Context, trends and challenges of energy storage

Cycle de formation Énergie-Environnement Séminaire 2017-2018, Genève

April 12, 2018

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Switzerland

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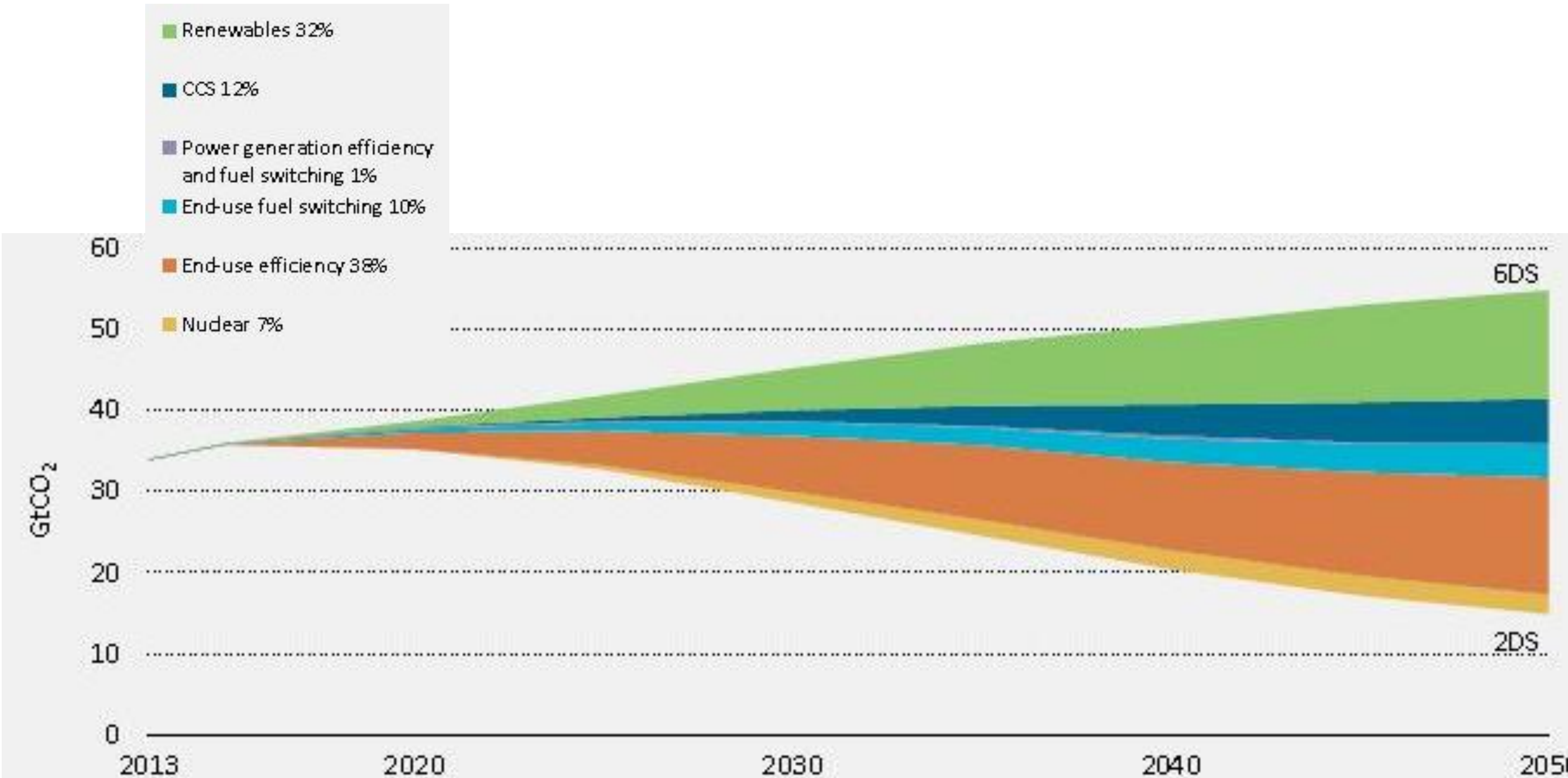
Renewable energy technologies

Global CO2 reductions by technology 2013-2050



IEA: Energy Technologies Perspectives 2016, Paris, 2016

Renewable energy technologies

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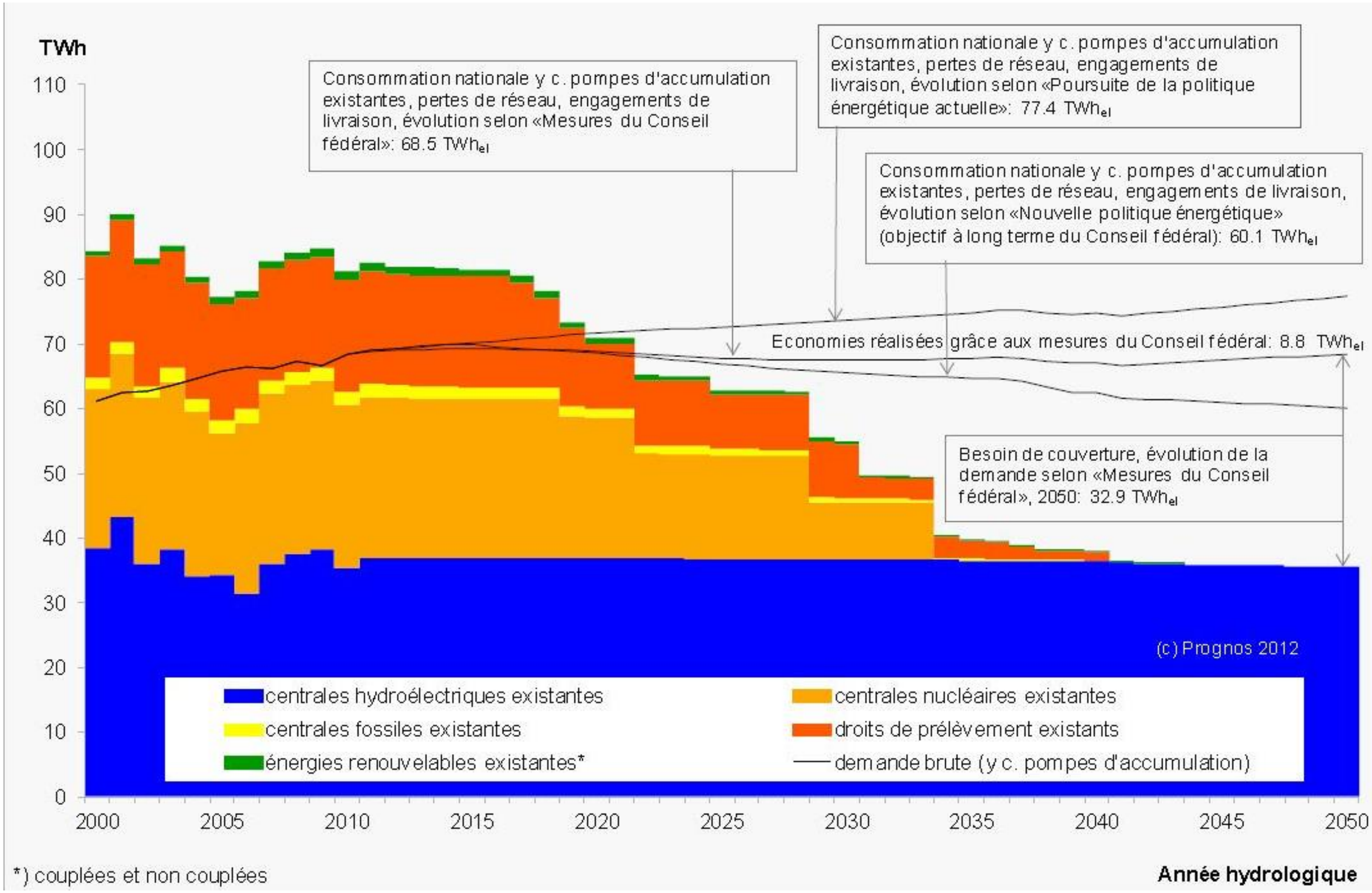

