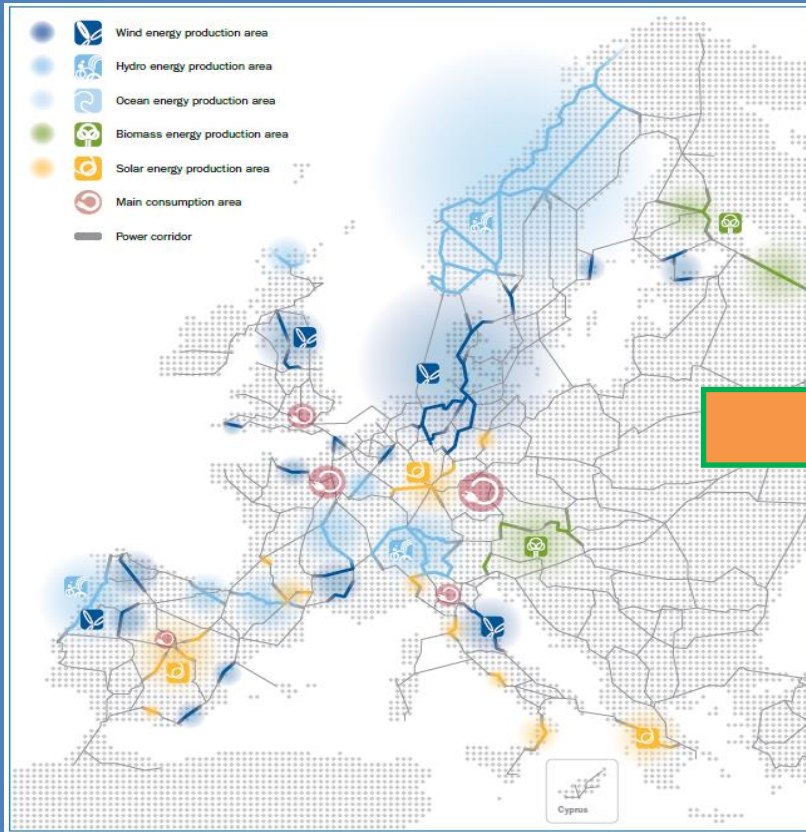


Contribution of Renewable energy to electricity consumption and expected contribution up till 2050

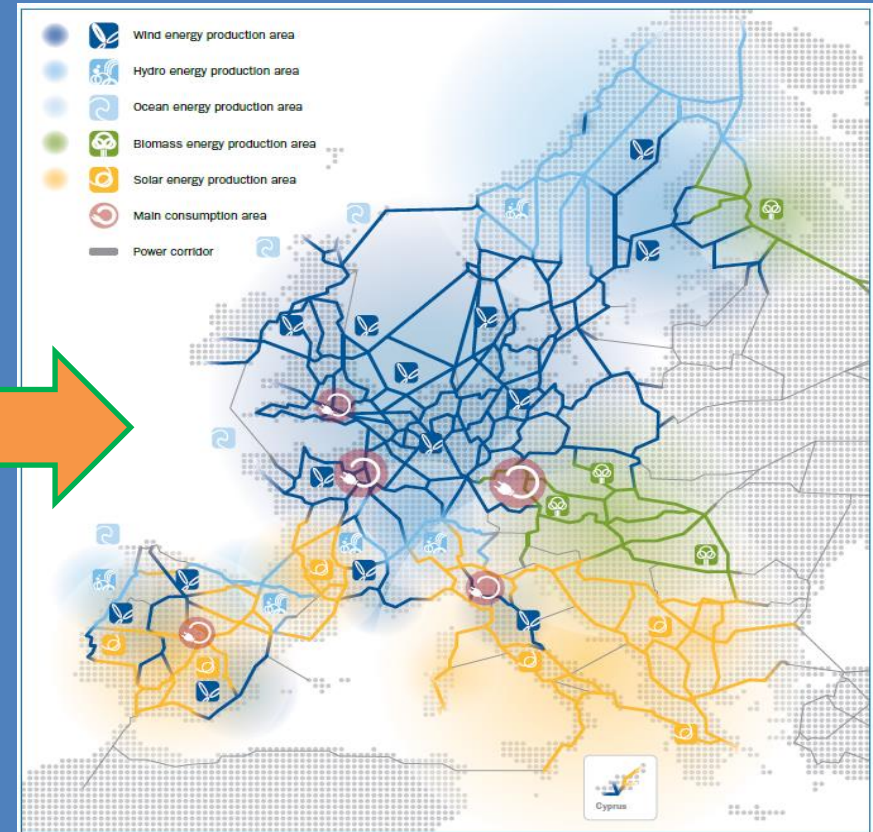
Source: EWEA EU Energy Policy to 2050



Motivation for Project (2)



