Study on energy storage and hydropower in the Alps

Review of options for safe and sustainable development

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80 million people, 7 countries, 48 regions, mountains and plains addressing together common challenges and opportunities

European Commission

Interreg Alpine Space AlpGov

This project is co-financed by the European Union via Interreg Alpine Space

University of Ljubljana

Established: in 1919

Members: 26 (3 Academies and 23 Faculties)

Students: 40.100

Employees: 5.700

Faculty of mechanical engineering

Chairs: 18

Laboratories: 37

Employees: 360 (2017)

Students: 1.811 (2017/18)

Graduates: 414 (2017)

Staff: 90 Professors

80 Teaching assistants

110 Researchers

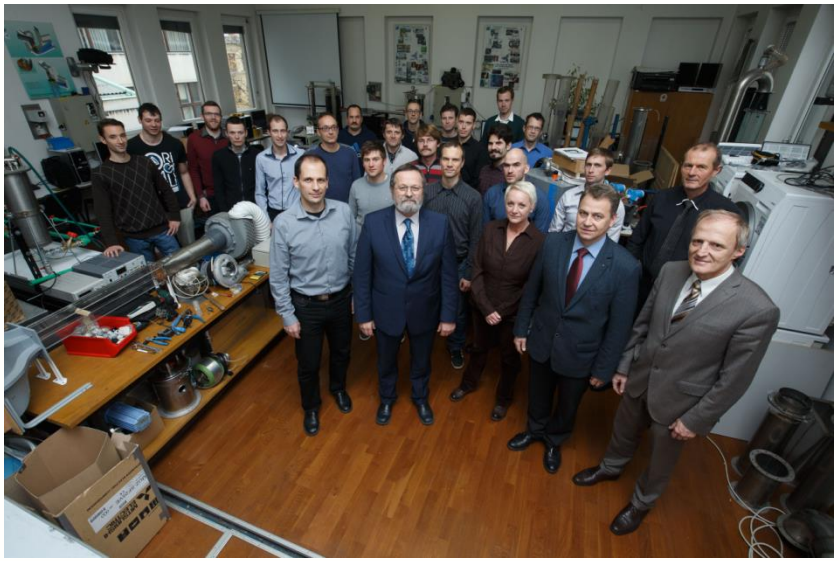
30 Young researchers

Chair of energy engineering

30 researchers and professors

Current projects:

- 1 ERC
- 2 H2020
- 1 Innoenergy
- 3 structural funds
- 5 national
- many industrial

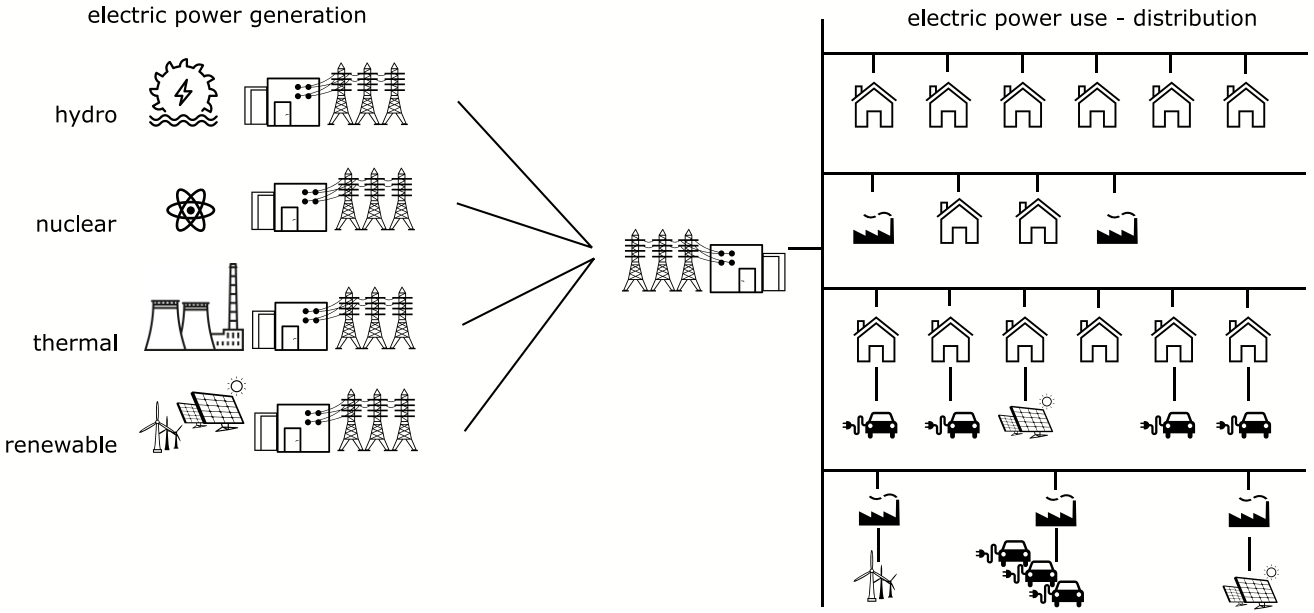


In the presentation ...