Prognos, 2012

Rolf Wüstenhagen, available at www.Swissinfo.ch

Renewable energy technologies

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Before

Now

Renewable energy technologies

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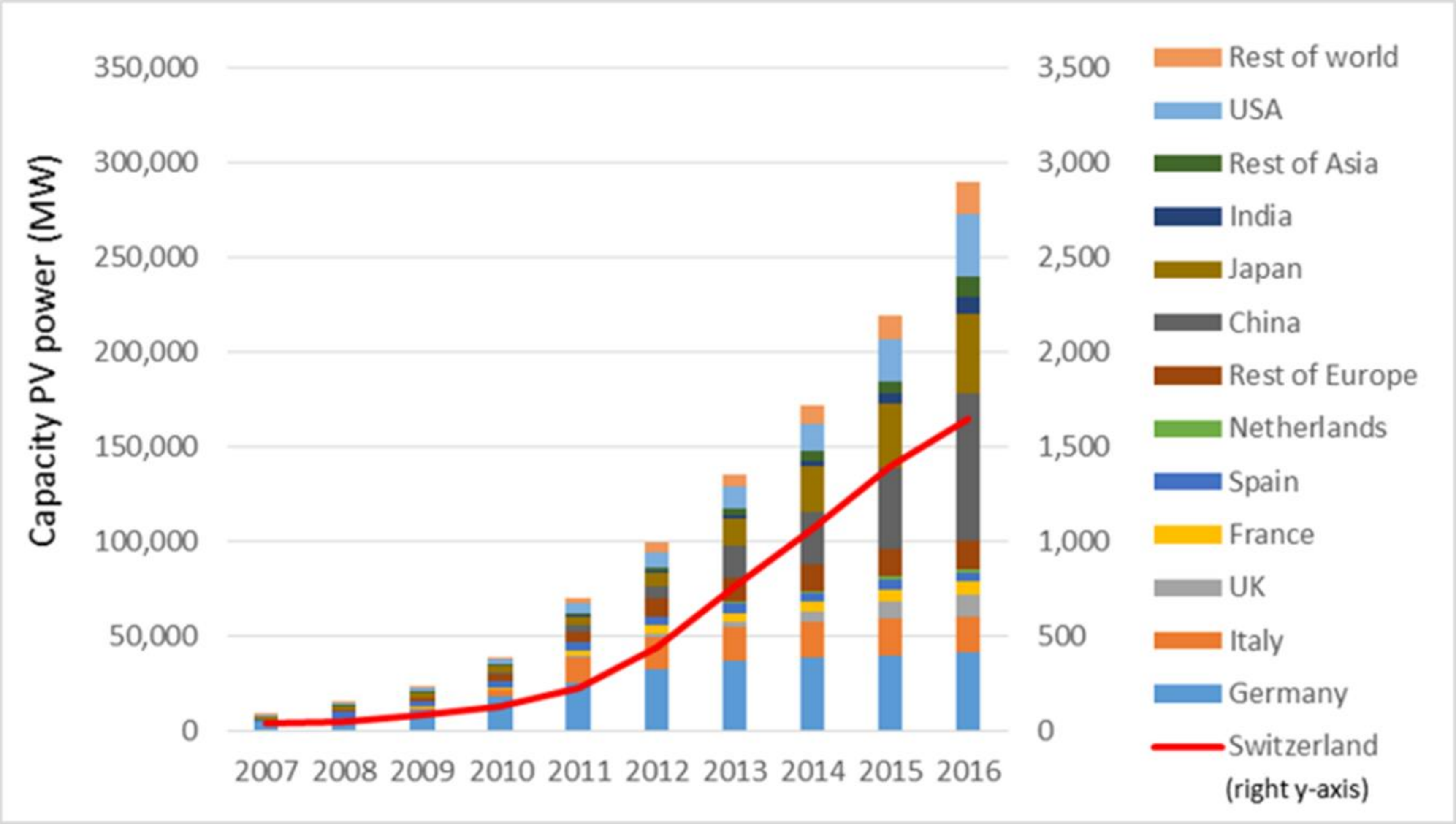
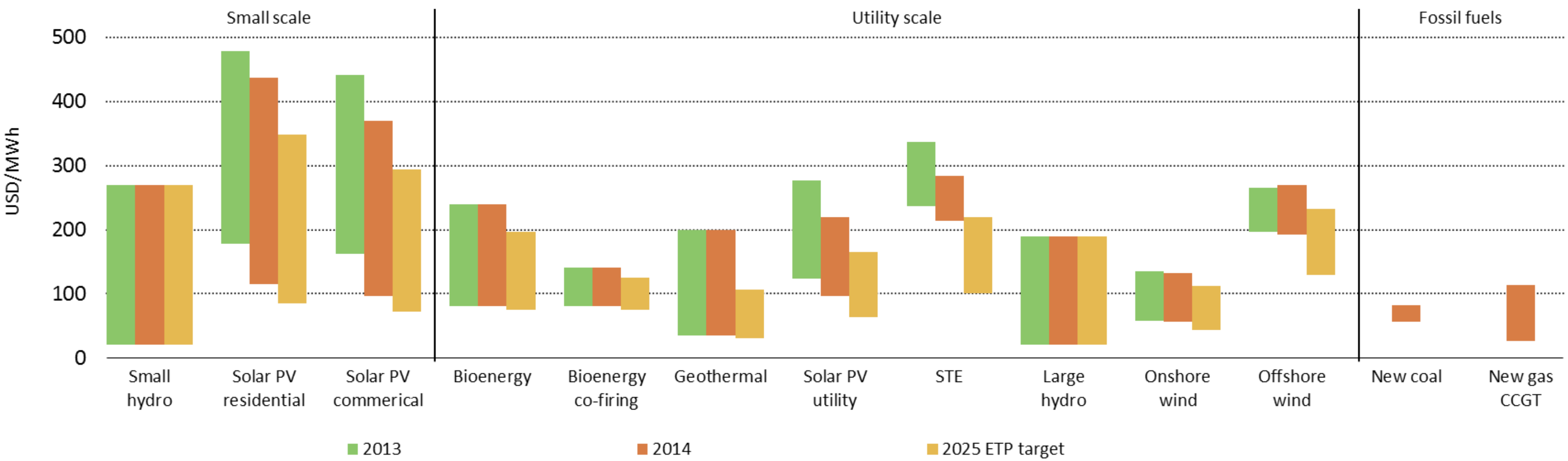


IRENA, 2017: Renewable Capacity Statistics in 2017

Renewable energy technologies

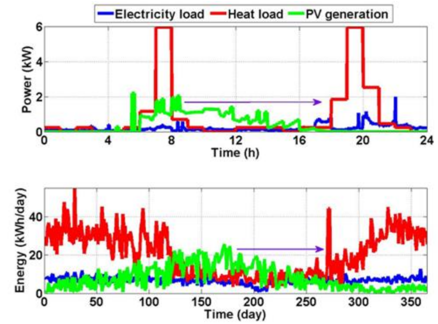


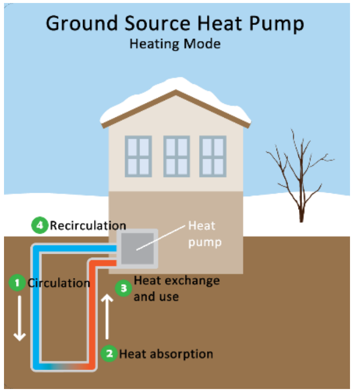
IEA: Energy Technologies Perspectives 2016, Paris, 2016

Challenges

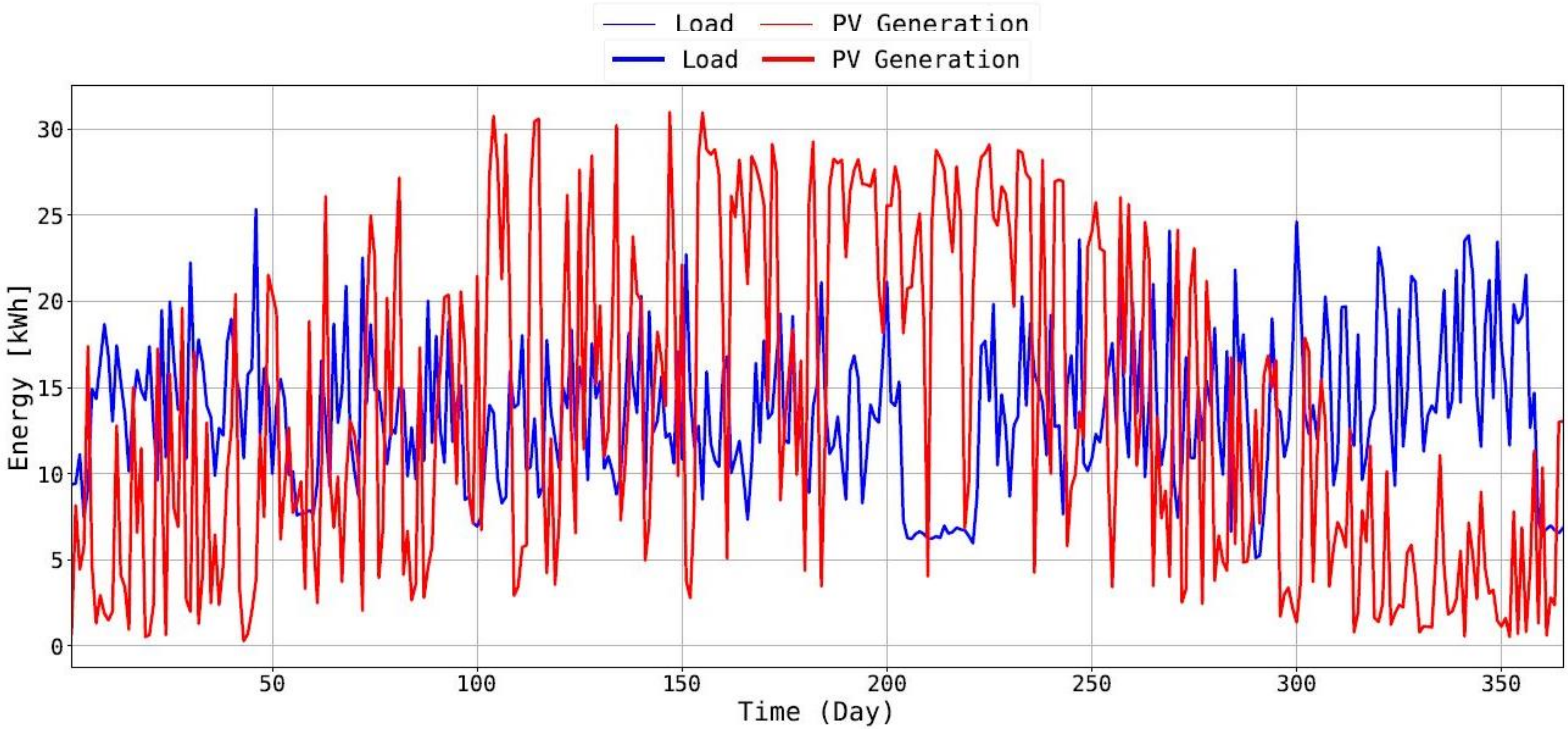
- V ility
- R
- Renewable
- Complexity of the futu m
- Acceptance
- Cost
- Interdisciplinary challenge
- Uncertain public and policy support