2010



2050

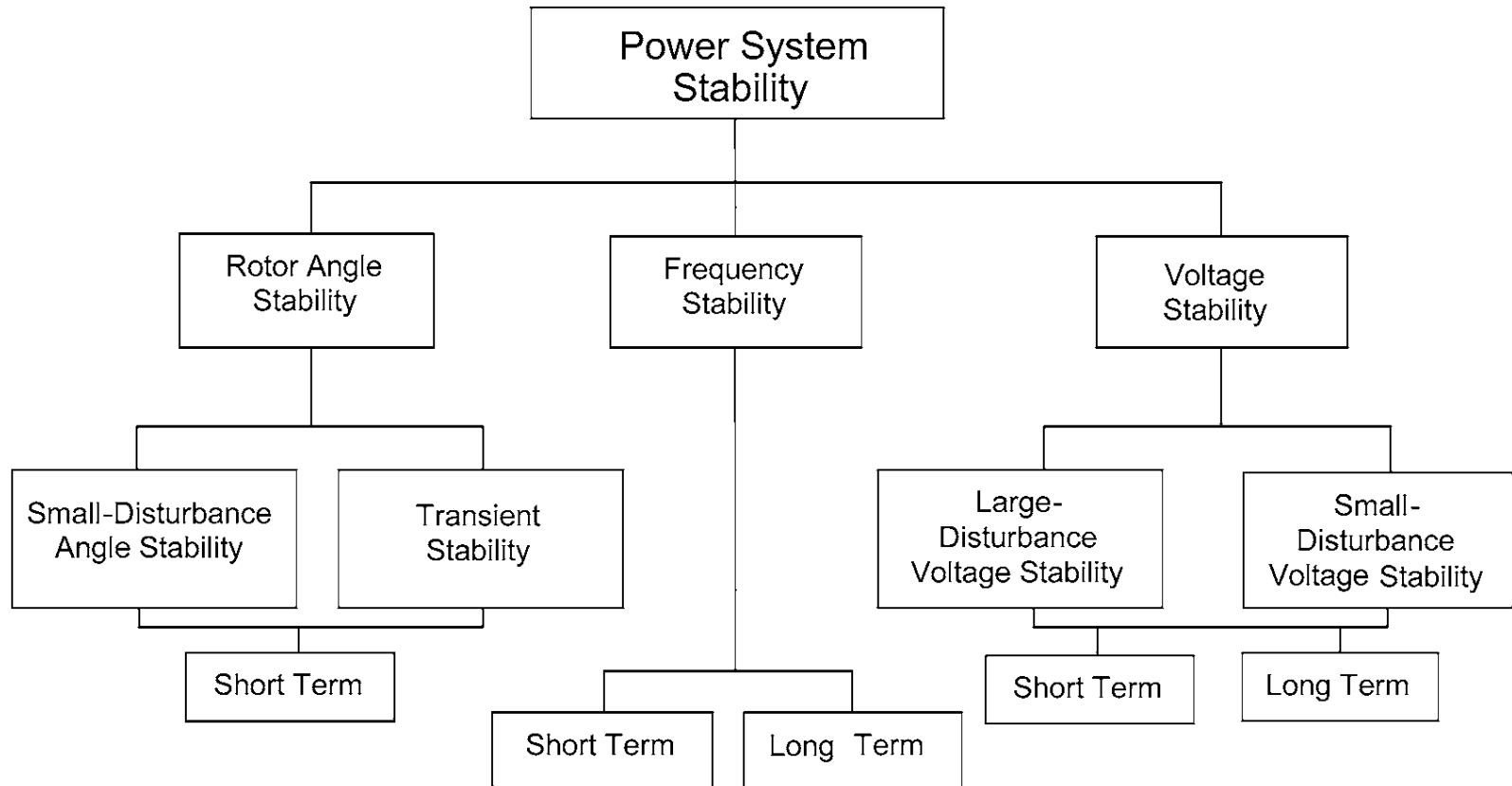
EU Policies to reduce greenhouse gas emissions.

