# Case Study on Electricity Storage Requirements in the Combined Systems of Austria and Germany

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# Overview

- **Analysed 2050 Scenarios for Austria & Germany**
- **Simulation Results for the combined System AT-DE**
- **Conclusions / Open Questions**



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# Analysed Scenarios for Austria & Germany

| [MW] | DE - 2050 Scenarios | | | AT - 2050 Scenarios | | Total AT-DE | |
|---|---|---|---|---|---|---|---|
| | A | B | C | B | C | BC | CC |
| Wind (onshore) | 60,000 | 63,000 | 55,000 | 4,240 | 4,710 | 67,710 | 59,710 |
| Wind (offshore) | 26,000 | 30,000 | 21,000 | 0 | 0 | 30,000 | 21,000 |
| PV | 70,000 | 45,000 | 100,000 | 7,880 | 26,000 | 71,960 | 126,960 |
| Hydropower<br>Run-of-River<br>HES<br>PHES<br>Small Hydropower | | 5,700<br><br>8,000 | | | 7,200<br>3,600<br>9,200<br>250 | | 12,900<br>3,600<br>17,200<br>250 |
| Other RES-E | 4,200 | 4,200 | 4,200 | 2,430 | 2,000 | 7,000 | |
| Yearly Peak Load | | 79.1 | | 20.7 | 13.6 | 92.5 | 92.5 |
| Energy Consumption [TWh] | | ~500 | | 126 | 83 | ~583 | ~583 |
| RES-E Generation [TWh] | | ~400 | | 75 | 94 | ~494 | ~494 |
| RES-E Share* | ~80% | ~80% | ~80% | ~60% | ~110% | | |

* On net electricity consumption, not electricity generation.



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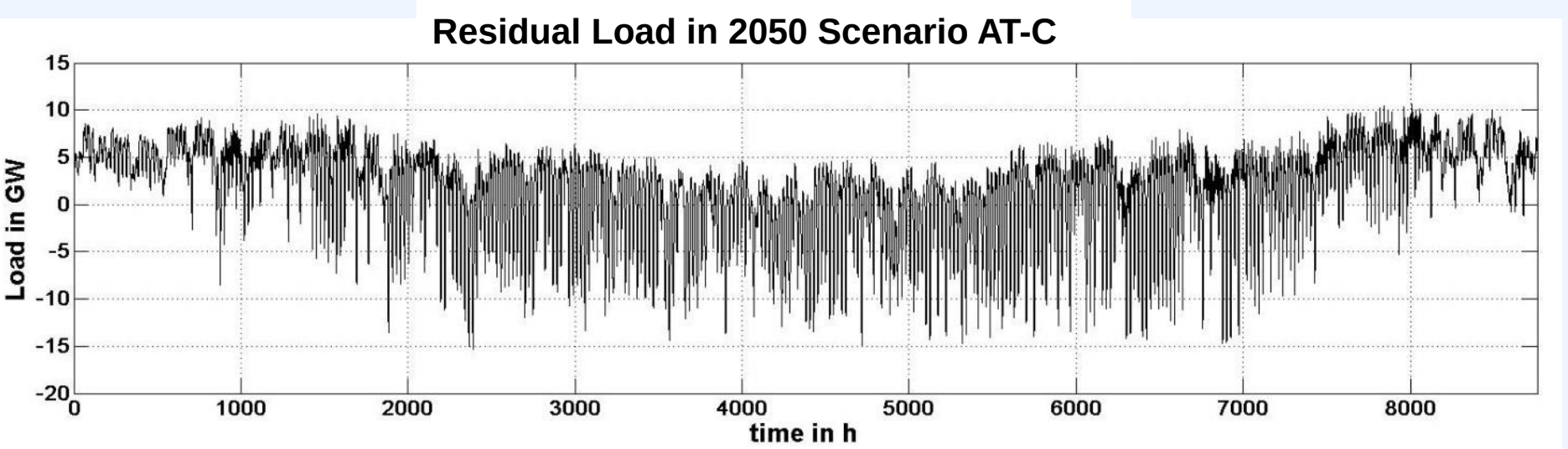
# Rejected Energy in Case of no Storage

| 2050 Scenario | Max. rejected power [GW] | Rejected Energy [TWh] |
|---|---|---|
| DE – A | 51.15 | 21.72 |
| DE – B | 38.85 | 15.85 |
| DE – C | 69.09 | 29.04 |
| AT – B | 0 | 0 |
| AT – C | 12.18 | 7.69 |
| BC | 43.07 | 11.34 |
| CC | 70.54 | 24.96 |