Is the transition possible ?





Variability



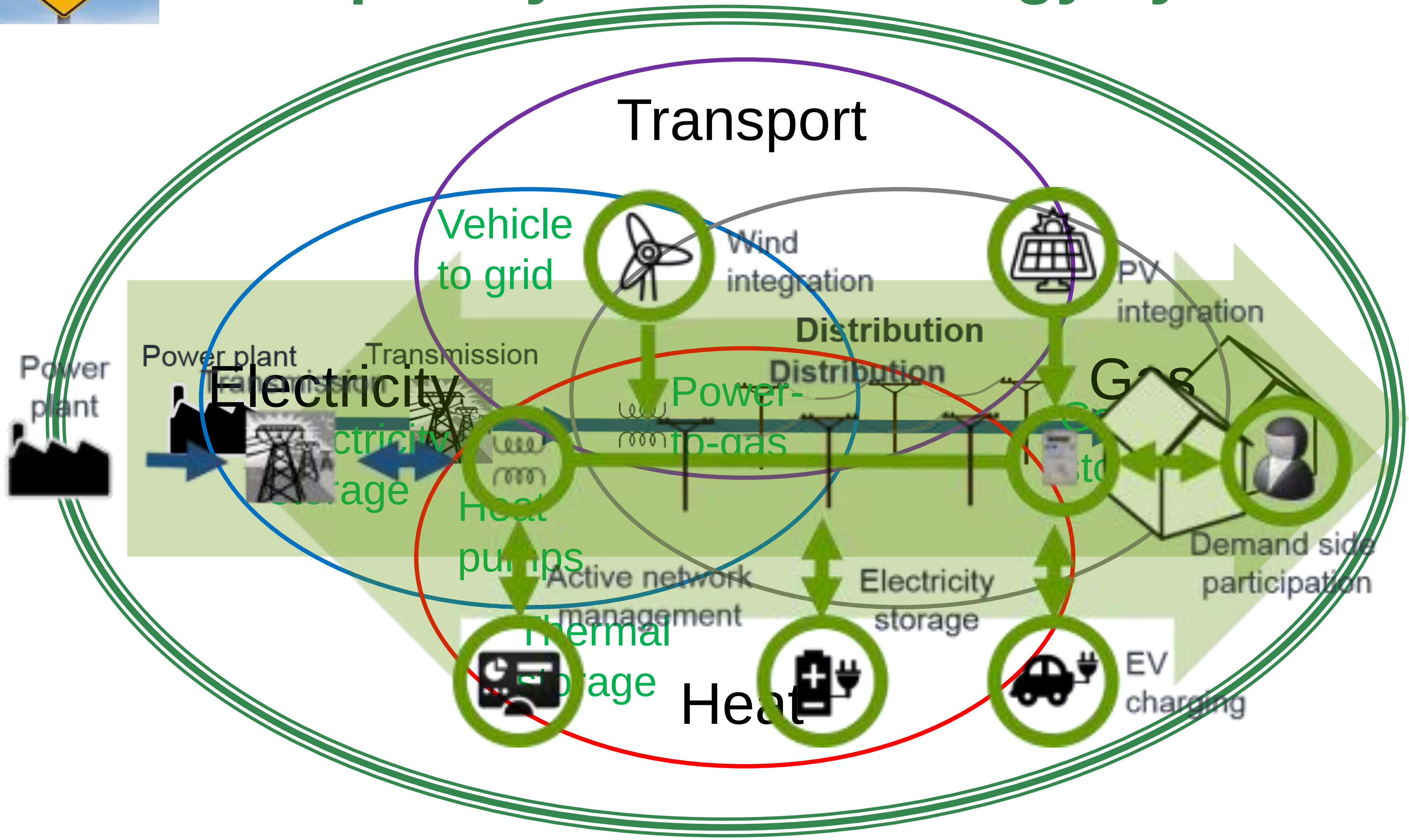
Pena-Bello et al., in preparation

Variability

Renewable energy technologies do not offer matching capability.

- Flexible generation
- Demand side management
- Interconnection
- Curtailment
- Energy storage (ES)

Complexity of future energy system



http://www.edsoforsmartgrids.eu/home/why-smart-grids/

Adapted from Hart et al., IEA-RETD, 2016

Contents

Energy storage

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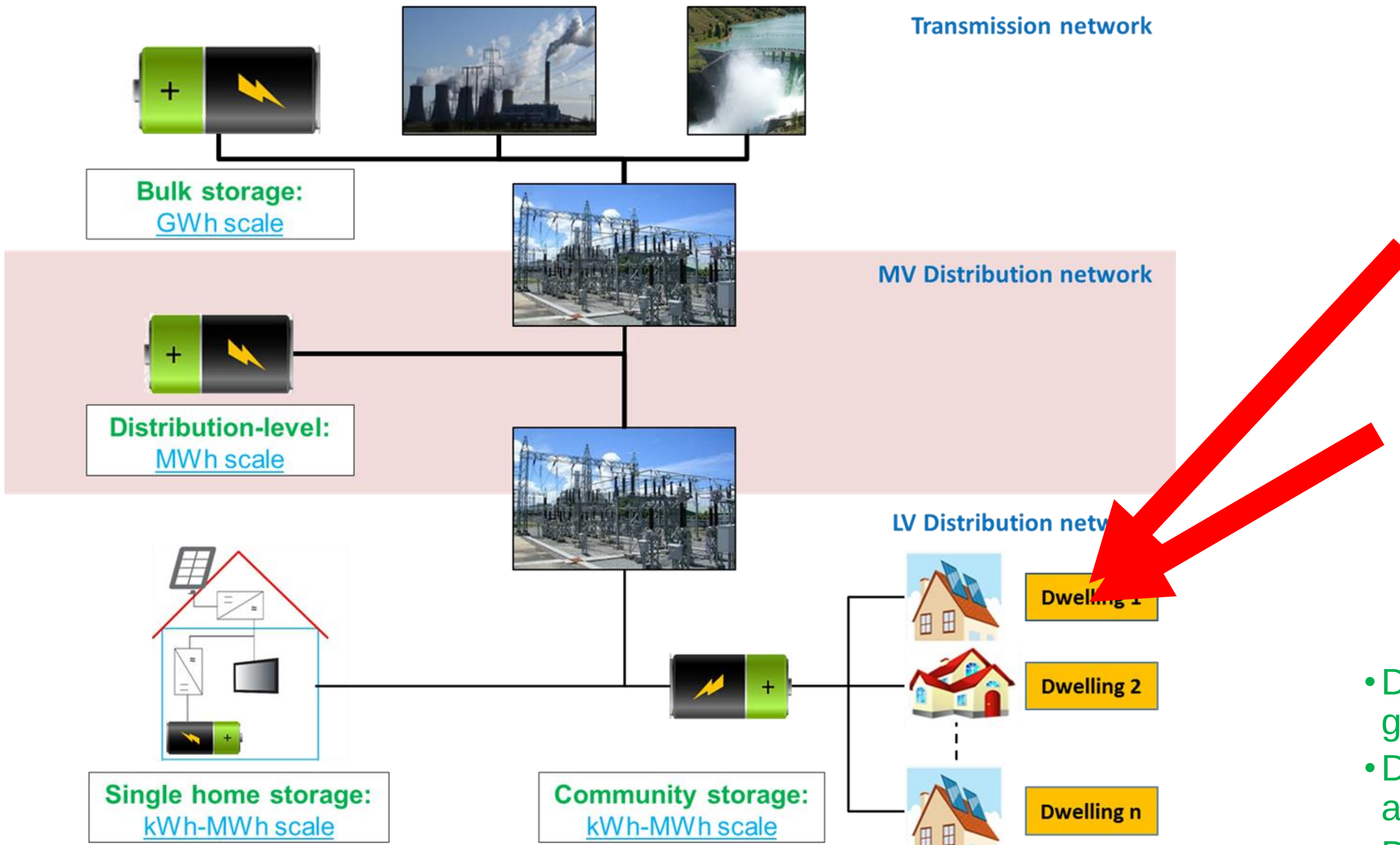

