Integration Renewables and Process Industry - APSCOM2018

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Abstract– The future electricity grids, with high penetration of renewable energy sources are facing challenges to maintain the grid stability. The process industry is under pressure to reduce the carbon footprint. This article describes a solution for both problems.

Keywords – Rotational Inertia, Power System Stability, Grid Integration of Renewables, Steam turbine drive compressors, VDF-drives, HVDC,

I. Introduction

Large-scale deployment of Renewable Energy Sources (RES) has led to significant generation shares of variable RES in power systems worldwide. RES units, notably inverter-connected wind turbines and solar photovoltaics (PV) that as such do not provide rotational inertia, are effectively displacing conventional generators and their rotating machinery. The traditional assumption that grid inertia is sufficiently high with only small variations over time is thus not valid for power systems with high RES shares. This has implications for frequency disturbances, dynamics and power system stability and operation. Frequency dynamics are faster in power systems with low rotational inertia, such as Wind turbines and Solar (PV), making frequency control and power system operation more challenging [1]

II. Problem Statement

Problem-1 is maintaining the grid frequency within an acceptable range is a necessary requirement for the stable operation of power systems. Frequency stability, and in turn stable operation, depend on the active power balance, meaning that the total power in-feed minus the total consumption (including systems losses) is kept close to zero. In normal operation small variations of this balance occur spontaneously. Deviations from its nominal value f0 (50 Hz or 60 Hz depending on region) should be kept small, as damaging vibrations in synchronous machines and load shedding occur for larger deviations. This can influence the whole power system, in the worst case ending in fault cascades and black-outs. Low levels of rotational inertia in a power system, caused in particular by inverter-connected RES, i.e. wind turbine and PV units that as such do not provide any inertia, have implications on frequency dynamics. Frequency dynamics are becoming faster in power systems with low rotational inertia. This can lead to situations in which traditional frequency control schemes become, relatively spoken, too slow for preventing large frequency deviations and the impeding consequences of this. The loss of rotational inertia as such and the time-variance of inertia lead to new frequency instability phenomena in power systems. Frequency and power system stability may be at risk.

Problem-2 is aiming at the carbon emission reduction in the process industry, e.g. Oil refineries, (Petro)chemicals or Air separation facilities. Electrification is one of the possible transition pathways for the process industry to contribute to an environmentally sustainable economy. As the process industry accounts for approximately one third of total energy use in the many countries, the use of (sustainable) electricity in the industry can have a significant impact on CO2-reduction in the process industry [2]. The process industry is using large sets of steam turbine driven – compressors, typically between 5 – 60 MW. The steam to drive these steam turbines is generated in large very high pressure steam boilers. These steam boilers are fueled by burning hydrocarbons in gas or liquid form and are producing significant amounts of CO2. See figure 1.

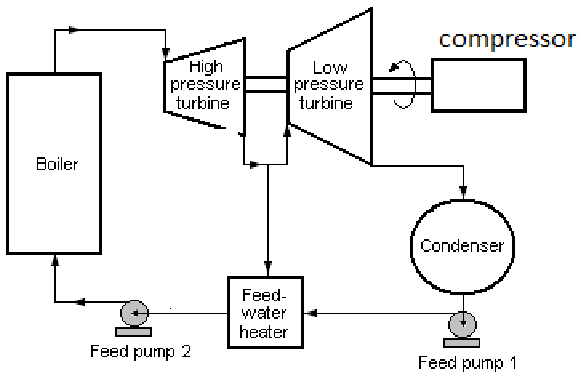

Fig. 1: Steam turbine driven compressors

In problem-3, see figure-2, HVDC transmission couplings are able to support the grid frequencies, however this relies on interacting control loops as published in [3, 4]. It is stated that transmission system operator (TSO) has the right to require that the HVDC connection should provide inertia emulation capability in response to frequency changes. Thus the HVDC converters should be capable if required to control rapidly the active power flow to limit the Rate of Change of grid frequency. So far no specific requirements are defined regarding the inertia emulation control concept and its performance parameters. For HVDC systems interconnecting two active AC grids, the inertia emulation is realized by detecting the frequency deviation in the HVDC converter controlling the active power flow. The HVDC converter is able in this case to adjust rapidly the active power and thus emulate the inertial response. In case of integrating offshore windfarms via HVDC system, a direct active power control at the offshore HVDC SEC will cause undesired controllers' interactions with the offshore windfarms power controllers and likely leads to instabilities in operation. Therefore, a coordination control strategy with the offshore windfarms must be implemented to provide the desired inertia support for the onshore grid.

