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A Joint Planning Model for Distributed Energy Resources and Water Desalination Plants

Abstract

This work presents a planning model for a distribution system to meet a growing electrical demand that includes a water desalination plants (WDP). The objective is to find the optimal sizes and locations for distributed energy resources (DERs) to supply the expected demands while optimizing the long-term profits for the distribution system operator (DSO). The DERs include photovoltaics (PV), wind turbines (WT), thermal generators (TG), and battery energy storage systems (BESS). The proposed model considers the coordination with the water desalination plant operator (WDPO) in the operational aspect to provide energy flexibility to the DSO.

Contributions and Importance of the Study

- **Developing a detailed desalination model that more accurately captures the features and characteristics of desalination operations.**
- **Developing a planning model to determine the optimal sizing and location of DERs such as PV, WT, TG, and BESS.**
- **Developing a coordination framework between the DSO and WDPO, which includes providing incentives to the WDPO for shifting the RO-WDP load considering its flexibility.**
- **Ensuring scalability, the proposed model is formulated as a MILP model that involves linearizing non-linear equations.**

Structure of the Proposed Model

- **The DN is considered to be connected to the bulk power grid. The DSO operates the DN, whereas the grid is operated by an independent system operator (ISO).**
- **The interaction between them for buying/selling electricity is based on a deregulated electricity market mechanism.**
- **To develop the optimal bids to be submitted in the day-ahead, DSO should predict the hourly production of RESs, the load of WDP after coordinating with WDPO, and a load of its other consumers.**
- **The DSO requests the WDPO to shift a portion of its load, and the DSO must provide an incentive to the WDPO.**