Generation

Renewable energy

Management

- Demand load and generator
- Different applications and technologies
- Different scales

Parra et al., 2016, Renewable & Sustainable Energy Reviews

Energy storage applications

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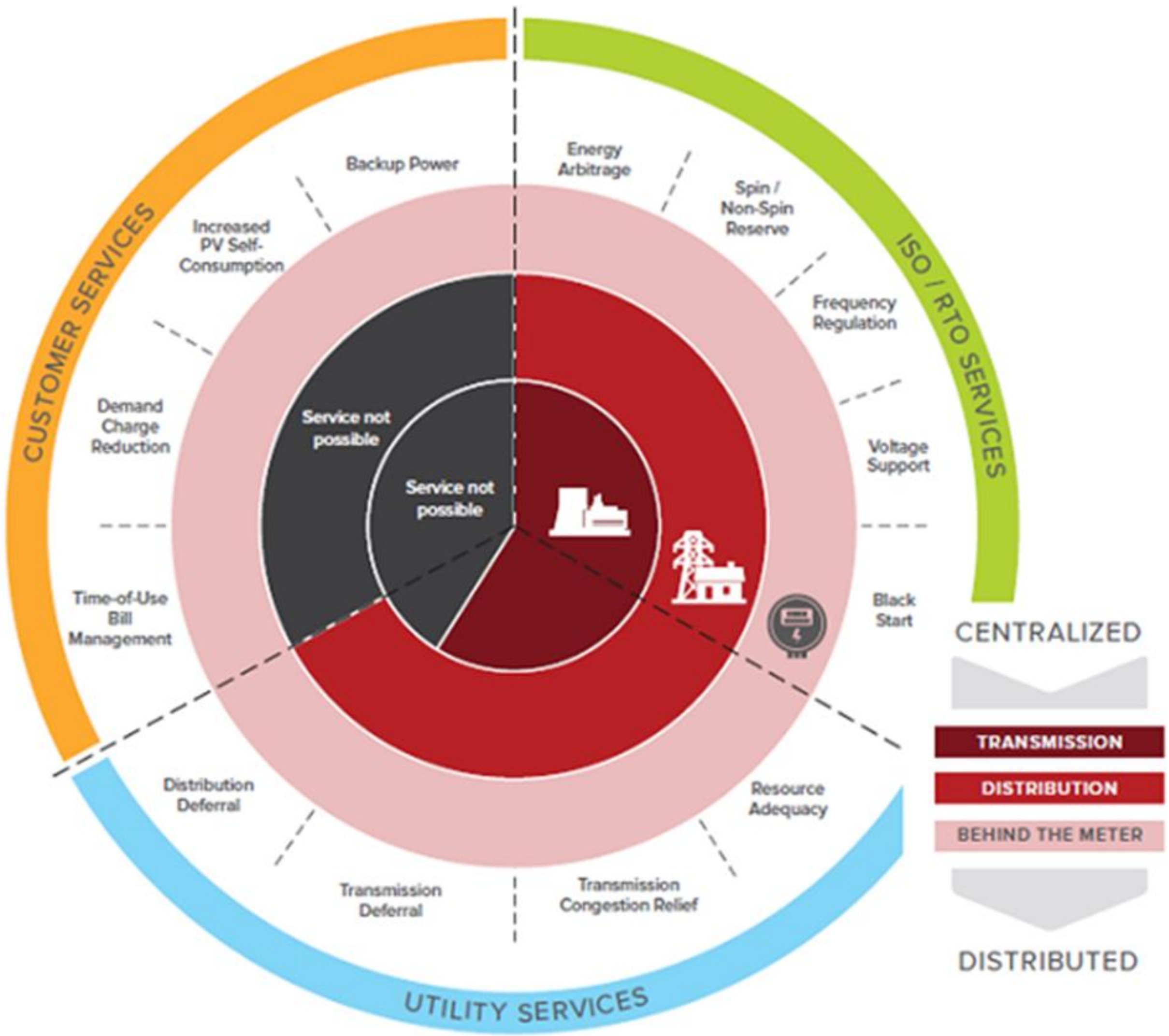
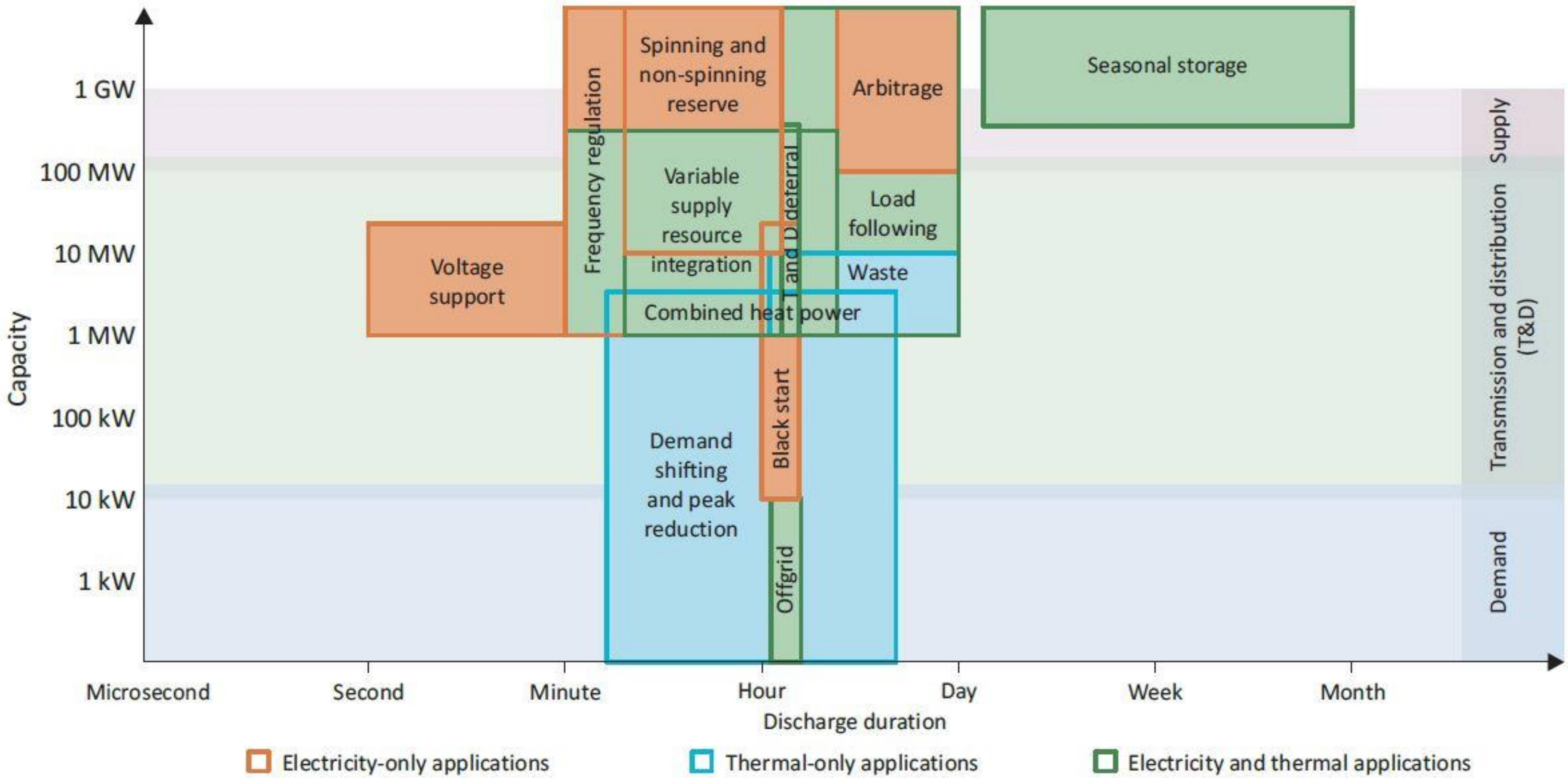


