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Research**

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Motivation Future energy systems will be dominated by variable Renewable Energy Sources (vRES). Yet, it is unclear if all vRES investments will recover their costs on an energy only market (EoM) and which market designs could promote necessary investments. Thus, the German case study of the TradeRES project [1] aims to assess vRES remuneration needs and policy options.

Methods We use AMIRIS [2, 3] to assess (among others) a scenario with 85% vRES share (S0). We assess a pure EoM and five different support instruments for vRES. These are: a fixed / variable market premium, two-way contracts for difference, capacity premia and a recent proposal from [4] (Financial CFD). All premia are iteratively adjusted so each vRES agent is refinanced. We evaluate cost recovery rates, power market prices, curtailment and other measures of market performance.

Results The data for Scenario S0 shows that EoM income alone is insufficient, as PV and wind operators cannot fully recover their costs. Market-based cost recovery rates vary depending on the support instrument due to the bidding and dispatch behaviour for vRES, resulting in different prices and market incomes. Our findings also indicate a significant sensitivity to the scenario considered, the degree of model-endogenous flexibility sources as well as backup fuel (hydrogen) prices.

Sources [1] <https://traderes.eu/> [2] doi: 10.21105/joss.05041 [3] <https://dlr-ve.gitlab.io/esy/amiris/home/> [4] <http://hdl.handle.net/10419>

4 - The reform of Balancing Markets: Insights from Portugal and Spain

Hugo Algarvio, António Couto, Fernando Lopes, Ana Estanqueiro

The legislation of the European Commission for regulating the European Internal Market of Electricity (EIME) establishes measures for the electricity market harmonization. These measures are designed to encourage the active participation of renewable generation in balancing markets (BMs). REStTrade (Multi-agent Trading of Renewable Production) tool models and enables the simulation of existing secondary and tertiary markets but also simulates improvements to current market designs. These changes, developed within the scope of H2020 TradeRES project (grant agreement no. 864276) are: i) 15-minute trades of reserves and penalty prices, ii) participation of smaller (0.1 MW) aggregated or single players, and iii) separate procurement and bidding of energy and capacity reserves. They are aligned with the EIME legislation. Furthermore, the tool can also compute the imbalance settlement (IS) based on the Portuguese or Spanish mechanisms such as a new approach for computing the dynamic procurement of secondary capacity. This work uses REStTrade to simulate the BMs of Portugal and Spain during 2019, where the weight penalties are around 18.5% and 21.3% of the wholesale market prices. The dynamic procurement increased the usage of its up and down capacities by 12% and 6% in Spain during the period 2019-2022, respectively. The simulation of a new IS mechanism during 2019 in Portugal and Spain, resulted in a reduced penalty of 12.2% and 4.4% of the wholesale prices paid, respectively.

■ MC-10

Monday, 12:30-14:00 - Room: 11 (building: 116)

Mobility and transportation in healthcare

Stream: OR in Health Services (ORAHs)

Invited session

Chair: Linke Potgieter

1 - Mobile clinic deployment in the Witzenberg region of South Africa.

Hannah Callaghan, Linke Potgieter

In South Africa, the Department of Health has introduced mobile clinics to improve access to healthcare for rural communities. In this study, we consider the Witzenberg region, where six mobile clinics have been deployed. The aim was to determine routes and schedules to improve the workload balance, fairness, and transportation cost, while ensuring patients get satisfactory care. The problem is modelled in three phases using both primary qualitative data and secondary quantitative data. In phase 1, a multi-vehicle routing problem is formulated to construct feasible daily routes for the mobiles. Phase 2 distributes the daily routes fairly between the mobile clinics to ensure fairness. Finally, in phase 3, a vehicle routing formulation is used to determine a 4-week schedule for each mobile clinic, by using the daily routes obtained during phase 2 as input. Four different service time estimations are used as input, resulting in four different schedules, each with their own advantages and disadvantages, including cost-effectiveness, robustness, fairness, and continuity of care. AHP was then performed with main decision makers to determine their preferred schedule. Final routes and schedules were determined based on model results, AHP results, and final practical input from the decision makers, resulting in an improvement in workload balance, a 23% reduction in total distance travelled and willingness by decision makers to implement the changes.

2 - Allocation-Routing Problem in a Multi-Hospital Home Hospitalization System: A Case Study of a Healthcare Provider in Portugal

Valentina Bonomi, Renata Mansini, Daniel Santos, Maria Lopes, Ana Barbosa-Povoa

We study a Multi-Hospital Home Hospitalization Allocation-Routing Problem (MH-HHARP) to provide a useful tool for a healthcare provider in Portugal for evaluating the impact of the opening of a new Home Hospitalization (HH) unit. Given the complexity of HH systems, where specialized nurses and doctors allocate their time between inpatient and outpatient systems, it is critical to efficiently manage their time and workload. For this purpose, we introduce a Mixed-Integer Linear Programming formulation that aims at minimizing routing costs, alongside introducing two other functions: workload balancing among nurses and the minimization of employed doctors. The model is validated using benchmark instances derived from the provider's historical data. Through single-objective resolutions, we provide an economic analysis that assesses the cost implications and the benefits of opening a new HH unit at the variation of objective function. Furthermore, we explore bi-objective problems through an epsilon-constraints method, presenting significant Pareto frontiers to facilitate the provider's decision-making process regarding the trade-offs between different objectives. A TOPSIS analysis is subsequently applied to identify the optimal solution for the provider according to varying objectives weights.

3 - The intra-hospital patient transportation problem with diverse rolling equipment

Angel Ruiz, Vinicius Martins Ton, Jose Eduardo Pecora

Intrahospital patient transportation is a crucial activity to hospital operations that also impacts patients' satisfaction. The problem consists in assigning each of the incoming transport requests to one of the available porters, in such a way that patients arrive to their destination on time, or their lateness is minimized. Some patients (i.e., hospitalized patients) are transported on the bed they occupy, while others (i.e., external patients) require a wheelchair provided by the hospital. Handling different types of transport equipment may require porters to switch equipment between two transport requests. For instance, a porter may have to visit an equipment depot to pickup (drop off) a wheelchair before (after) serving a request which requires it, increasing the total traveled distance, and reducing the availability of porters to answer other requests. To the best of our knowledge, this work is the first modeling and solving this realistic version of the intra-hospital patient transportation problem with various types of rolling equipment. We propose and compare the performance of several approaches (including a mixed integer linear programming model, a constraint programming model, a constructive heuristic, and a local search heuristic) with respect to metrics widely used by hospital managers over a set of instances inspired by a real mid-size hospital. The local search heuristic produced excellent results and proved its suitability to be used in real applications.