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XXXVII Cycle

PhD Poster Day - September 30th, 2022
Multicommodity energy systems

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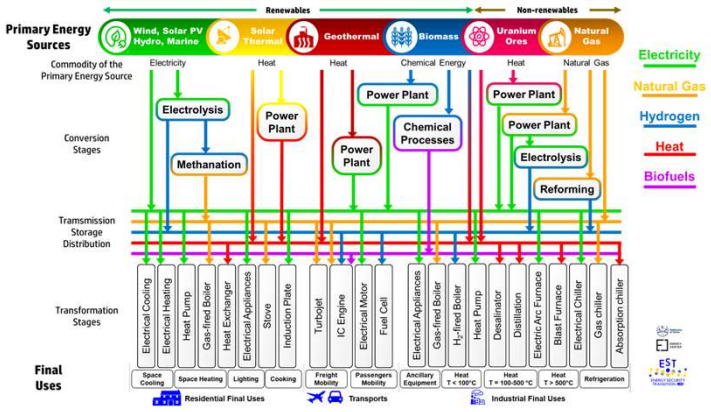
Research context and motivation

- Energy-related activities are intrinsically interacting with the spheres of air, water, and food, which can be regarded as the three essential goods for the survival of mankind. Energy sector is responsible for around 73% of the global GHG emissions, and for the quasi-totality of emissions of other air pollutants (SO_2, NO_x, PM2.5). About 10% of the global water withdrawals, and 3% of the total water consumption is due to the energy sector as well; 88% of water withdrawn by the energy sector is destined to power production, whereas 64% of water consumption is devoted to primary energy production. The energy system has therefore an intrinsic relation with the quality of air and pollution, as well as impacts on the availability of water and food.
- The transition towards a decarbonized energy system is presently an undeferrable need, to be tackled as soon as possible if we want to mitigate the harmful impacts of fossil energy resources on both the ecosystem and on people's health. However, the implementation of the Transition is considerably challenging, given that in 2019 about 80 percent of the global Total Primary Energy Supply (TPES) was covered by fossil sources.
- Electricity will reasonably assume a pivotal role in accomplishing the decarbonization of the energy system, but the complete electrification of final energy uses is considerably challenging, if not unfeasible. Most importantly, the large penetration of RES whose power output is intermittent and non-controllable, introduces the need for the installation of further storage capacity, to be able to always match the users' demand for electricity. In this context, the design and implementation of a multicommodity energy system could be the key for accomplishing the goals of the Transition.

Addressed research questions/problems

- An effective energy transition should accomplish satisfactory levels of energy security, sustainability, and equity, what is better known as energy trilemma.
- The prioritization of the attributes of the trilemma might be unchanged even during the course of the energy transition, even if from a different perspective. In fact, the raw materials needed to install further generation, transmission, and storage capacity required by the energy transition would only shift the problem of security from energy commodities to the materials required to build the technological infrastructure of the various commodity chains.
- On the one hand, the transition towards a renewable-based energy sector is an undeferrable need, because of its important impact on the overall emissions balance. On the other hand, a single final use can be fed by more than one commodity, and their coexistence/competition paves the way to the development of a multi-commodity energy system, enabling the implementation of the so-called "cross-sector integration".

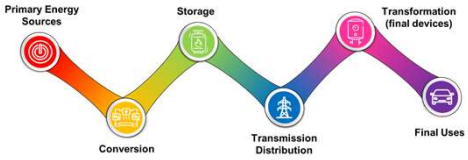


Submitted and published works

- Bompard, E., Botterud, A., Corgnati, S.P., Forte, A., Mazza, A., Papa, C., "*A Conceptual Framework for Comparing Alternative Commodities in the Energy Transition*", Applied Energy Symposium: MIT A+B 2022, Cambridge (USA), 2021
- Bompard, E., Corgnati, S., Forte, A., Fullli, G., Grosso, D., Masera, M., Mazza, A., Profumo, F., "*ENEMED – MED & Italian Energy Report, Chapter 1: The Game of Energy in the Mediterranean Basin: a Multidimensional Vision*", Napoli, 2021
- Bompard, E., Forte, A., Grosso, D., Mazza, A., "*ENEMED – MED & Italian Energy Report, Chapter 4: Commodity Interplay In The Mediterranean Basin*", Napoli, 2021

Novel contributions

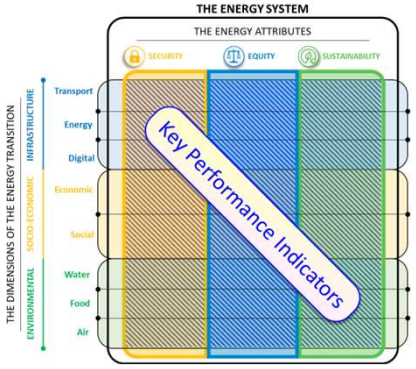
- The proposed method introduces a novel approach to energy system modelling, different from the methodologies that can be found in literature. While they usually adopt a technology-oriented approach, here the alternatives are compared on a commodity basis.



- The core of the analysis are the so-called energy commodity chains, defined as the representation of the energy flow, from primary sources to final uses, including its use and/or manipulation in intermediate stages, such as conversion, transmission, distribution, and transformation into appliances and devices providing the final energy service.

Adopted methodologies

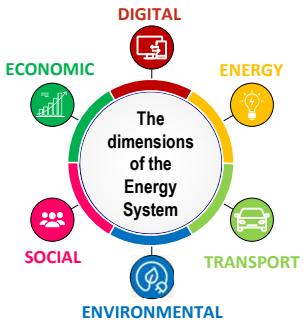
- The comparison of different options for the energy transition is based on a quantitative and comparative analysis, capable of capturing the interactions in terms of the desirable energy attributes we want to achieve. An objective, and quantitative evaluation of the attributes and the multidimensional assessment of the energy transition is ensured thanks to the introduction of a set of adequate numerical KPIs.



- The energy system interacts with its domains/subdomains and has three desirable attributes that are achievable by the energy transition and related to all the domains. They are measured by the KPIs, which quantitatively formalize the interaction between the energy system and the domains with respect to their achievement

Future work

- The energy transition process impacts on several macro-domains, which can be identified in the infrastructural, the socio-economic, and the environmental domain, each of which is constantly interacting with the energy system. The formulation of an exhaustive answer to the problem of the best commodity mix for the energy transition requires a broader analysis, which not only takes into account technical and efficiency related aspects, but also analyses the socioeconomic implications, as well as the environmental impacts of the various commodity chains.



List of attended classes

- 01DUARO –Floating Offshore Wind Turbines Dynamic Modeling Advances (13/04/2022, 16.00)
- 01QSARP – Heuristics and metaheuristics for problem solving: new trends and software tools (29/08/2022, 26.67)
- 01RRPRV – Lean startup e lean business for l'innovation management (19/04/2022, 33.33)
- 01DOPRO – Marine Energy (18/05/2022, 26.67)
- 01UNVRV – Navigating the hiring process: CV, tests, interview (07/04/2022, 2.67)
- 01UNYRV – Personal branding (06/04/2022, 1.33)
- 01LEVRV – Power system economics (07/09/2022, 26.67)
- 02SFURV – Programmazione scientifica avanzata in matlab (21/04/2022, 40.00)
- 01SYBRV – Research integrity (08/04/2022, 6.67)
- 02RHORV – The new Internet Society: entering the black-box of digital innovations (08/04/2022, 8.00)
- 01SWPRV – Time management (07/04/2022, 2.67)
- 01SHMRV – Enterpreneural Finance (08/04/2022, 6.67)

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