Source: EWEA EU Energy Policy to 2050

Motivation for Project (3)

HVAC	HVDC
Can only connect unique resources – synchronous generators	Can connect characteristically distinct resources – renewables and fossil fuels
Unacceptable environmental footprint	Very little environmental footprint
Limited power transfer	More power can be transmitted for an equivalent AC system.
Cost grows higher beyond distances of 600km	Cost is much less beyond the same distance
Higher insulation requirements	Lower insulation requirements compared
Production and consumption of reactive power	Unity power factor
Overloading is avoided at all cost for stability reasons	Can be overloaded up to 1.2x rated power continuously

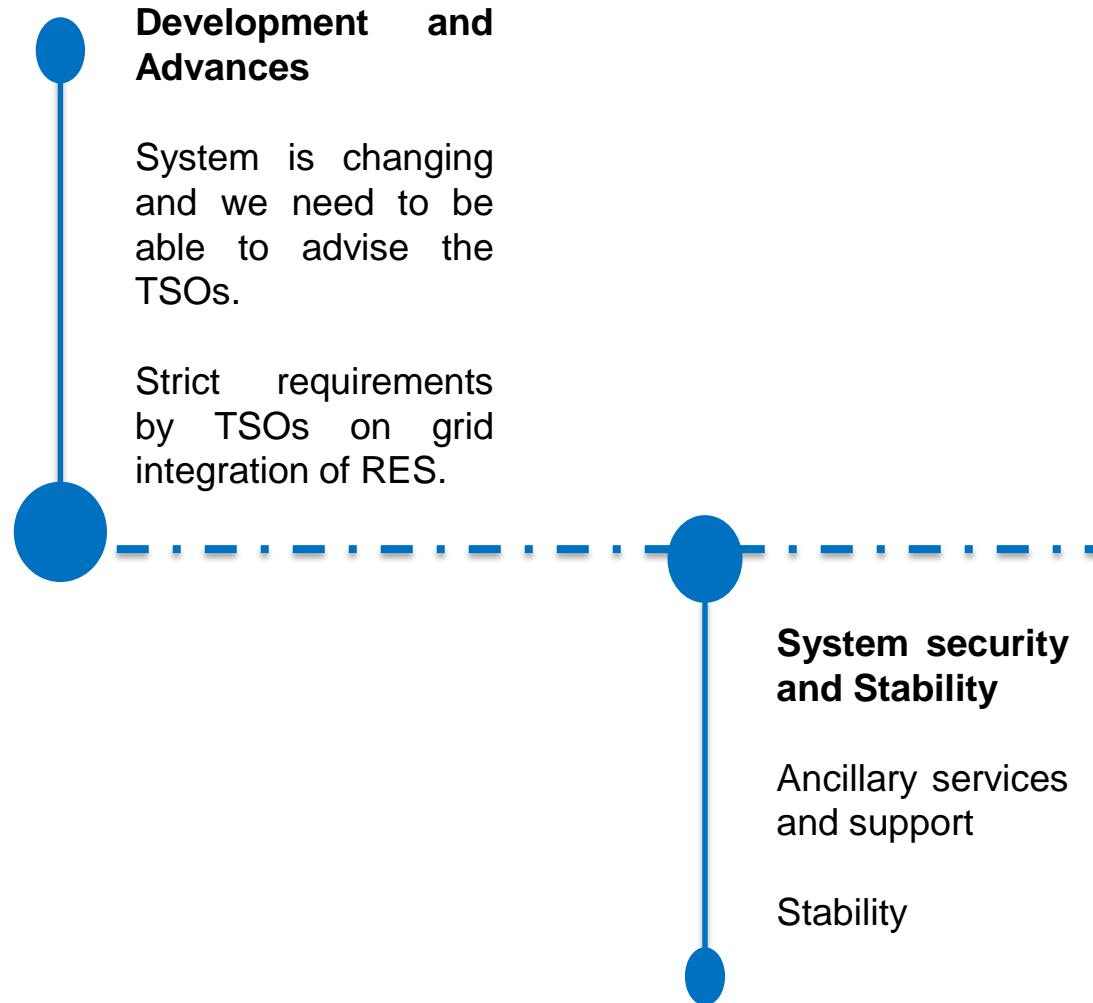
Motivation for Project (4)



