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# THE EFFECT OF DEPLOYING LARGE-SCALE ENERGY STORAGES IN ITALY

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# The problem

Reaching net zero by 2050 requires the deployment of a significant amount of **Grid-Scale Energy Storage Systems** to deal with the uncertainty of renewable energy sources

However, how can the **location** of a storage affect:

- the **overall social welfare**
- the **total carbon emissions**?

This is particularly relevant in **constrained networks**, where energy storages may actually contribute to shifting the generation mix towards dirtier sources, **increasing carbon emissions**.

Here, we show the **system-level effect** of deploying large-scale energy storages in different **regions of Italy**

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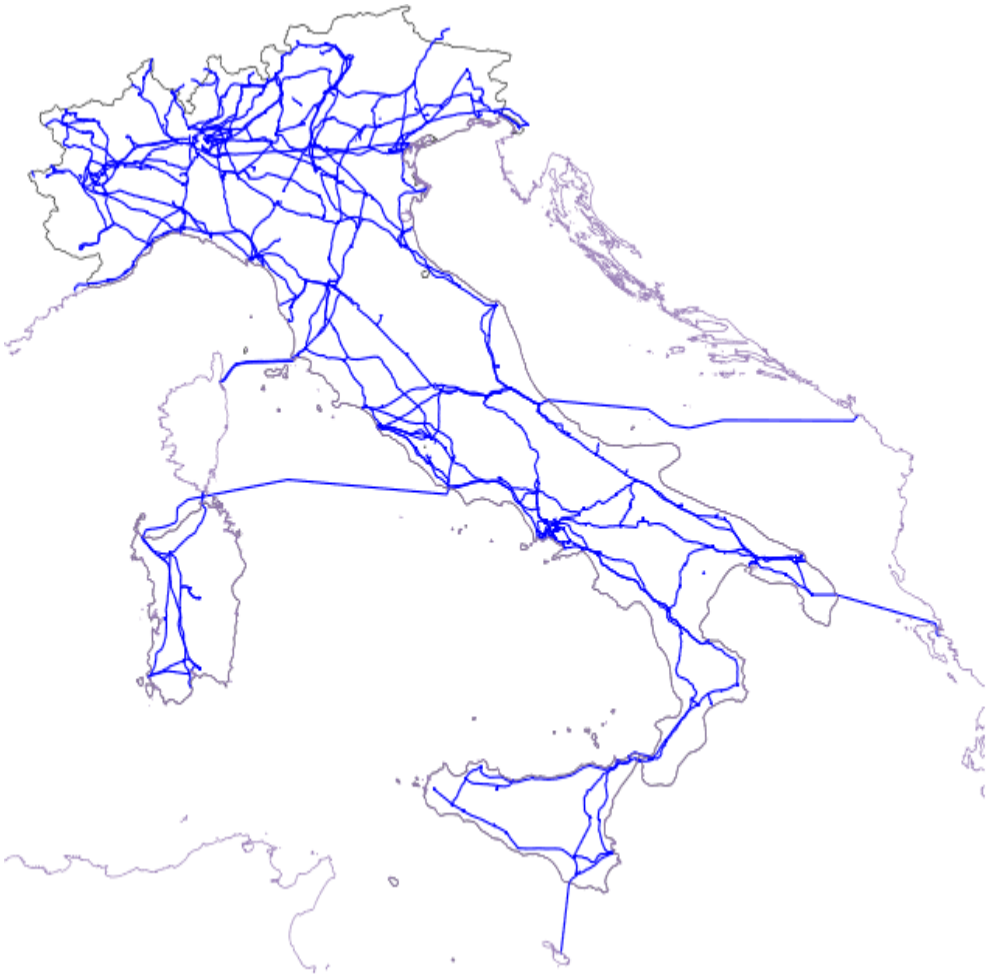
# High-fidelity network model

We have created a **high-fidelity network**, which includes:

- **existing Italian** grid (see Figure),
- **planned expansions** up to 2025

The resulting network consists of more than 2,000 electrical elements including:

- ~900 transmission lines (400kV–132kV)
- ~1,000 transformers (including 11 phase shifters)
- 4 HVDC cables



Italian high-voltage (≥220kV) transmission network.

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# Test case settings

To assess the change in **social welfare** and **carbon emissions**, we have compared a base case and several test cases

## Base case

We simulated the **Italian day-ahead market** using the actual data obtained from the **Italian market operator** (GME).

The data:

- **first week** of **February 2023**,
- **71,000** market orders **each day**.

