Ph.D. in Information Technology: Thesis Defenses

January 24th, 2020

Room Conferenze "E. Gatti" – 10.00 am

Federica BERTONI – XXXII Cycle

“Advancing joint design and operation of water resources systems under uncertainty”

Advisor: Prof. **Andrea Castelletti**

Abstract:

Globally, many countries are actively seeking to maximize the hydropower potential of major river basins, yielding proposals for constructing approximately 3,700 major dams in the near future. The planning of new water reservoir systems raises several major challenges that must be conjunctively accounted for within the system design phase, namely (i) potentially conflicting and heterogeneous objectives; (ii) interdependency between dam size and operations; (iii) future uncertainties in the main external drivers (e.g., climate, human demands); and (iv) vast amount of information that is becoming increasingly available to system planners at different temporal and spatial scales. Such issues must be jointly addressed through novel, integrated approaches in order to design efficient yet sustainable infrastructures able to satisfy multiple water needs and perform well under a wide range of external future changes.

Building on these research challenges, the main goal of this thesis is to advance the current planning and operation of water reservoir systems, focusing on the coupling of dam sizing and operation design in order to thoroughly capture their interdependencies also with respect to uncertainty in the main external drivers. In addition, the role of exogenous information (e.g., streamflow forecasts) in dam design is investigated to further analyze how dam design is shaped by information feedbacks.

We contribute novel methodological approaches as the primary outcome of our research, which have been developed by extending and integrating existing optimization techniques traditionally applied to the water management field in order to additionally account for the planning dimension of the problem, cover all the challenges of current planning and operation of water resource systems, and eventually provide supporting tools to water system planners intended to design water reservoir systems in complex, highly uncertain decision making contexts.

Federico GIUDICI – XXXII Cycle

“Optimal design of off-grid water-energy systems in small Mediterranean islands”

Advisor: Prof. **Andrea Castelletti**

Abstract:

Small Mediterranean islands represent a paradigmatic example of remote, off-grid systems facing a large number of sustainability issues, mainly due to their distance from the mainland, the lack of accessible water sources, and the high seasonal variability of both water and electricity demand. Energy security is generally reliant on carbon intensive diesel generators, which are usually oversized to meet peak summer electricity demand driven by high touristic fluxes. Potable water is often produced by energy intensive desalination technologies, which strongly impact on the electricity system, increasing air pollution and greenhouse gas emissions.

In order to improve the economic and environmental sustainability of small islands, the design of hybrid energy systems, combining traditional power generation with renewable energy sources and storage technologies, represents a viable and promising solution.

This thesis contributes novel methodologies for supporting energy systems transition towards decarbonization, helping decision makers to identify viable solutions at different temporal scales in light of plausible future conditions that might unfold. In particular, we develop a set of modelling and optimization tools for optimizing both the design and the operations of off-grid water-energy systems, also considering the uncertainty related to future changes in the main external drivers. The proposed methodologies allow us to (i) investigate the benefits of explicitly considering the interdependency between hybrid energy system design and desalination plant operation with respect to multiple economical, environmental and efficiency objectives, (ii) assess the vulnerability of hybrid energy systems to the future uncertainty in the main external drivers, and (iii) design solutions that are robust with respect to this uncertainty.

We test our novel approaches on the real case study of the Italian Ustica island.

PhD Committee:

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