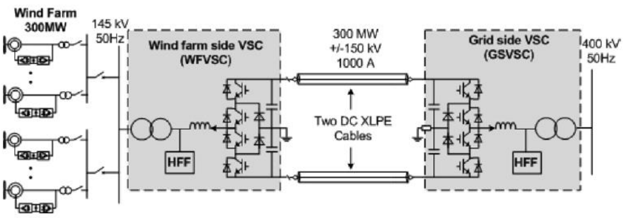

Fig. 2: High-Voltage-Direct-Current (HVDC)

III. INNOVATION

Figure-3 visualizes the setup of the proposed innovation, in which the amount of excess RES renewable electricity will preferably be used in the process industry. Rule of thumb; an "industrialized country with 10 million inhabitants" has a "process industry with steam turbines" of approximately 2000-3000 MW "installed steam turbine – power", which is enables "power balance-capacity" against "RES renewable installed power".

In this proposal the gas compressors are driven by two different drives on one shaft; one Electrical-drive and one steam turbine. Advantage is that the required compressor power can be shifted between electrical (from renewables) and steam (from burning hydrocarbons)

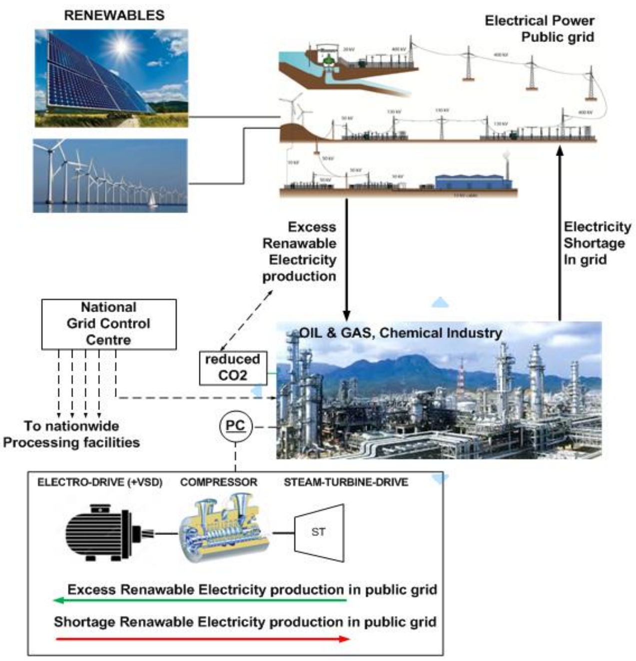

Fig. 3: Integration Renewables and Process Industry

If there is a shortage on RES electricity, due to "no wind" and "no sun" conditions the compressor load can be shifted towards the steam turbine. If there is an excess of RES electricity in the grid, the compressor load can shifted to the electrical drive, reducing the steam demand and therefor reducing the CO2 emission in the process industry.

Figure 4 visualize the details of this concept; The compressor load is determined by the local control system in the process industry; "Pressure Control (PC)". The "load shift" between electrical drive and steam turbine drive is set by "National Grid Control Centre", depending on the grid frequency.

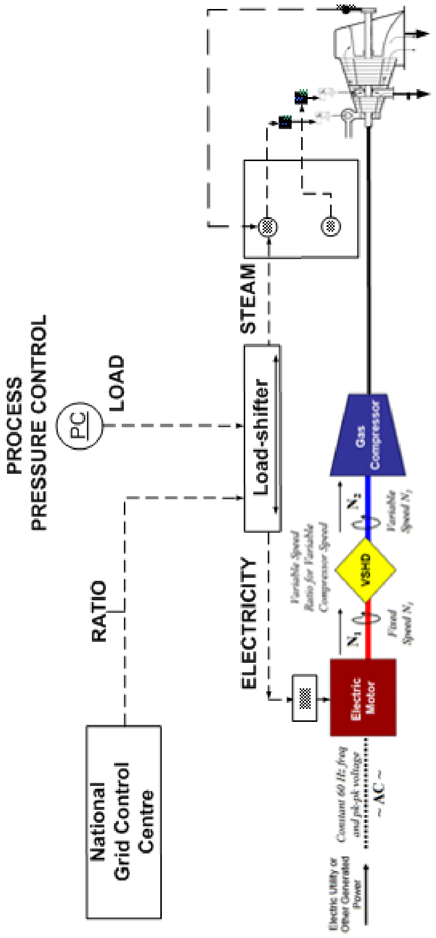

Fig. 4: Technical implementation Dual Drive system

The National Grid Control Centre is setting the "load shift" - setpoint in parallel to all processing facilities in the electrical grid area, nationwide.

Advantages are;

1. The rotational inertia will be maintained due to the inclusion of the Dual Drive system in a grid with high RES penetration.
2. The electrical grid with high RES penetration has extra balancing power, which can be made available within minutes time frame.
3. The process industry has extra means of reducing the carbon footprint.

References

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