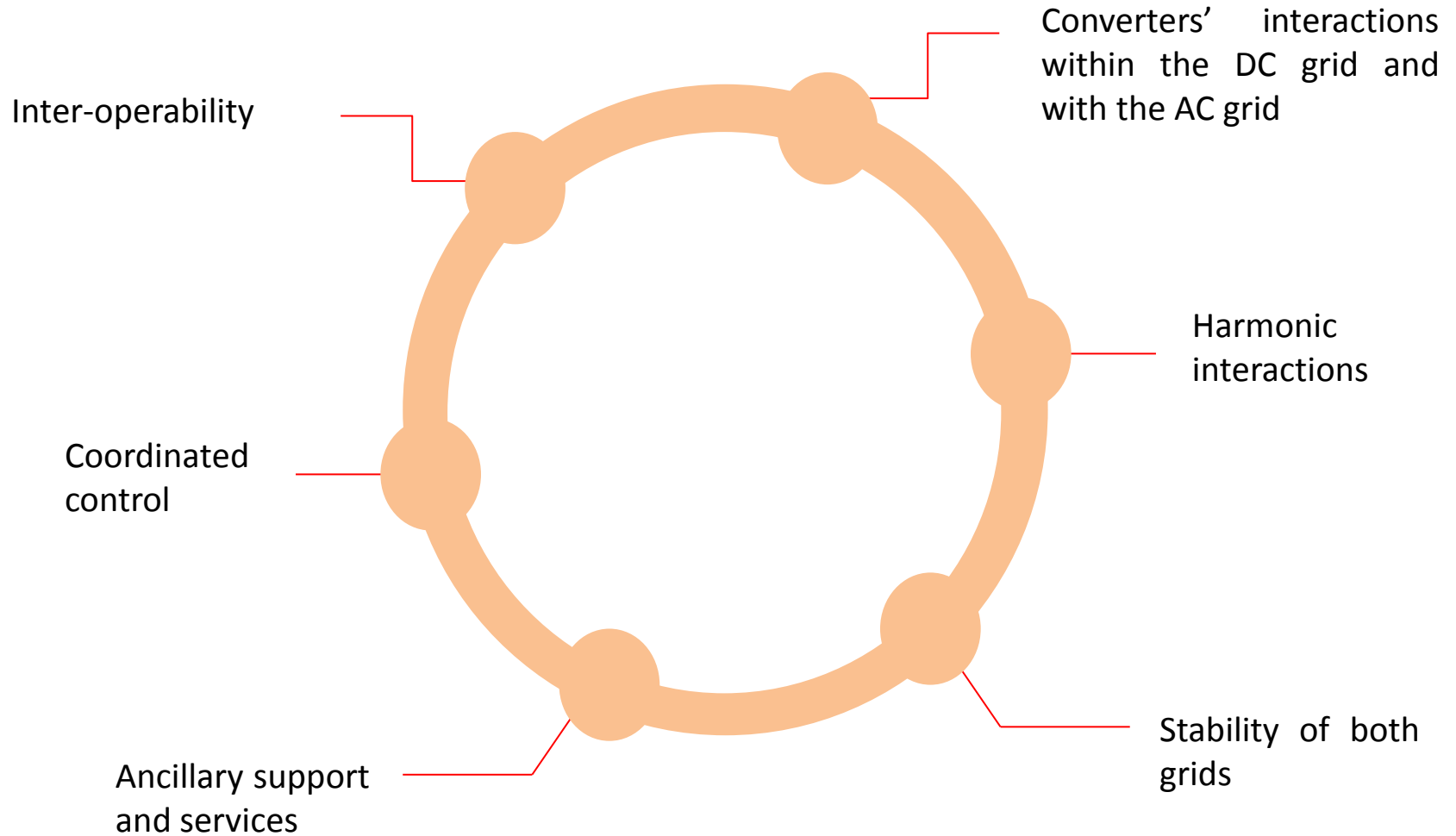
Conventional Power System Stability Classification

Source: Definition and Classification of Power System Stability

Motivation for Project (5)



Technical Issues



Trends

- Phenomena mostly studied from perspective of conventional power system.
- Oscillation damping (part of ancillary services).
- Multi-variable control is gaining ground.
- Communication requirements.
- Determining new CCT of circuit breakers to ensure stability with increasing power electronic converters.