Dr. David Parra, April 12, 2018

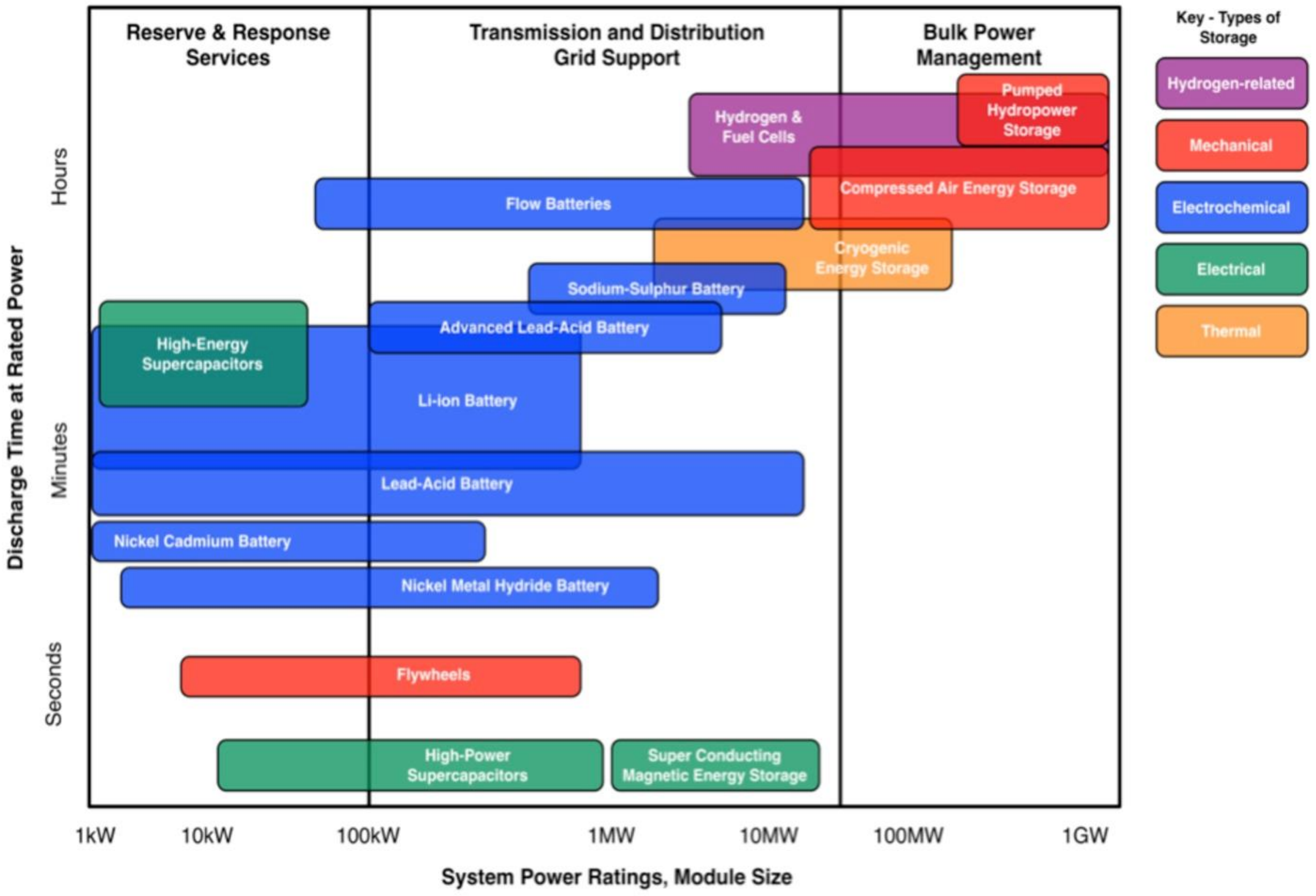
The Economics of Battery Energy Storage 2015, Rocky Mountain Institute

Energy storage applications



Technology Roadmap. Energy Storage 2014. International Energy Agency

Energy storage Technologies



P. Taylor et al., Pathways for energy storage in the UK

Energy storage Technologies

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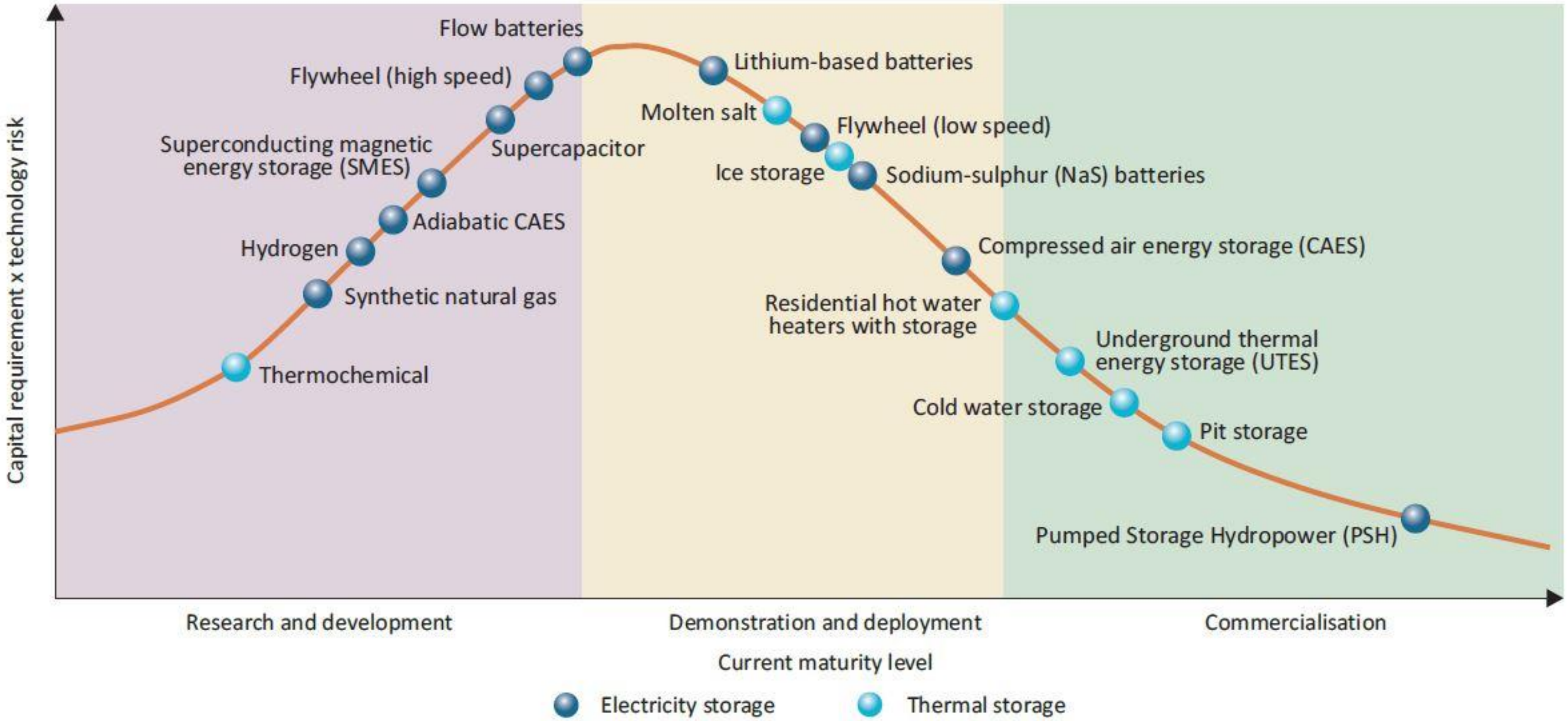

