On the Prospects and Limits of Sector Coupling

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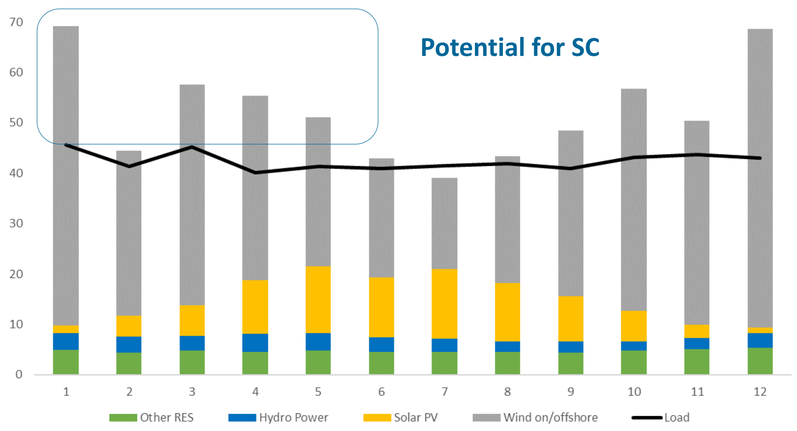
1. MOTIVATION

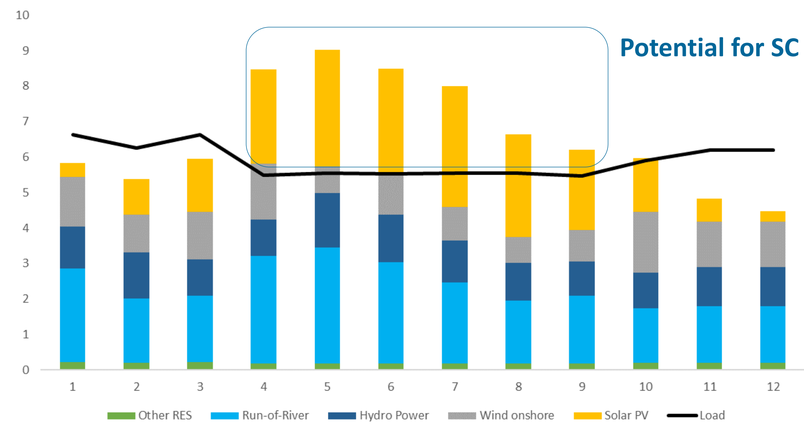
With the increasing shares of variable renewable energy (VRE), such as wind & solar PV, surplus electricity emerges to a growing extent throughout the year. The intermittence of these power sources will demand flexibility and seasonal storage in various forms other than electricity for efficient load balancing.

Generation from variable renewable energy (VRE) and load in a 100% RES scenario

GERMANY: high on/off shore wind potential



AUSTRIA: high hydro power and solar PV potential



Exemplary data derived from Umweltbundesamt, energy-charts.de, e-control.at

SECTOR COUPLING (SC) REVEALS SYSTEMATIC BENEFITS COMPARED TO A PURELY ELECTRIC STORAGE SOLUTION: it uses power surplus via Power-to-X (P2X) technologies through direct electrification or as gas, heat or liquid in industry, transport and residential (heat & power) sectors.

P2Gas (P2G)	P2Heat (P2H)	P2Liquid (P2L)	P2Fuel (P2F)	P2Transport (P2T)	P2Industry (P2I)

2. WHAT IS SECTOR COUPLING?

The term “Sector Coupling” emerged in the course of the German Energiewende and specifically aims at the efficient use of surplus power from VRE.

DEFINIION

Energy engineering & economy of connecting electricity, heat, mobility and industrial processes and infrastructures. Aiming at decarbonisation, while increasing flexibility of energy use in industry, households & transport achieving profitability, sustainability & supply security [1].

Energy source linked to a type of service (e.g. heat) - new links created between energy carriers → **indirect electrification of processes** [2].

The basic principle of SC, however, has already been discussed earlier. Rough timeline of INITIAL IDEAS/PAPERS & PROJECTS for P2X systems:

1903	1972	2005	2010	2010	**2013**	2013	2014
Era of excess heat use (CHP)	NASA heating from wind power	H2 from wind power	H2 from wind power Norway	Liquid fuel from Solar PV	**P2X „Sector Coupling“**	**P2G** ETOGAS Audi - wind power	**P2H** district heating Harbin China