- peer to peer trading
- requirements for energy storage
- PHS comparison with battery storage
- SWOT analysis of PHS
- proposed solution
- recommendations to EUSALP

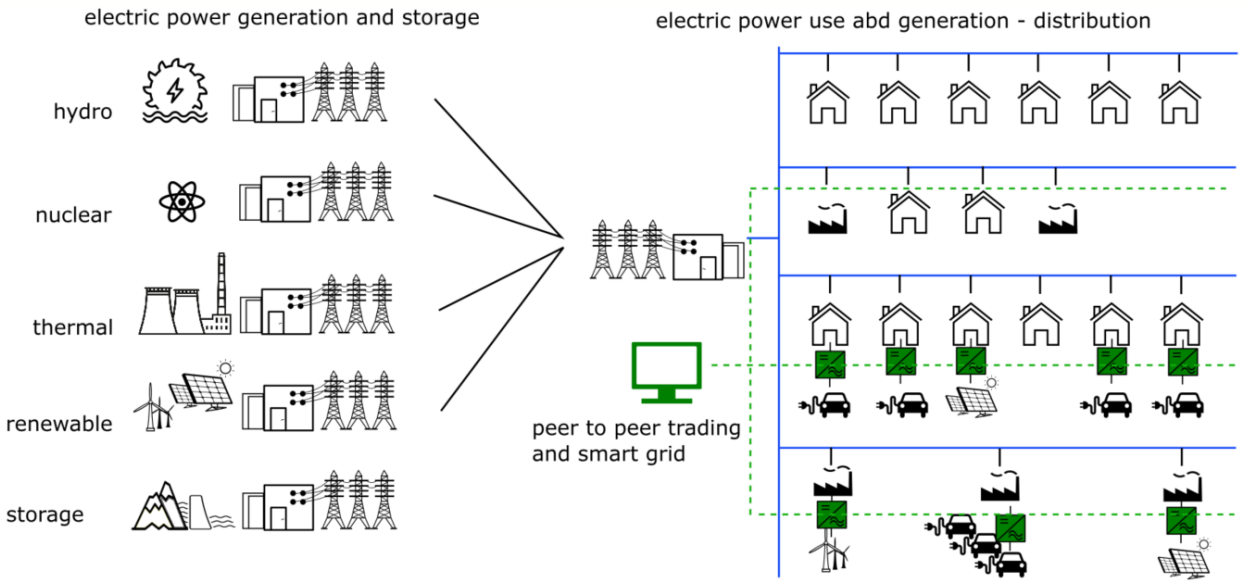
Electric energy generation and distribution

- no smart grid
- production on distribution level
- overloading of distribution lines possible
- average settings of producers (no V, f control)

