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6th InnoDC Meeting Barcelona

Anubhav Jain – ESR 15

PhD: Blackstart & Islanding capabilities of Offshore Wind Power Plants

 $P = \frac{1}{2}\rho A v^3 C_p$

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Problem Definition

I iterature review:

- \blacktriangleright Motivation TSO | WFO
- Target States challenges & solutions

Motivation

High volume integration of RES far from loads Increased trans-national power exchanges Decreased Var reserve due to SG replacement Power electronics EMT, Inertial decoupling Uncontrolled Islanding, Protection settings re-design Complicated grid operation: stability, reliability

Grid forming / Blackstart-able WTs

Increased risk of wide-area blackouts eg: South Australia 2017, UK 2019

> Voltage source rather than traditional current source

TSO

easurement TS-1 Auxiliaries TS-2

Large OWPPs with modern WTs can address Blackstart requirements targeted conventionally to large thermal plants (ENTSO-E codes)

Steady winds far-from-shore, thus lesser availability-uncertainty Fast, fully-controlled, high-power, green blackstart capability of VSC-HVDC OWPP Advanced V,f control functionalities from state-of-art PE interface of modern WTs

No waiting for end of network reconstruction; controlled islanding to ensure continuity of power supply Reduce the overall impact of a blackout event: reduced restoration time & unserved load Replace backup offshore diesel generator for auxiliary power & energization Cost benefits, reduced shipping downtime, increased reliability & CO2 displacement

Onshore

TS-5

Islanded Operation

Parallel Operation

Self-Sustain

Self-Start

5 Controlled

4 Offshore Grid Forming

HVDC

PCC1

Substation



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<u>Control solutions for Blackstart capability</u> Islanding operation of Offshore wind power plants Wind Integration Workshop Proc. 17th (Stock.holm)

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Functional Specification

I iterature review:

- ➢ Gap between BSU technical requirements & state-of-art WT capabilities.
- grid ➢ Future code recommendations.

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Preliminary Results (TS-5)

Energization simulation:



<u>Black Start by HV dc-connected Offshore Wind Power Plants</u> Proc. IECON – 45th Annual Conf. of IEEE Industrial Electronics Society 2019 (Lisbon)





Grid Forming OWPP

Focus – WT GFM control:

- ➢ Identifying the major different strategies.
- Compare transient behaviour during energization.

Grid-forming control strategies for black start by offshore wind power plants in Wind Energy Science 2020 (EAWE) Spcl. Iss. WESC 2019





Hard v Soft Energization

Focus – offshore & HVDC transients:

Offshore Network: hard-switching vs soft-start.

- Onshore MMC: controlled pre-charging.
- Sensitivity analyses: PIR/PIT (hard) | Ramp-rate (soft)



<u>Blackstart</u> from HVDCconnected Offshore Wind: Hard vs Soft Energization in Renewable Power Generation 2020 (IET)





Ongoing & Next steps

➢ Model detail

- WPP Sequential start up
- WTTr inrush, saturation
- WT GSC Switching model, Finite DC link.
- > Transients:
 - o Synchronization
 - Trafo Sympathetic Interaction
 - o SOV, TOV
 - DC link dynamics

> Studies:

- Stability & Robustness
- Capability Assessment

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o CO2 displacement

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