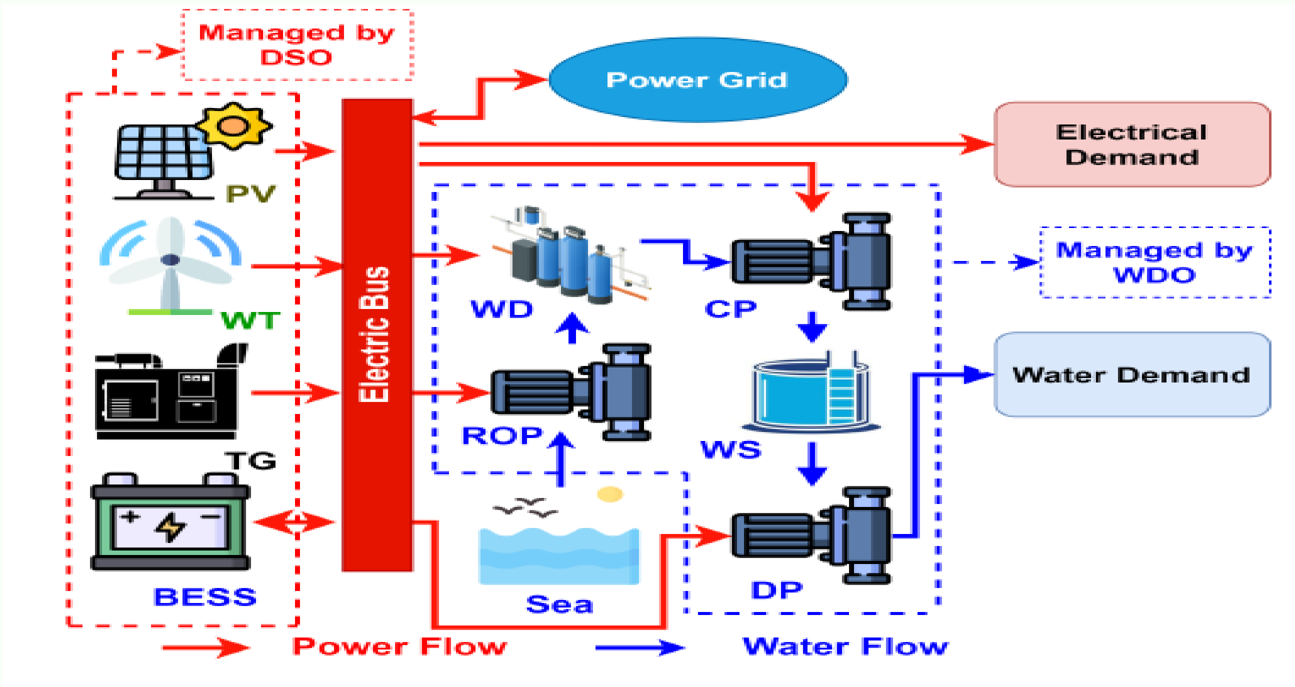

Fig. 1. Proposed model overview

Conclusion and Remarks

- **A planning model is proposed for finding the optimal sizes and locations of DERs to feed a growing electrical demand that includes WDPs. The operational aspect considers the coordination with WDPO as an incentive for WDPO to shift a portion of its load. The primary motivation of this work is to study the impact of coordination on the DSO's long-term profitability, capacities, and sizing of DERs, as well as the benefits to the WDPO.**
- **Two cases have been considered to analyze coordination benefits: case I considers coordination, while case II does not. From the obtained results, the coordination caused the DSO overall profits to increase by 1.79%, while the WDPO overall costs has dropped by 3.19%.**

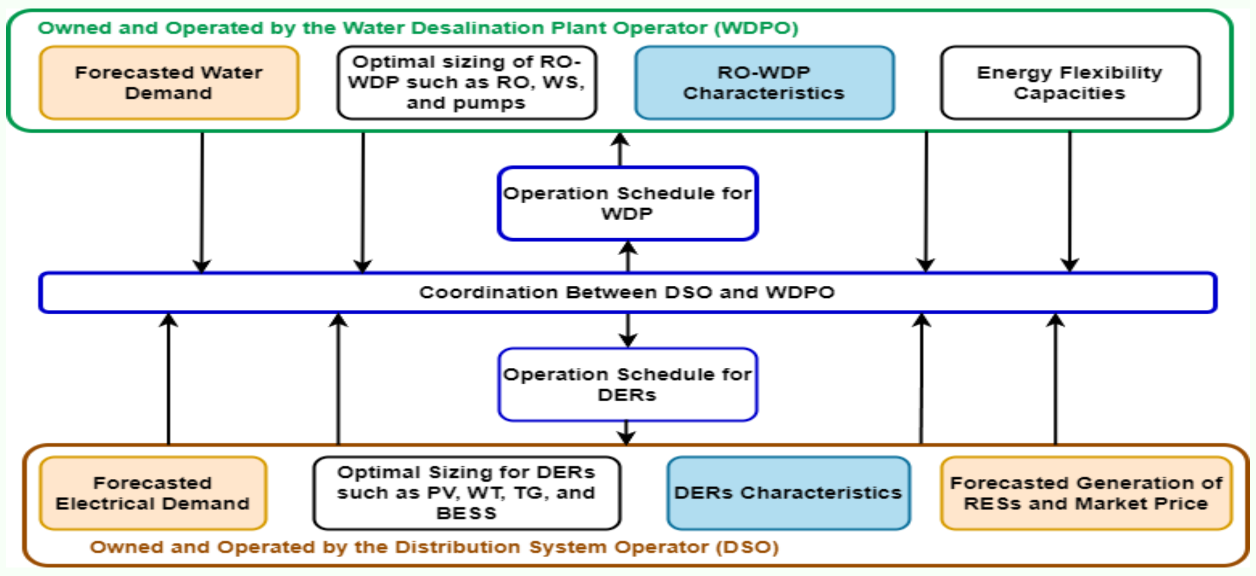

Fig. 2. Coordination framework of DSO and WDPO

Test Results

- **The proposed model is assessed in two cases in this section:**
  - **In case I: The coordination with WDPO is considered.**
  - **In case II: The coordination is not considered.**
- **The following parameters are used:**
  - **A medium voltage 38 radial DN.**
  - **15 years planning horizon.**
  - **Peak water demand = 150 m3/hr,**
  - **Electrical peak demand = 6.06 MW.**
  - **PV, WT, energy prices, and the electrical load are from ERCOT.**