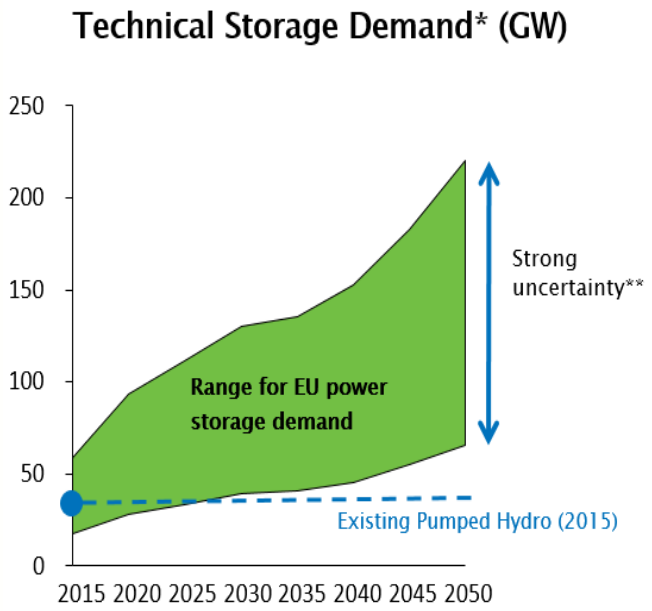


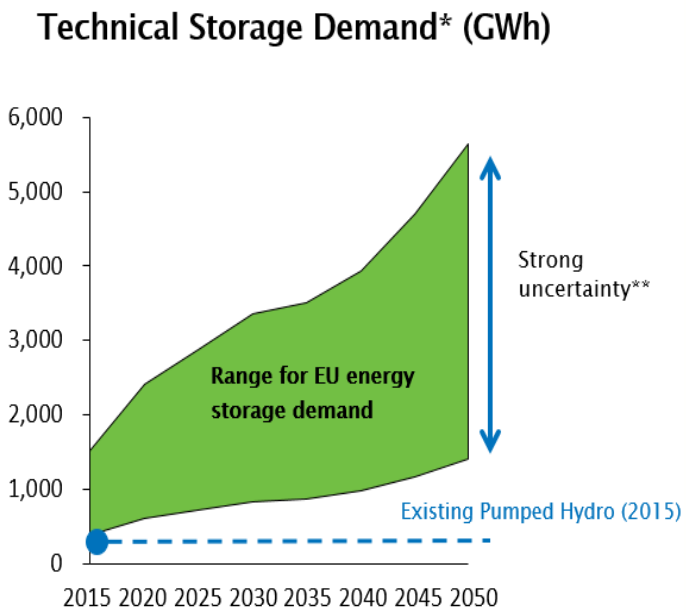
Peer to peer trading - current development

- smart "direct" contracts
- cheaper
- currently offered by startups
- **locally self sufficient**
- only in Slovenia with few customers
- no storage
- regulation of generation (V, f)



Requirements for "technical" energy storage - EU

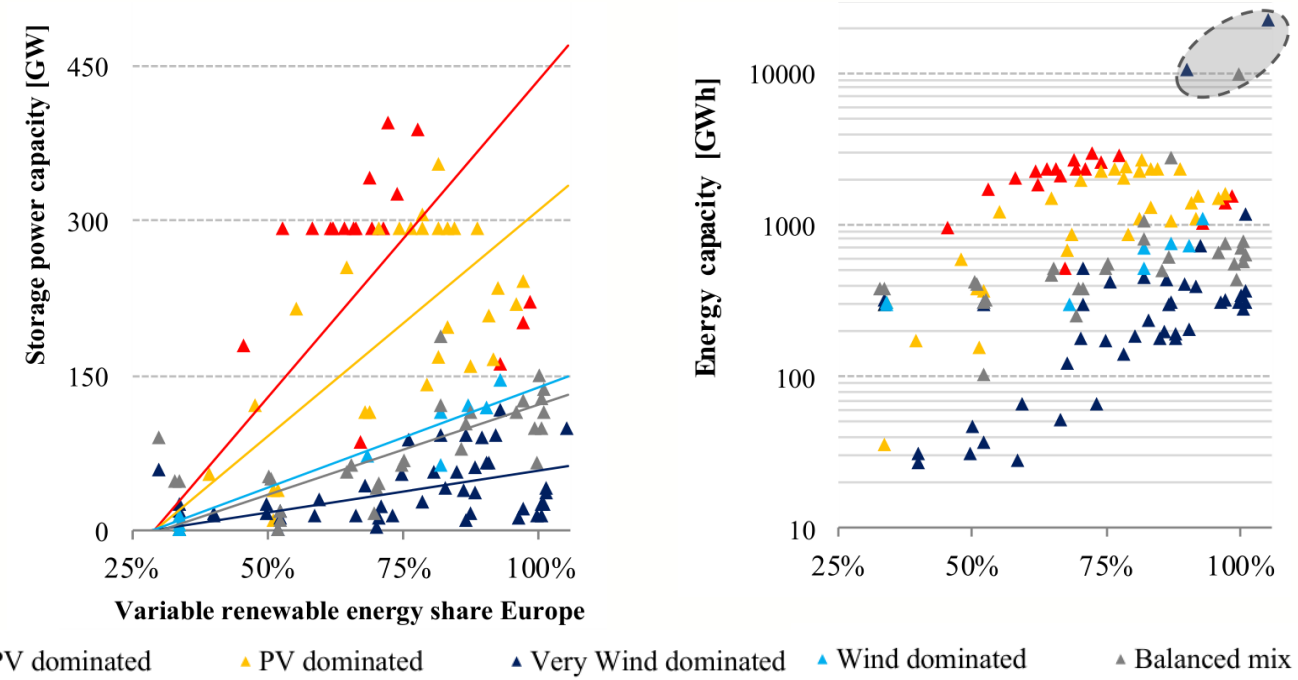




source: EASE Study on Energy Storage Demand, European association for energy storage, 2018