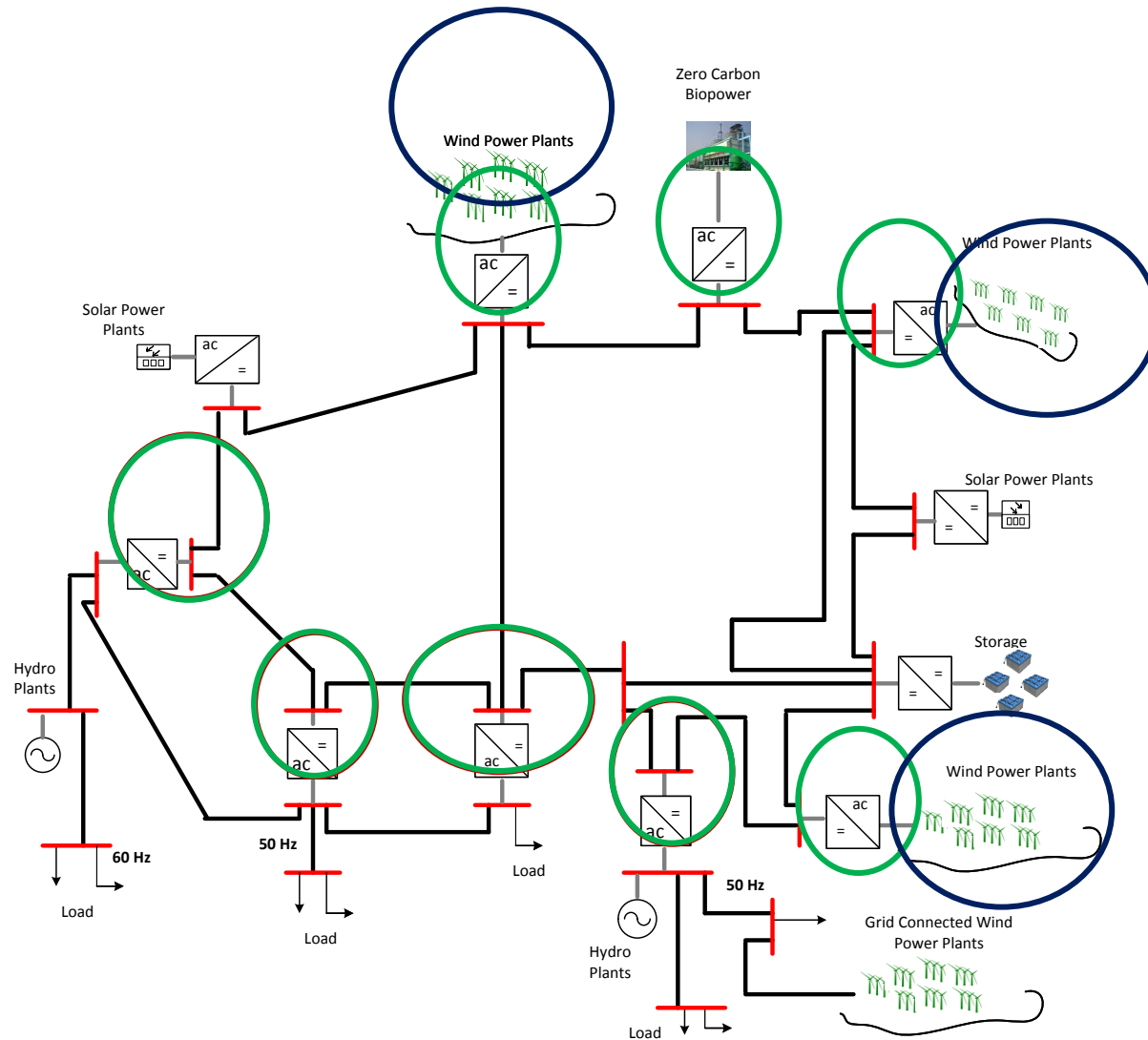


State-of-Art on AC-DC Interaction

- Brilliant contributions towards identification of AC-DC grid dynamic interactions – but only a few.
- Oscillation damping.
- Controller design and synthesis.
- Influence of system variables on dynamic characteristics and stability of AC-DC grids.
- Study of mainly AC system phenomena.