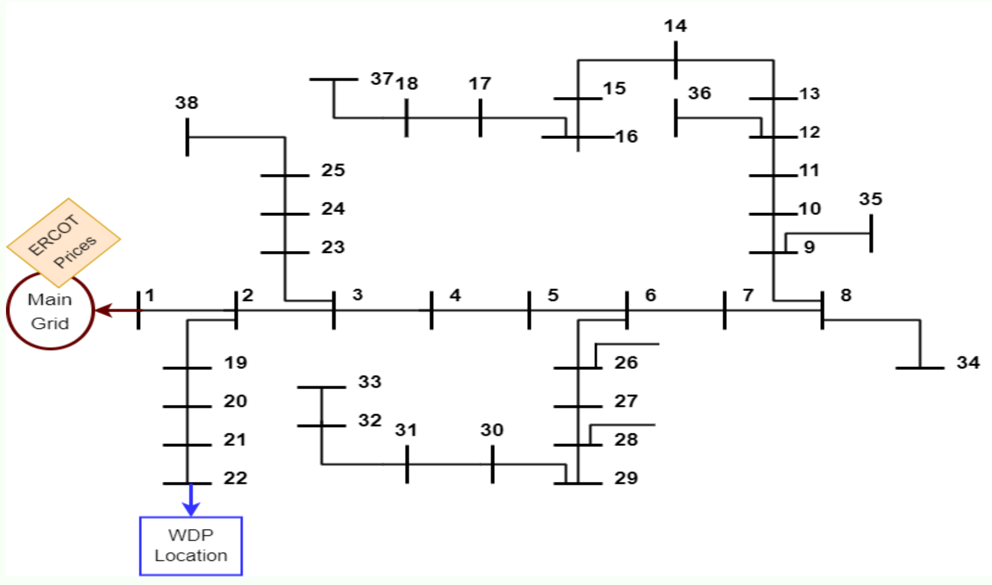

Fig. 3. Test IEEE 38-bus radial DN

Table 1. Overall payoff and optimal sizing in both cases

	With coordination	Without coordination	Coordination gains
Profits to DSO	$8.29M	$8.14M	1.79%
Costs to WDPO	$417 Thousands	$431 Thousands	-3.19%
DERs Capacity Installation			
PV	1.624	1.597	1.68%
WT	4.063	3.537	13.84%
TG	-	0.335	-
BESS	1.526	0.93	48.53%

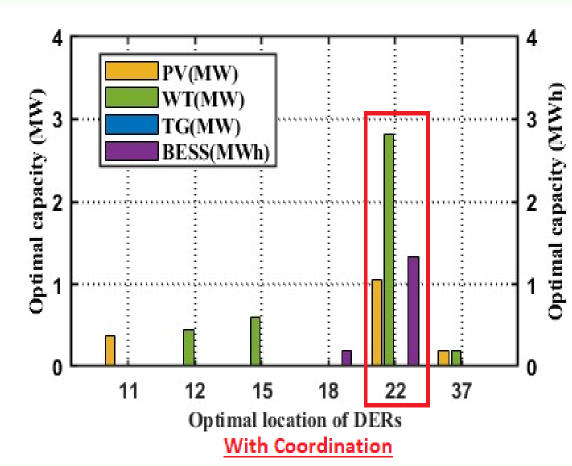

Fig 4. Case I: Optimal sizing and location of DERs

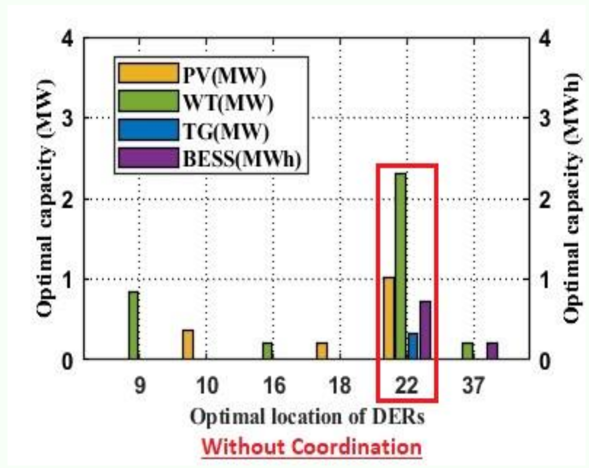

Fig 5. Case II: Optimal sizing and location of DERs