Requirements for "technical" energy storage - EU

PV-dominated scenarios correlate to high storage requirements, in both power and energy, **wind-dominated** scenarios require significantly lower storage



source: Cebulla et al How much electrical energy storage do we need? J. C. Production 181 (2018)

Electric energy storage options

- pumped hydro storage PHS
- compressed air energy storage CAES
- batteries, electrical energy storage EES
- magnetic energy MES
- hydrogen energy storage HES
- demand side management DSM

- we will analyse batteries EES and pumped hydro storage PHS

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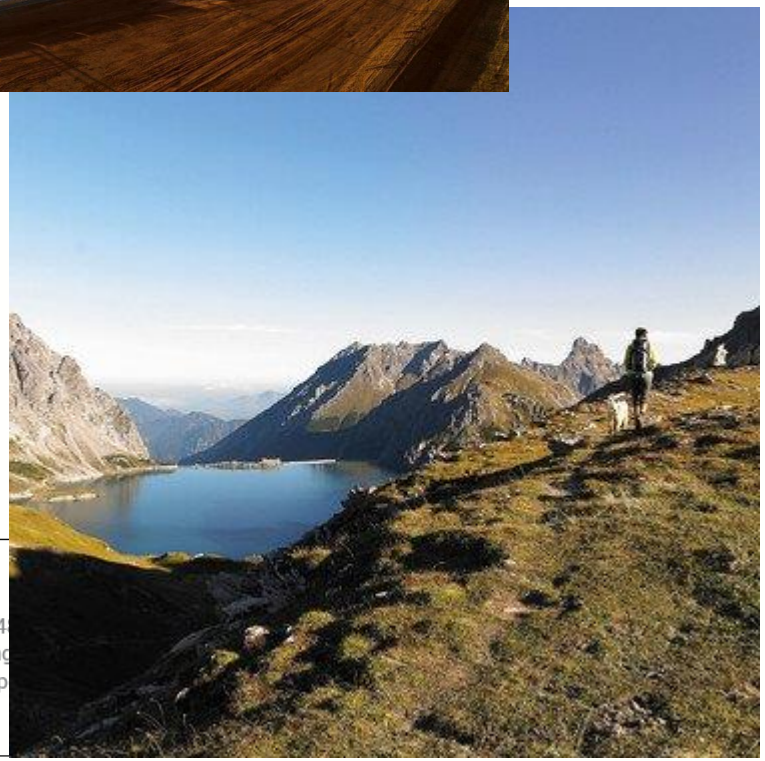
Which one you prefer?

EES has

- high cost
- very low stored energy
- imported / politics
- not proven and short lifetime
- social aspects
- waste
- no benefits for local community
- very fast response time

vs:



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PHS SWOT analysis - strengths

very favourable geographical conditions for PHS (+++)
storage requirements are high and increasing (+++)
possibility to sell/buy outside Alpine region (+++)
very high amount of stored energy (+++)
very long lifetime (+++)
developed technology, very reliable (+++)
locally available (+++)
no seasonal variability (+++)
reliable energy source (+++)
cheap operation (+++)
predictable operation and maintenance cost (+++)
good energy received over energy invested (++)
no state support required (++)
profitable (++)
improved water management (++)
retention of surface and ground waters (++)
regulation of rivers (++)
high efficiency (++)
immediately available (++)
source of income during manufacture and construction (++)
use of existing infrastructure (reservoirs, penstocks) (+)
limited manpower required (M&O) (+)
possible long term storage (+)
short response time (+)
power plant in cavern - no environmental concern (+)

PHS SWOT analysis - weaknesses

substantial investment costs (--)
need for financing (--)
few information available for the specialists – data on social risks not available (--)
limited income to local communities from hydro power (--)
long return on investment (--)
long pre-investment period (--)
low specific energey (-)
dams and penstocks impact on landscape (-)
unable to operate during a long-term draught (-)
insufficient and unsatisfactory equipment – investors have too little focus on quality (-)
new transmission lines required (-)
need of high head (elevation of upper reservoir) (-)
long construction time (civil, mechanical) (-)