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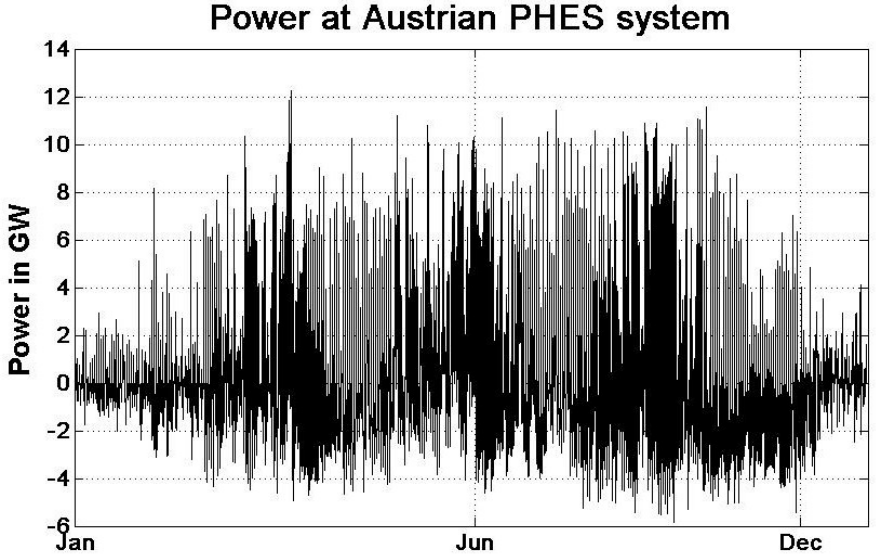
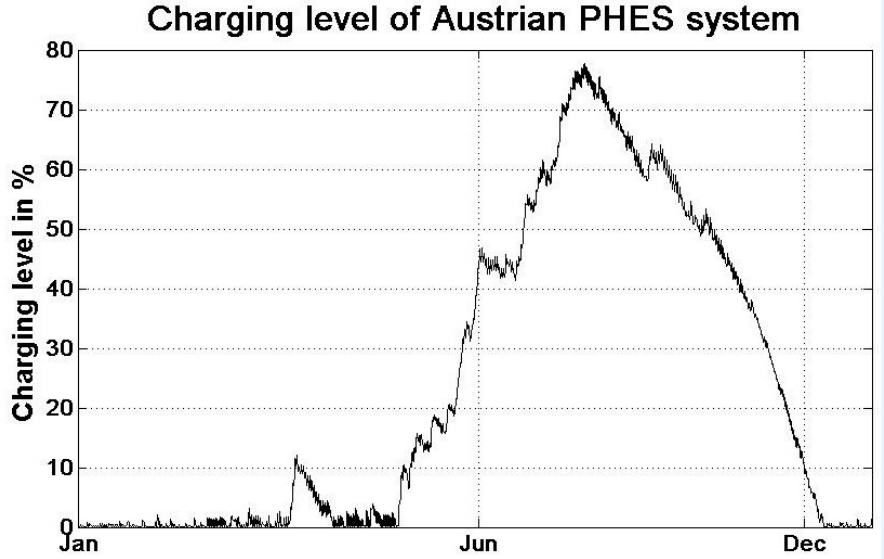
# Storage Needs of the Isolated Systems AT & DE

| 2050 Scenario | Additionally needed power [GW] | | Additionally needed capacity [GWh] |
|---|---|---|---|
| | Charing | Discharging | |
| DE – A | 38.79 | 25.17 | 1,308 |
| DE – B | 31.85 | 25.74 | 1,534 |
| DE – C | 55.16 | 29.04 | 950 |
| AT – B | 0 | 0 | 0 |
| AT – C | 3 | 0 | 0 |