Technology Roadmap. Energy Storage 2014, International Energy Agency

Energy storage Technologies

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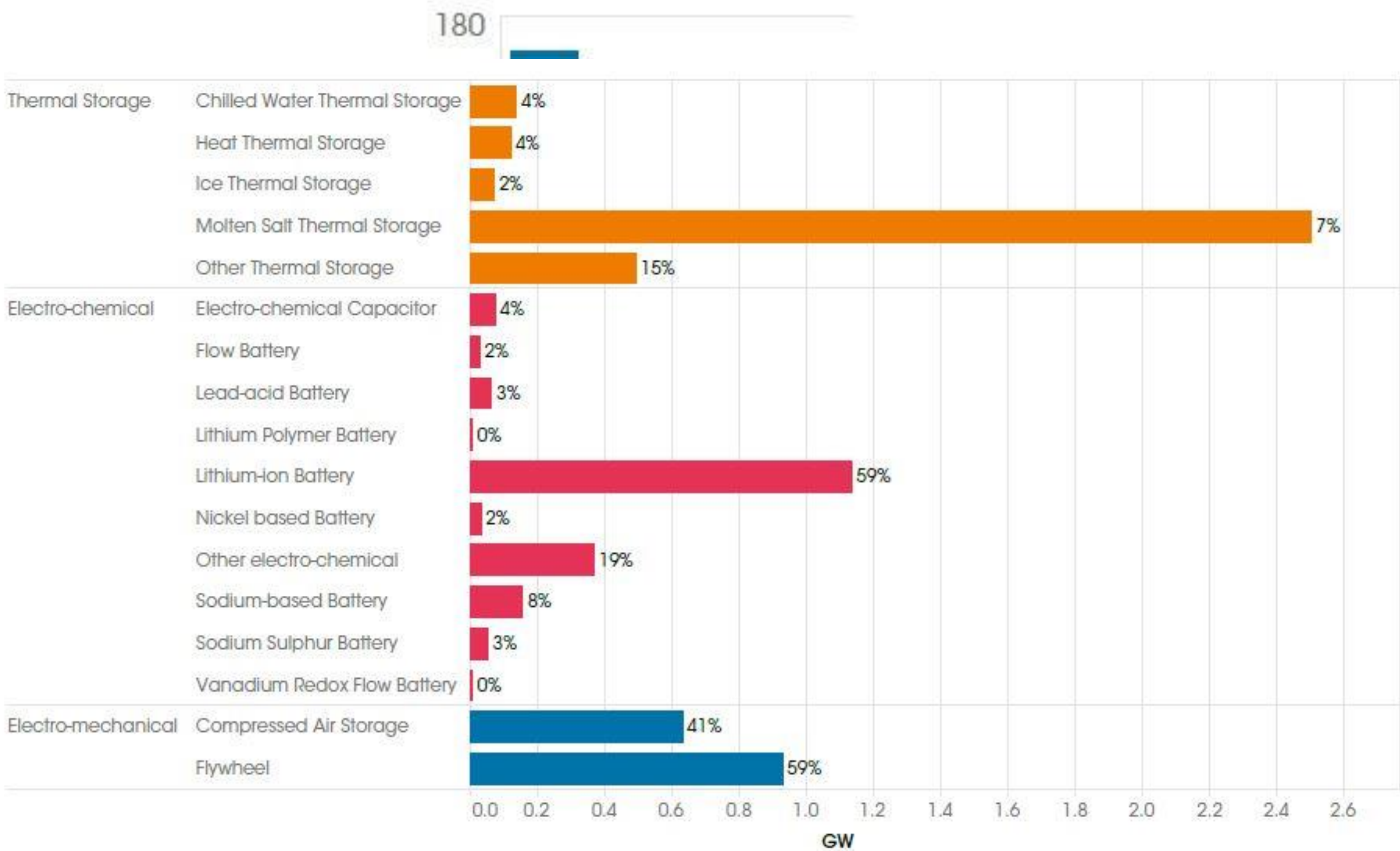
Mid-2017-Globally



Electricity storage and renewables: Costs and Markets to 2030, IRENA

Energy storage Technologies

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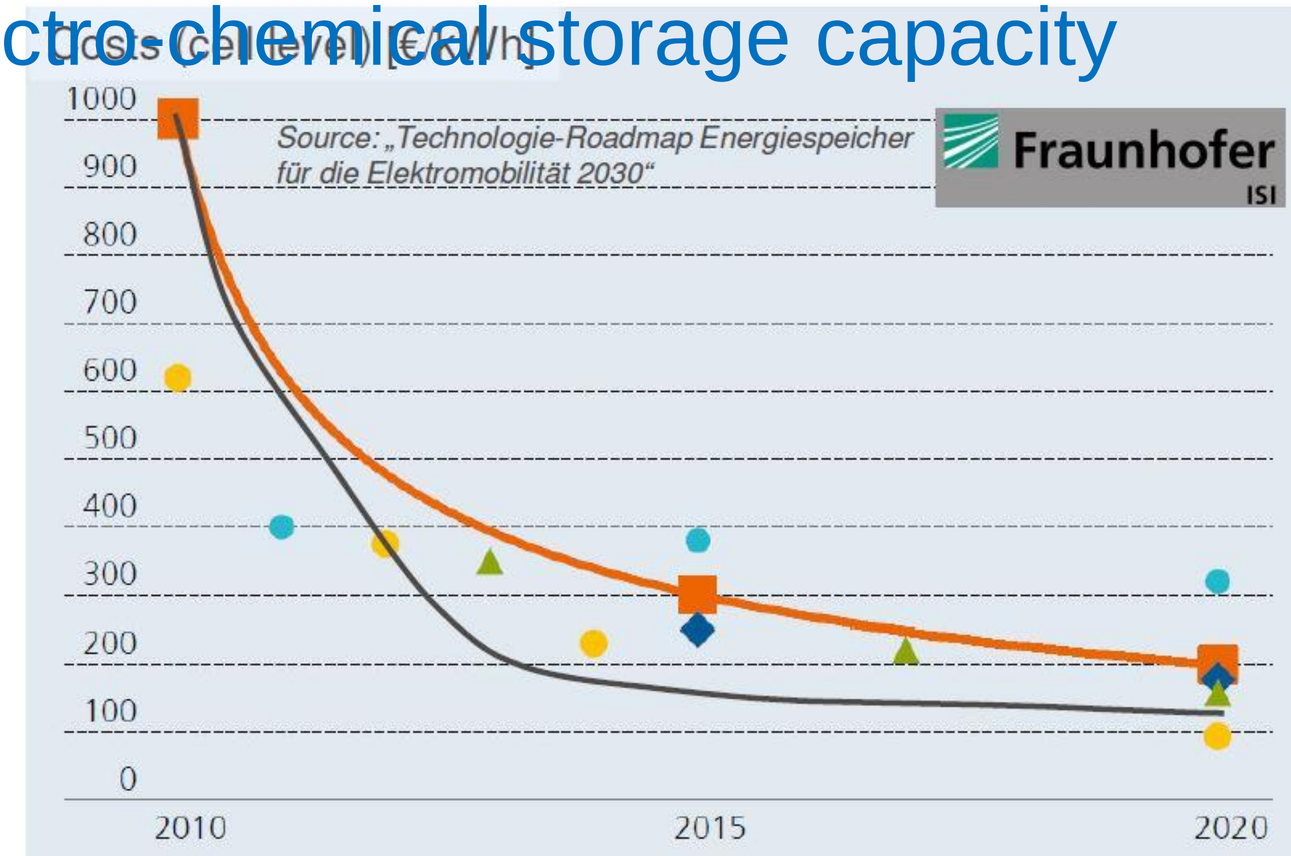
Global electro-chemical storage capacity



own estimation

Consumer-cells still cheaper (see TESLA)