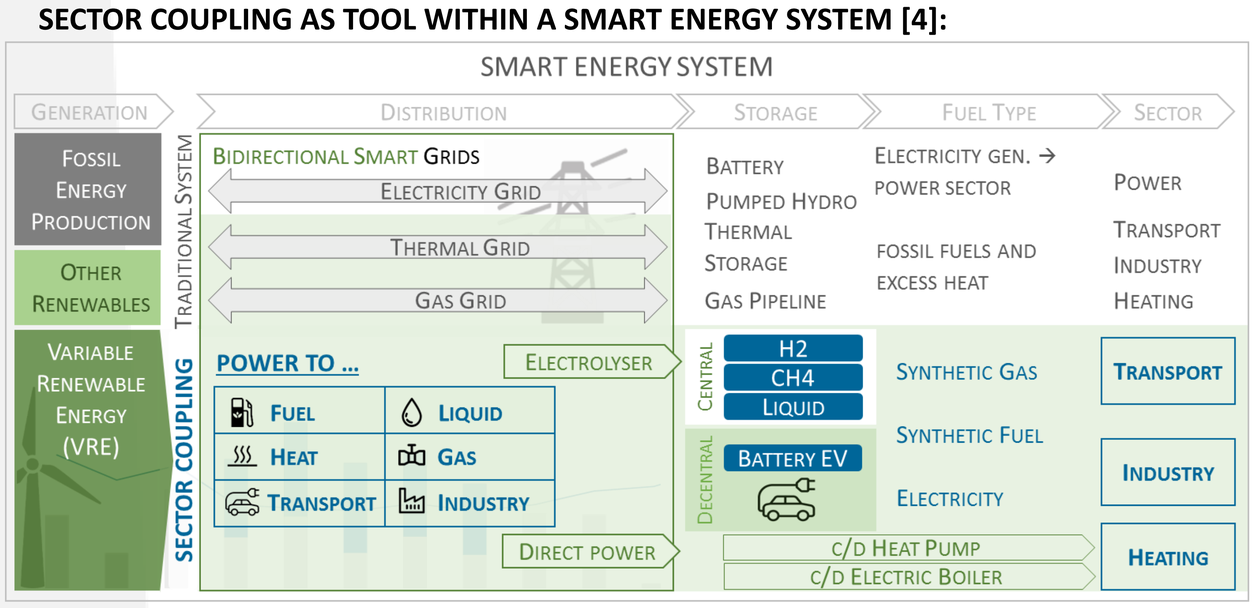
EXAMPLE

DENMARK: PIONEER IN INTEGRATING LARGE SHARES OF WIND POWER

A Power to Heat (P2H) strategy in which surplus VRE power is utilized for heating, may increase wind power use in Helsinki to 64% of yearly electricity demand and cover 30% of yearly heat demand [3].

3. PATHWAYS AND CATEGORIES OF SECTOR COUPLING

SECTOR COUPLING AS TOOL WITHIN A SMART ENERGY SYSTEM [4]:



OVERVIEW: PATHWAYS OF SECTOR COUPLING

POWER (VRE)

Central | **Decentral**

Direct electrification
P2X (gas, liquid, heat…)
Re-electrification via e.g. Gas 2 Power

TRANSPORT | **INDUSTRY** | **RESIDENTIAL**

4. CURRENT LIMITS OF SECTOR COUPLING AND RESEARCH NEED

SC REQUIRES HOLISTIC SYSTEM CHANGE OF ALL SECTORS

A Technology enablement within energy system, acceptance within sectors, consideration of all competing technologies.

GREATER LEVELS OF PROSUMAGE - LESS WIDE AREA LOAD BALANCING & OPTIMAL PV SYSTEM SIZES

B Increased system cost, efficiency loss, evidence on rebound effect missing.

P2G STUDIES LACK ANALYSIS ON LCA, BUSINESS MODELS & TIME SERIES

C Research need for local conditions, gas trading, larger spatial & temporal resolution.

IMPLEMENTATION OF P2G/H AS BUFFER FOR VRE FEED-IN

D P2G & P2H not yet used as buffer for VRE → negative electricity prices, payments for wind power curtailment, needs to become more attractive.

References:
[1] Bundesverband der Energie-und Wasserwirtschaft e.V. (BDEW), “10 Thesen zur Sektorkopplung,” Berlin, 2017.
[2] IRENA, IEA, REN21, “Renewable Energy Policies in a Time of Transition,” IRENA, OECD/IEA and REN21, 2018.
[3] P. D. Lund, J. Mikkola and J. Ypyä, “Smart energy system design for large clean power schemes in urban areas,” Journal of Cleaner Production, vol. 103, pp. 437-445, 2015.
[4] B. Mathiesen, H. Lund, D. Connolly, H. Wenzel, P. A. Østergaard, B. Möller, S. Nielsen, I. Ridjan, P. Karnøe, K. Sperling and F. Hvelplund, “Smart Energy Systems for coherent 100% renewable energy and transport solutions,” Applied Energy, vol. 145, pp. 139-154, 2015.

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