State-of-Art on Ancillary Support



Gaps in Literature (1)

- Most focus is on “relatively” short distance.
- Almost exclusively cables (No OHL).
- WPP not modelled in great detail.
- Either AC or DC side modelled in detail.
- Size of one grid overshadows the size of the other – cannot be generalized.
- Scenarios are either on the AC side or on the DC side; rarely both.

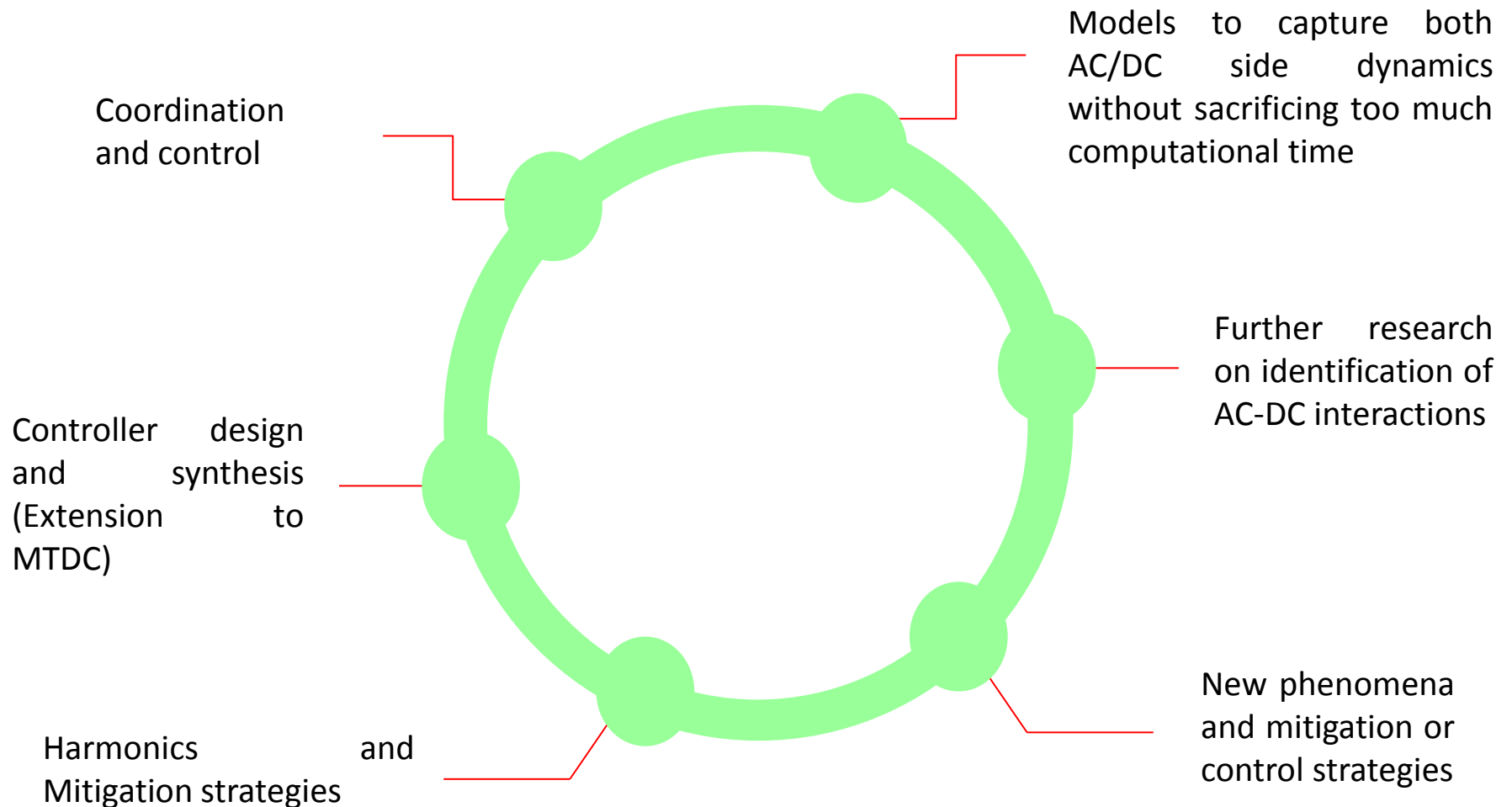


Gaps in Literature (2)