Electricity storage and renewables: Costs and Markets to 2030, IRENA

Residential market-Germany

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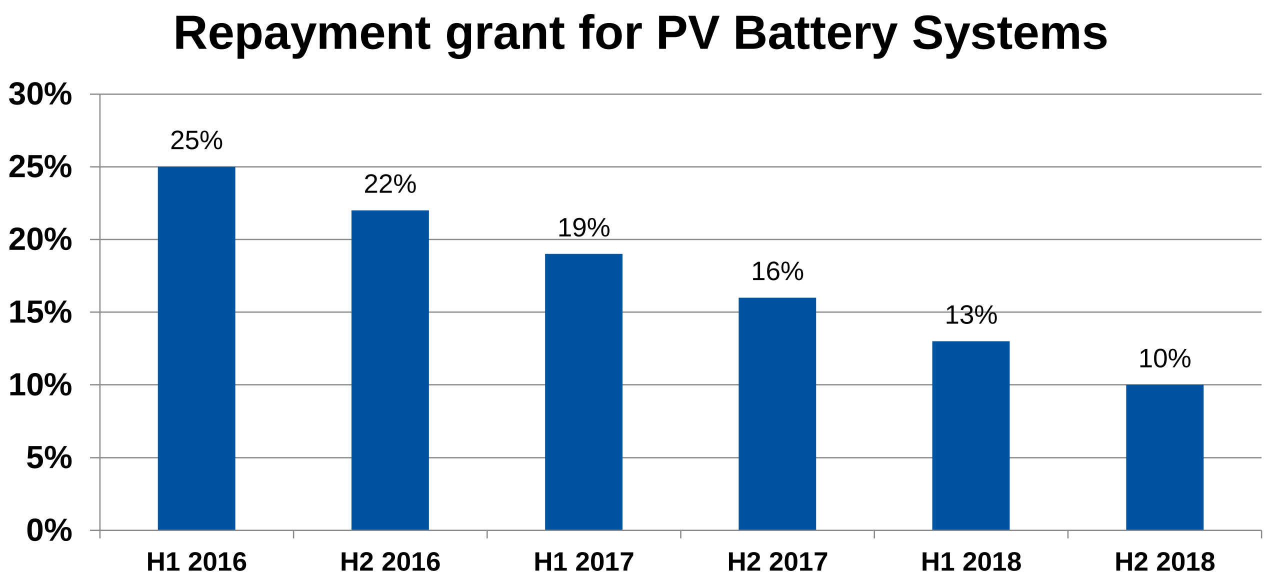
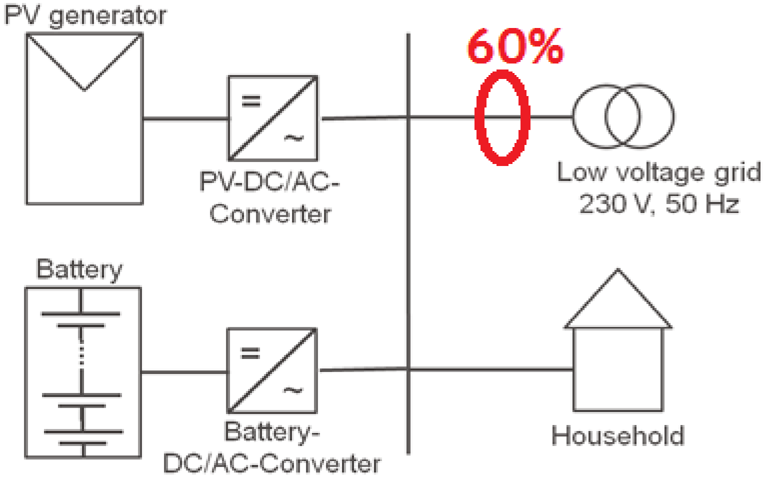
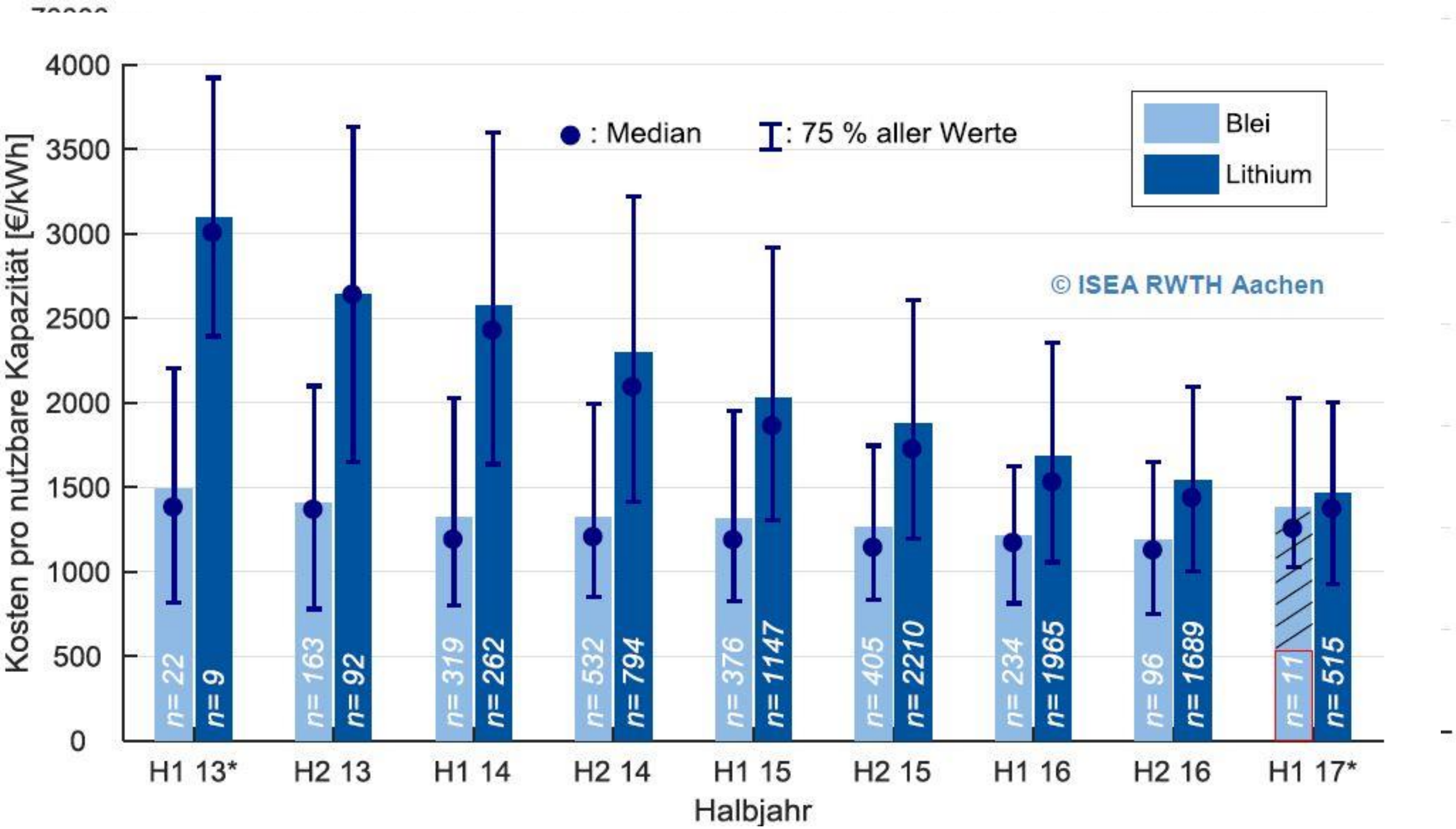




Wissenschaftliches Mess-und Evaluierungsprogram Solarstrompeicher 2.0, J. Figgener et al.

Residential market-Germany



Wissenschaftliches Mess-und Evaluierungsprogram Solarstrompeicher 2.0, J. Figgener et al.

Switzerland - 5 GWh of pumped-hydro ca

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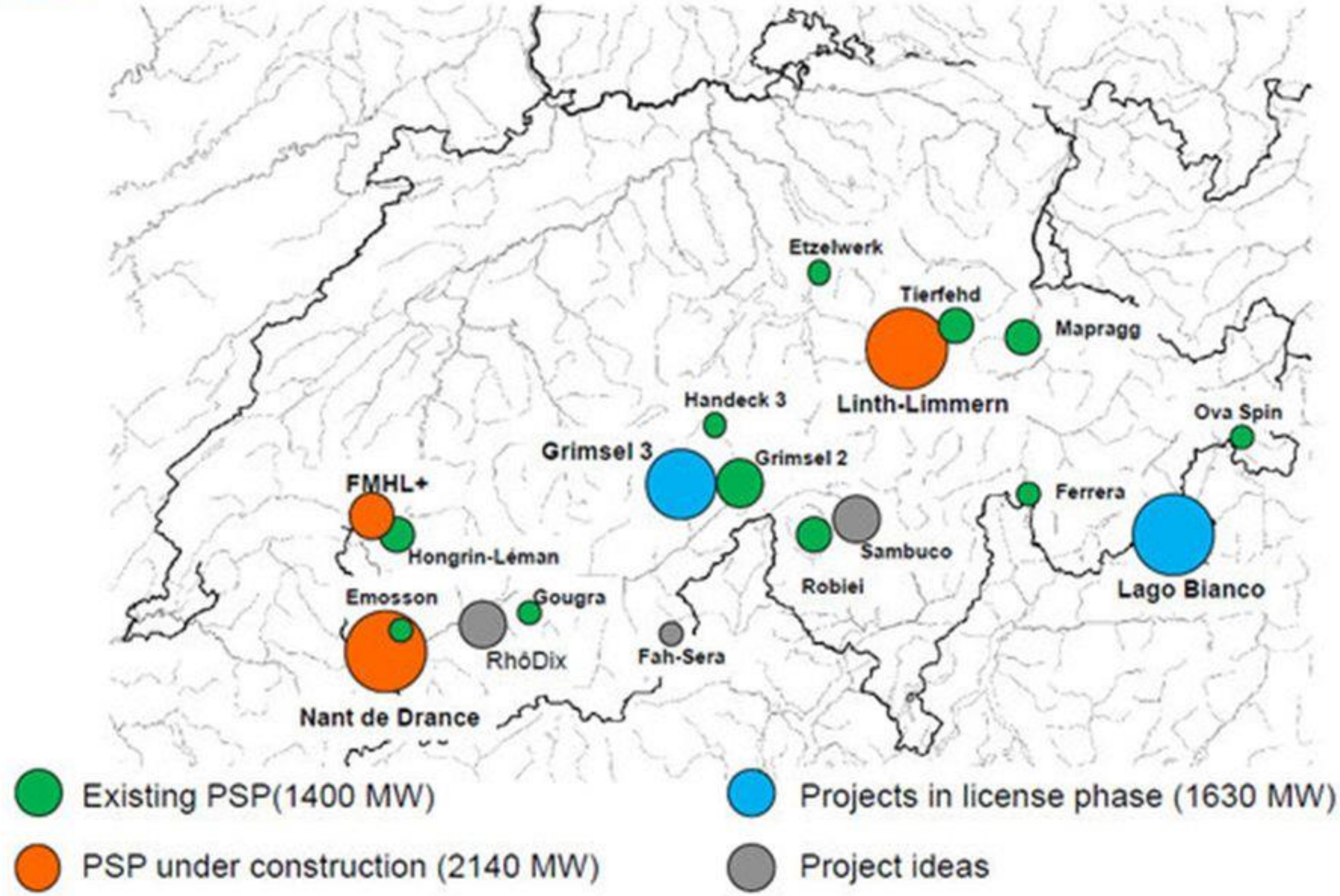
EPFL
ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE

Pompage – turbinage - Suisse



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Presentation from Marcel Jufer, EPFL