**2050 Scenario AT-C**



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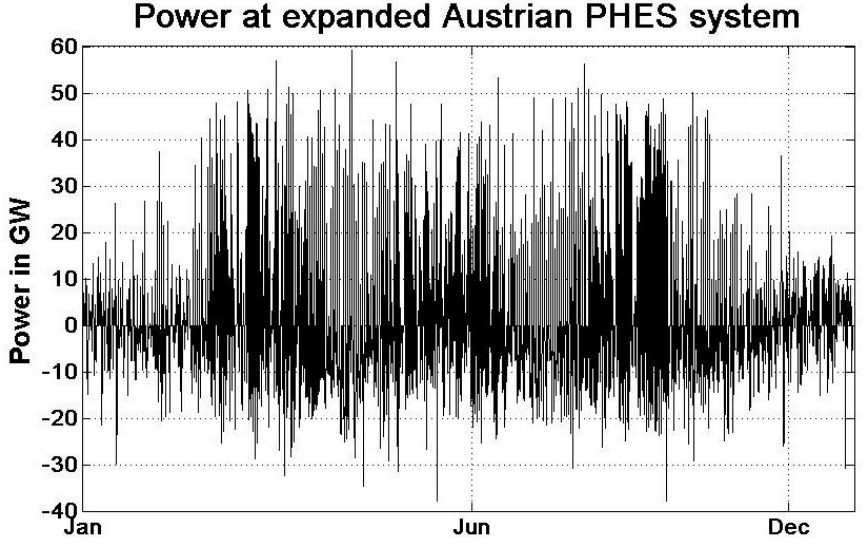
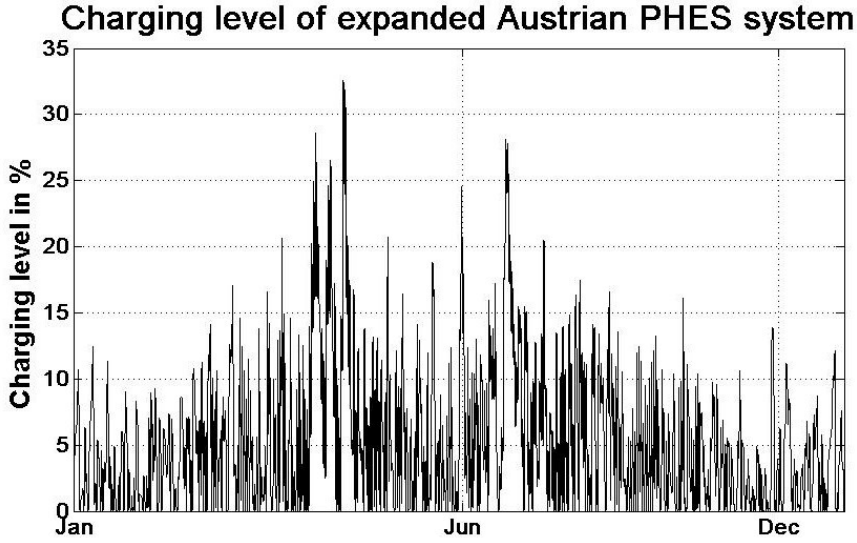
# Storage Needs in the Combined System AT-DE

| 2050 Scenario | Country | Stored Energy [GWh] | Provided Energy [GWh] | Max. used power [GW] | |
|---|---|---|---|---|---|
| | | | | Charge | Discharge |
| BC | DE | 17,111 | 13,838 | 8.0 | 8.0 |
| | AT | 27,005 | 21,399 | 36.4 | 37.2 |
| CC | DE | 20,174 | 16,321 | 8.0 | 8.0 |
| | AT | 44,102 | 35,672 | 59.2 | 37.7 |