PHS SWOT analysis - opportunities

low CO_2 footprint (+++)

sell equipment worldwide, large market (++)

sell service worldwide (++)

tourism, recreation, attraction and sports (++)

brings new investment and funding to local community (++)

environmentally acceptable (+)

no waste, noise, EMF or pollution (+)

sell knowledge worldwide (+)

involve local communities to invest their own land (+)

local communities financial benefit (+)

dialogue among environmental experts and engineers (+)

centralised building permit office (+)

prevent immigration of people from undeveloped regions (+)

human resources - design, manufacture, service (+)

safe (+)

development of fishing (+)

careful planning may reduce environmental impact (+)

peer to peer trading (+)

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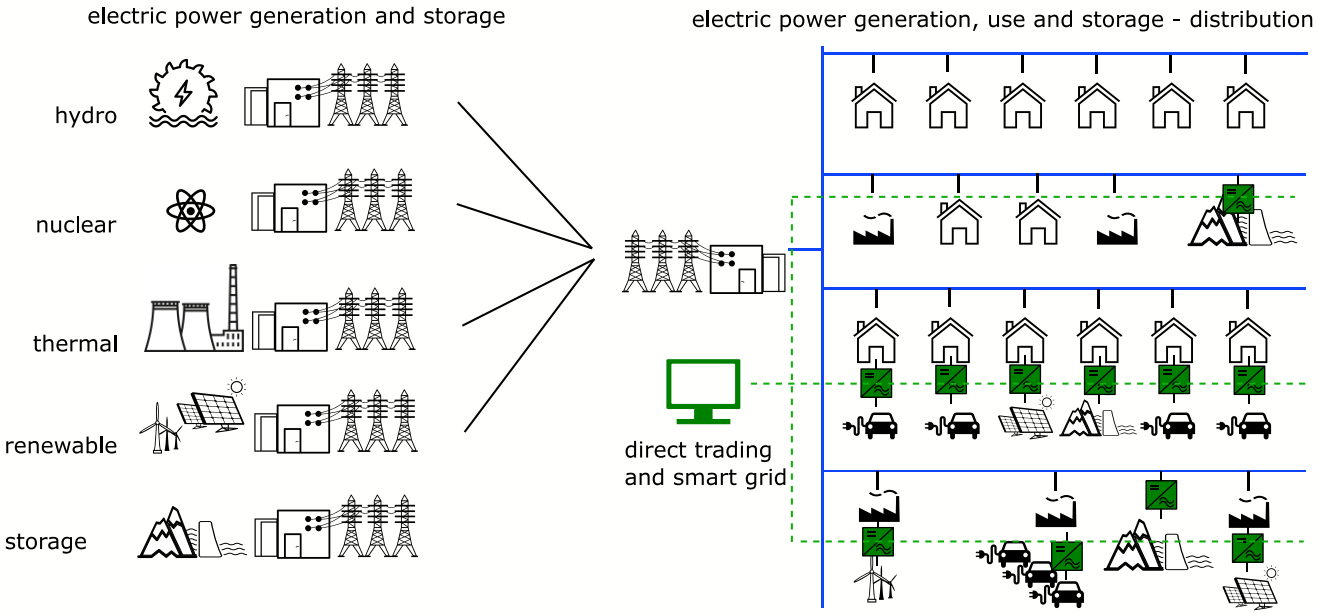
PHS SWOT analysis - threats

inability of local communities to participate in PHS (--)
radically new battery technologies emerge (-)
high governmental support to producers in USA, China, etc.(-)
climate change (-)
worldwide political instability (-)
financing - limited interest among investors (globally) (-)
technology improvements of other storage technologies (-)
limited public (local population) interest (-)
possibility of conflicts due to installation in protected areas (-)
displacement of people may be required (-)
negative impact on the fish population and ecosystems (-)
further increase of protected areas size and importance (-)
environmental restrictions increase (-)
unfavourable legal framework changes (-)

Proposed solution

- **increase PHS** on generation level
- peer to peer trading **with local energy storage**



Recomendations for EUSALP

- we will need PHS due to large share of RES and electromobility - up to 5500 GWh in year 2050
- PHS are better than other storage options in Alpine region
- **provide favourable conditions for PHS** (current storage capabilities are by far not enough)
- pre investment period must be shortened, dialogue with local community improved etc.
- benefits of peer to peer trading should be used and legislation modified