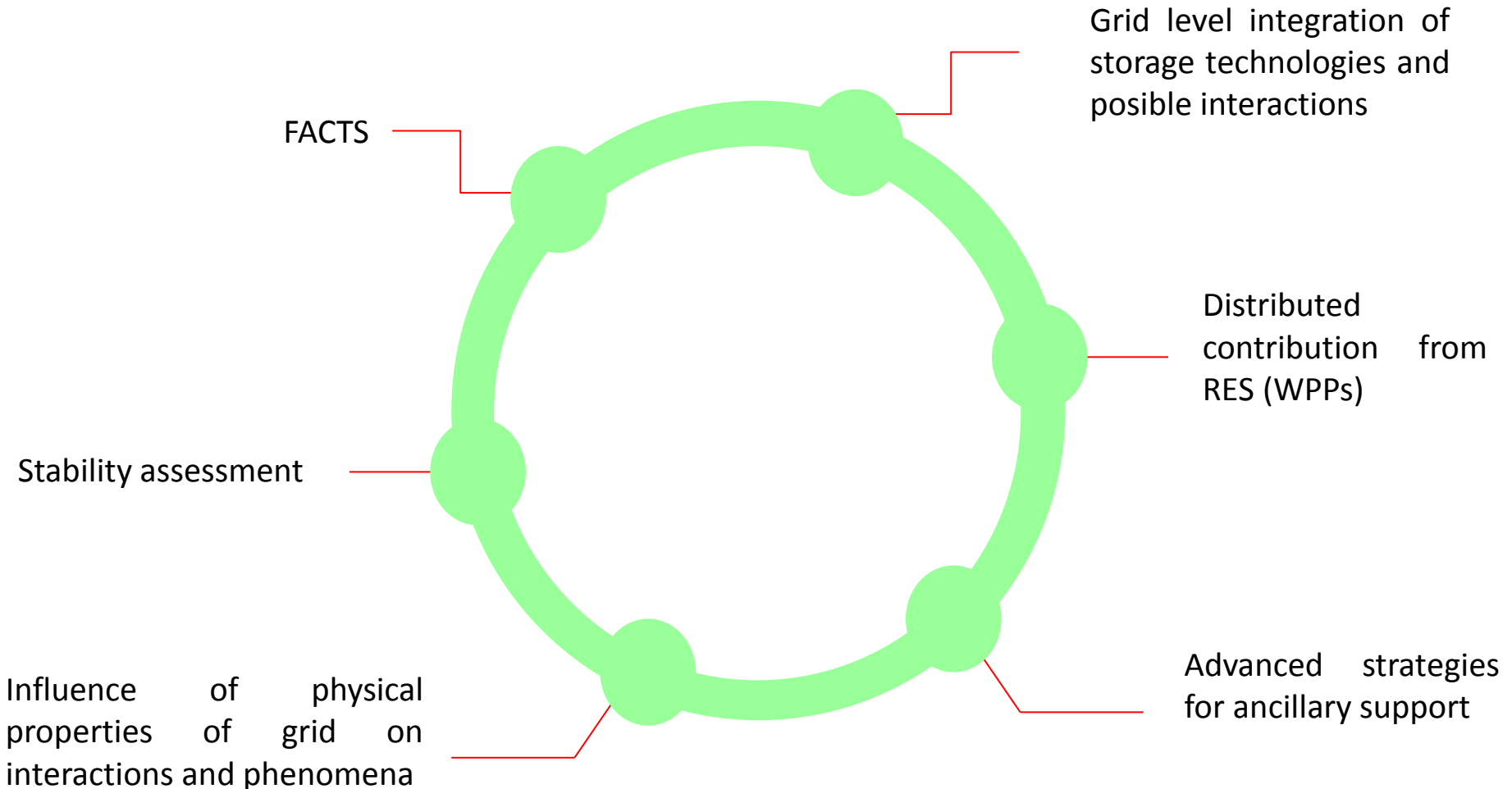
- Dynamic system evolution based on progressive integration of renewables has not given attention.
- Proposals are too specific.
- Almost no studies on harmonic interactions.
- More attention on ancillary support from the DC grid.