**2050 Scenario CC**



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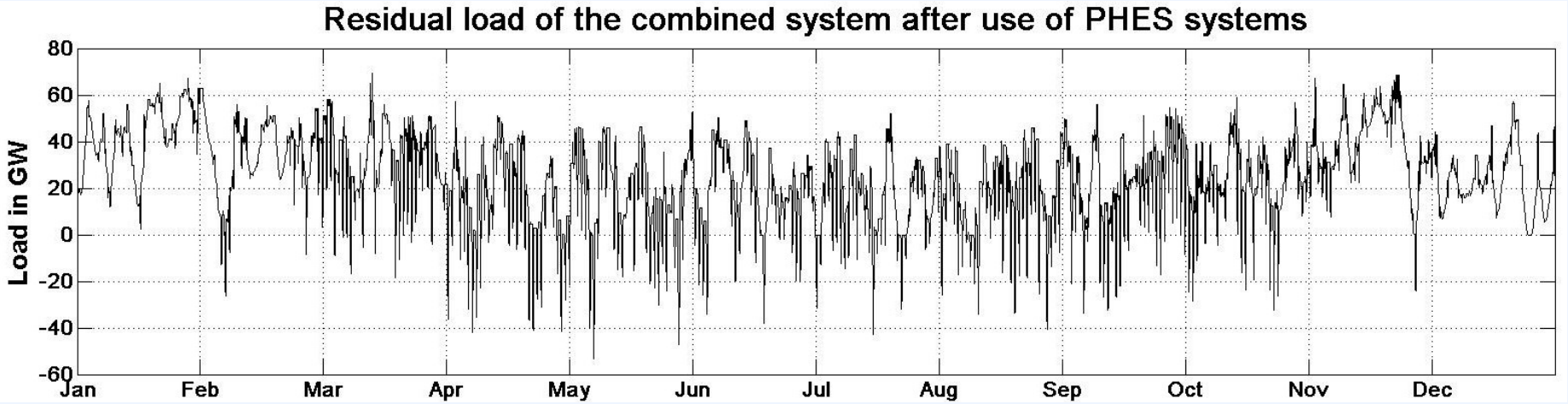
# Limited Transmission Capacity

- Limiting the transmission capacity to the expected installed power of Austrian PHES systems in 2050 – **9.2 GW**
- Rejected energy in the combined system AT-DE can be reduced from 25 TWh to 9 TWh (Scenario CC)
- More energy would get lost when using less efficient technologies like power-to-hydrogen or power-to-gas




**2050 Scenario CC**



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# Limited Transmission Capacity

| 2050 Scenario | Country | Stored Energy [GWh] | Provided Energy [GWh] | Max. used power [GW] | |
|---|---|---|---|---|---|
| | | | | Charge | Discharge |
| BC | DE | 20,228 | 16,365 | 8.0 | 8.0 |
| | AT | 20,859 | 16,762 | 9.2 | 9.2 |
| CC | DE | 17,161 | 13,878 | 8.0 | 8.0 |
| | AT | 20,326 | 16,020 | 9.2 | 9.2 |

## Capacity Factor of the German and Austrian PHES Systems

| | German PHES | | | Austrian PHES | | |
|---|---|---|---|---|---|---|
| | Charge | Disch. | Total | Charge | Disch. | Total |
| AC | 24.5% | 19.8% | 44.3% | 25.2% | 19.9% | 45.1% |
| BC | 28.9% | 23.4% | 52.2% | 25.9% | 20.8% | 46.7% |



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# Conclusions

- High energy storage potential in the Austrian Alps (i.e. pumped-hydro)
- Development of this potential has advantages for both electricity systems AT & DE
- Transmission capacity & energy storage needs are too high for a full exploitation of RES-E potential available in both countries
- By increasing the transmission capacity from 2.2 GW to 9.2 GW in 2050, the rejected energy in the worst case scenario in the combined system AT-DE could be reduced from 25 TWh to 9 TWh
- Open questions / simplification of analysis:
  - Public opinion / opposition against new PHES & transmission lines
  - Determining the actual usable potential in the Austrian Alps
  - Taking into account other system dynamics of the reservoirs (e.g. snowmelt, rain and downstream riverchains of Austrian hydropower plants)



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# Thank you for your Attention!


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