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Tradeoffs between revenue and emissions in energy storage operation

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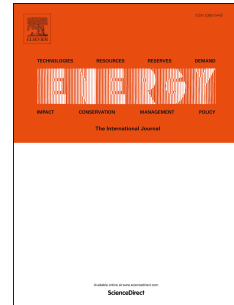
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1 Tradeoffs between revenue and emissions in energy storage operation

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6 **Abstract**

7 Grid-level energy storage is an emerging technology that provides operational flexibility
8 for managing electricity demand, integrating renewable energy, and improving system
9 reliability. However, it has been established that revenue-maximizing grid-level energy
10 storage tends to increase system emissions in current US electricity grids. In this work,
11 we consider storage operational strategies that value both revenue and CO₂ emissions to
12 understand the tradeoffs between these two criteria. We use actual electricity prices and
13 marginal emissions factors in a linear programming model that optimizes operation
14 between annual revenue and CO₂ emissions to find the Pareto Frontier for 22 eGRID sub-
15 regions. We find that, in many US regions, marginal storage-induced CO₂ emissions can
16 be decreased significantly (25-50%) with little effect on revenue (1-5%). Electricity grids
17 with larger flexibility in daily electricity prices and in marginal emissions factors have
18 more potential to reduce annual storage CO₂ emissions at low cost to storage operators.
19 These results show that negative environmental effects of storage operation can be
20 reduced or eliminated at low cost through voluntary or regulatory shifts in operational
21 patterns.

22 **Key words:** *energy storage, marginal emissions, electricity system, CO₂*

23 **Highlights:**

24 -Existing literature agrees that revenue- or value-maximizing energy storage increases
25 electricity system emissions

26 -We use a linear programming model of storage operation that values both revenue and
27 CO₂ emissions

28 -Marginal storage-induced emissions can be drastically reduced (~50%) with little loss of
29 revenue

30 -Increasing the round-trip efficiency of storage provides more capability to reduce
31 storage-related emissions at low cost

32

33 **Introduction:**

34 Energy storage refers to various technologies, such as pumped hydro, compressed air
35 energy storage (CAES), and batteries, used to store electrical energy. Grid-level energy
36 storage can provide a variety of benefits to electricity systems, from renewable energy
37 integration to frequency regulation, but can generally be considered a tool for increasing
38 operational flexibility of the grid [1], [2]. While still an emerging technology, grid-level
39 energy storage is a promising solution for modernizing the electricity grid and integrating
40 cleaner energy sources such as wind and solar power.

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