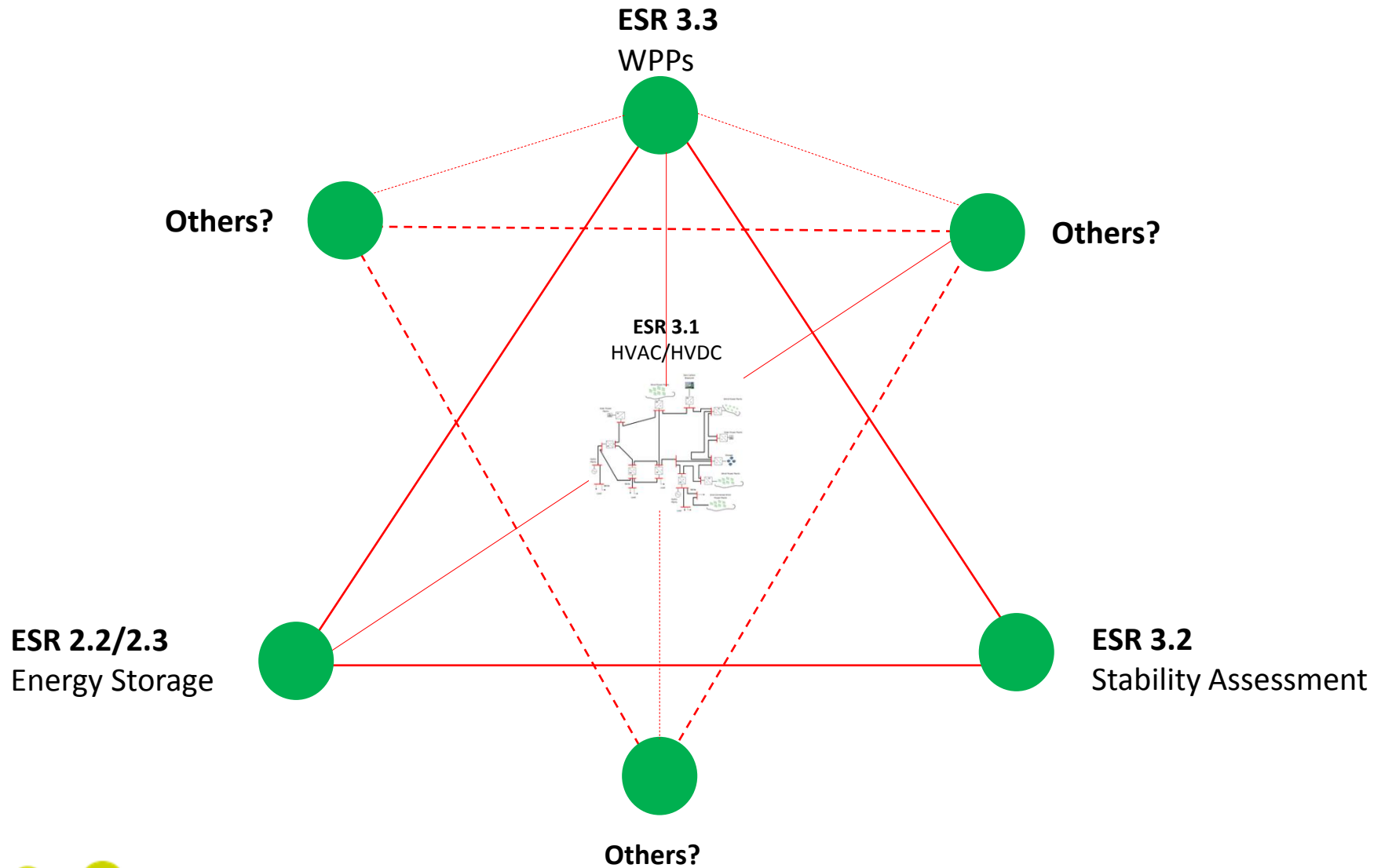
Direction of this Work (1)



Direction of this Work (2)



Collaborations (Second Year)



Next Steps...(Tentative)

December

Framework for modelling
Software acclimatization
Multivariable Control Review
Modelling
Extracurricular Courses

Review report/Paper

May(June)-September

Studies (Harmonics, Stability, control)

Conference/Journal Paper

January-April (May)

Modelling (detailed and averaged)
Developing tools
Model Validation
Extracurricular Courses

Conference/Journal Paper

THANK YOU!