Using the developed **high-fidelity network** to properly account for location

## Test case

**Base case + storage** in each region of Italy (node with the highest demand)

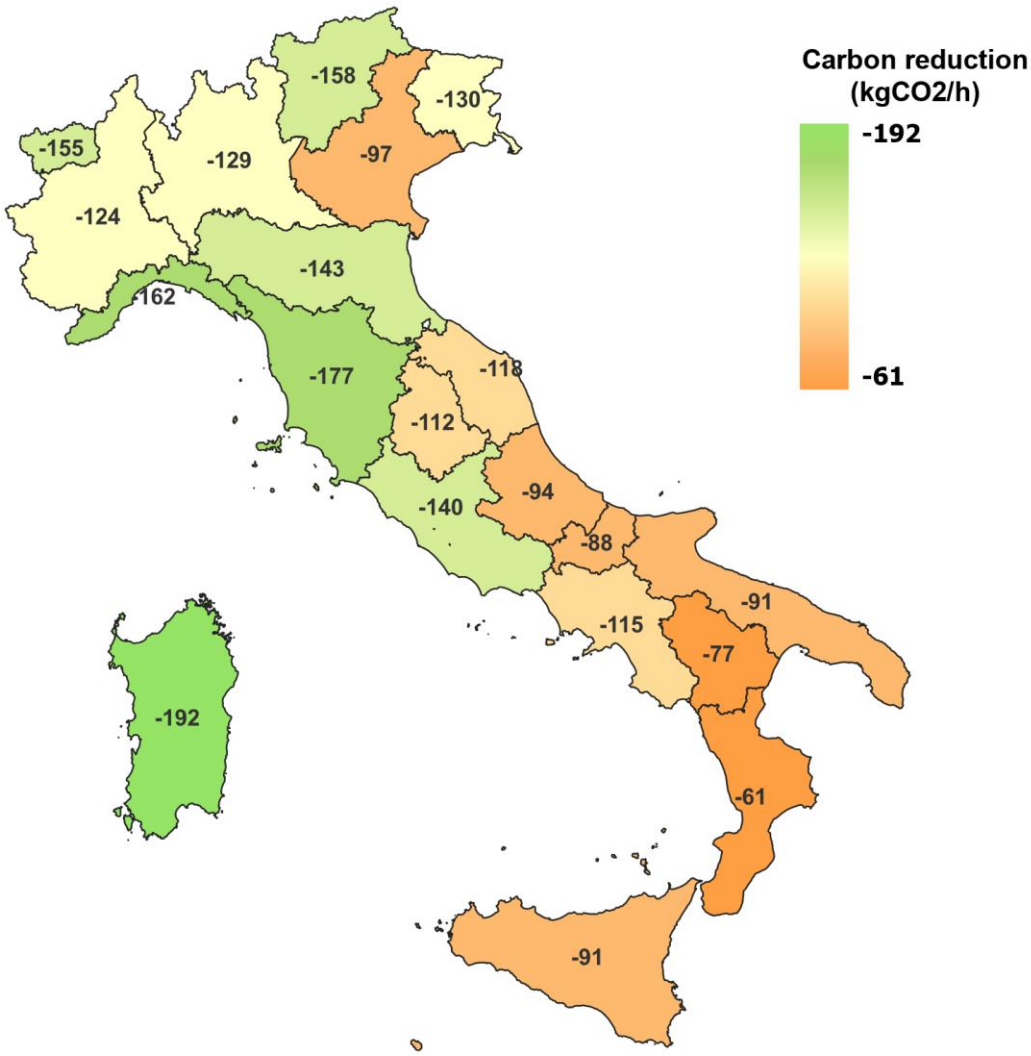
| Energy storage parameters* (Lithium-ion battery) | |
|---|---|
| Rated Power (MW) | 10 |
| Duration (h) | 2 |
| Capex – Energy ($/kWh) | 461.15 |
| Fixed O&M ($/kW-year) | 2.79 |
| Decommiss. Costs ($/kWh) | 2.65 |
| Round-trip Eff. | 83% |
| Project life (years) | 20 |
| DoD | 80% |
| Disc. factor - WACC | 7% |

* Pacific Northwest National Laboratory, https://www.pnnl.gov/lithium-ion-battery-lfp-and-nmc

# Results – Change in social welfare

| Region | Potential benefit (€/h) (A) | Storage investment and O&M cost (€/h) (B) | Net benefit (€/h) (C=A-B) |
|---|---|---|---|
| Sardinia | 186 | 94 | 92 |
| Trentino Alto Adige | 38 | 94 | -56 |
| Friuli Venezia Giulia | 36 | 94 | -58 |
| Veneto | 36 | 94 | -58 |
| Campania | 36 | 94 | -58 |
| Sicily | 36 | 94 | -58 |
| Calabria | 36 | 94 | -58 |
| Basilicata | 36 | 94 | -58 |
| Marche | 36 | 94 | -58 |
| Apulia | 36 | 94 | -58 |
| Abruzzo | 36 | 94 | -58 |
| Molise | 35 | 94 | -58 |
| Umbria | 35 | 94 | -59 |
| Lazio | 35 | 94 | -59 |
| Tuscany | 35 | 94 | -59 |
| Emilia Romagna | 35 | 94 | -59 |
| Lombardy | 35 | 94 | -59 |
| Liguria | 35 | 94 | -59 |
| Piedmont | 35 | 94 | -59 |
| Aosta Valley | 35 | 94 | -59 |

# Results – Change in carbon emissions




| Test case: Sardinia | |
|---|---|
| Technology | Generation mix difference w.r.t. base case (MWh) |
| Wind Onshore | 80.55 |
| Fossil Coal-based gas | 28.34 |
| Solar | 14.61 |
| Other | 13.17 |
| Hydro Reservoir | 13.06 |
| Biomass | 12.82 |
| Hydro Run-of-river | -2.44 |
| Fossil Oil | -15.33 |
| DSR/Emb. gen. | -34.28 |
| Fossil Gas | -121.98 |

# Conclusion

**Key messages** from these initial results

- The **cost of grid-scale lithium-ion technologies** still seems **relatively higher** than the expected benefit in terms of social welfare increase in most Italian regions.
- However, the **potential benefit in terms of carbon emission reduction** can be significant in all regions.

**Limitations/Future work**:

- Including other markets, e.g., **ancillary services**, may yield higher benefits
- Including **different periods** with higher demand and/or more intermittent renewable resources (particularly solar power).

Note: a **capacity market** has been recently introduced in Italy. These payments are recovered through tariffs levied on electricity users, therefore have not been considered in this work as they cancel each other at the aggregate level.