Switzerland

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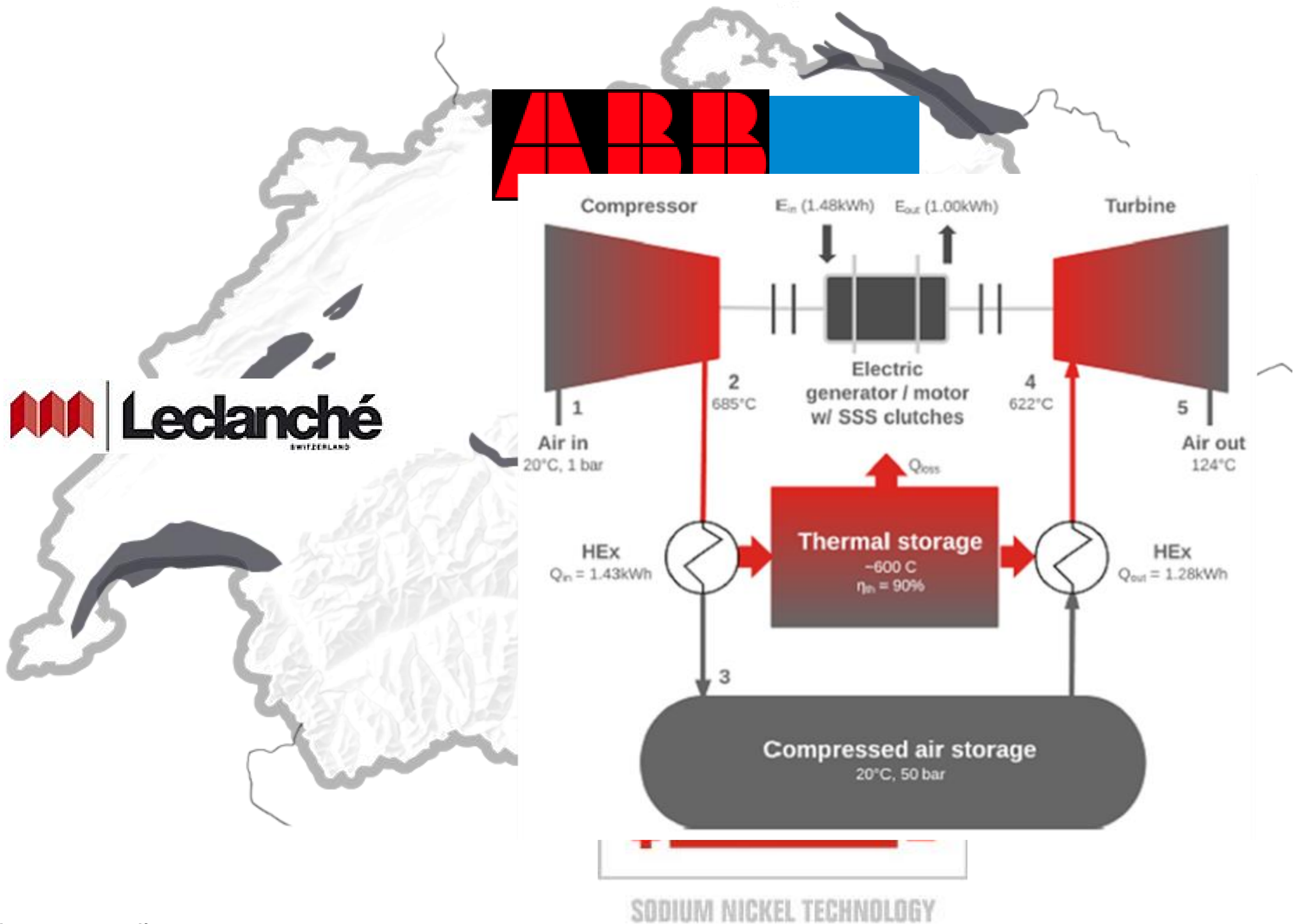
Battery storage



Switzerland-Canton Vaud

	Villa	Habitat collectif	Administration	Commerce
Surface de référence énergétique [m2]	200	1'200	1'000	1'000
Consommation annuelle [MWh]	5.1	27	48.5	58
Installation Photovoltaïque	Puissance : 6 kWp Production : 6 MWh/an Coût : 18'000 CHF	Puissance : 33 kWp Production : 33 MWh/an Coût : 64'400 CHF	Puissance : 50 kWp Production : 50 MWh/an Coût : 93'200 CHF	Puissance : 60 kWp Production : 60 MWh/an Coût : CHF 109'200 CHF
Batterie	Capacité : 6 kWh Coût : 12'000 CHF	Capacité : 33 kWh Coût : 35'000 CHF	Capacité : 20 kWh Coût : 24'000 CHF	Capacité : 25 kWh Coût : 28'000 CHF

CHF 2000 + 400 CHF/kWh

Swiss Competence Center in Storage- Phase I (2014-2017)

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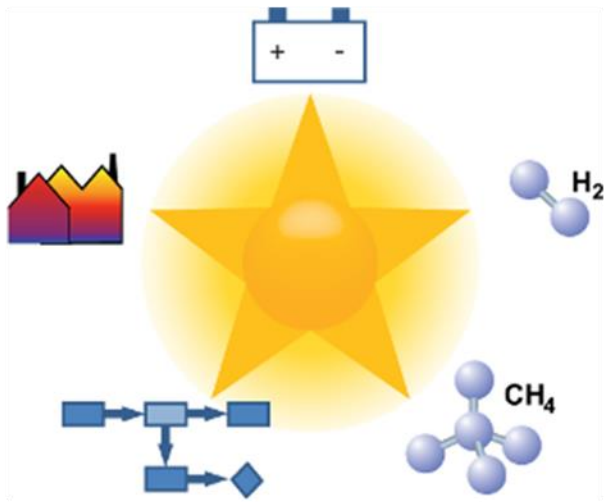
Advanced battery and battery materials



Thermal energy storage

Hydrogen production and storage

Technology interaction of storage systems

Advanced catalysts for CO_2 reduction

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PAUL SCHERRER INSTITUT PSI

Lucerne University of Applied Sciences and Arts HOCHSCHULE LUZERN

SCCER-STORAGE phase II (2017-2020)

Technology Level

Expand Assessment Methodology
- Focus on Thermal Energy Storage
- Future ES technology

Assess Demonstrators
- Coordinated, common Methods
- P2G, P2H2

Close links to all WP 1- 4
Link to Joint Activity Demonstrators

Energy-Systems Level

- Identify role of Energy Storage
- Centralized/decentralized ES
- Time scales of ES
- Capacity of ES

Link to WP 1- 4
Link to Joint activity Scenarios and Modelling

Socio Economic Level
- Policy and technological change
- GDP, effects on employment

Close link to SCCER CREST
Link to Joint Activity Socio-economic and technical planning of multi-energy systems

Component

Energy System

Socio Economic / Policy

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UNIGE's research

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1. Life cycle cost and life cycle emissions
2. Combination of applications
3. Renewable heat and fuel
4. Analysis at various scales, namely local, district and national
5. Community scale

Storage
Swiss Competence Centers for Energy Research
Lucerne University of Applied Sciences and Arts
HOCHSCHULE LUZERN
PAUL SCHERRER INSTITUT
PSI
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Life cycle cost and emissions-Study 1

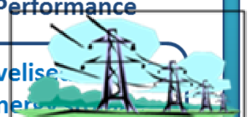
1 MW	Short TS 0.01h	Medium TS 4.5h	Long TS 2'160h
Cycles	20 per day	1 per day	1 per year
Annual Energy Supply from Storage	81 MWh	1'643 MWh	2'160 MWh

Technology Performance

efficiency, durability, Lifetime, etc

Economic Performance

levelised energy … (LCOES)

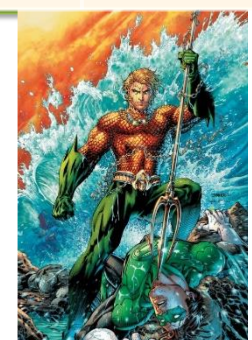


Environmental Performance

emissions (GHG)

100 MW	Short TS 0.01h	Medium TS 4.5h	Long TS 2'160h
Cycles	20 per day	1 per day	1 per year
Annual Energy Supply from Storage	8'091 MWh	164'250 MWh	216'000 MWh

ons



Parra et al., 2017, Energy

Research questions

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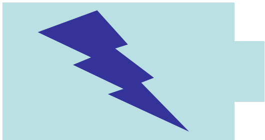
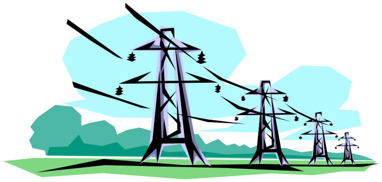
- How the energy storage technologies compare with each other at different discharge time and system scales?

- How do key parameters affect the performance of storage? (costs, lifetime, round-trip efficiency, price & type of electricity)



?

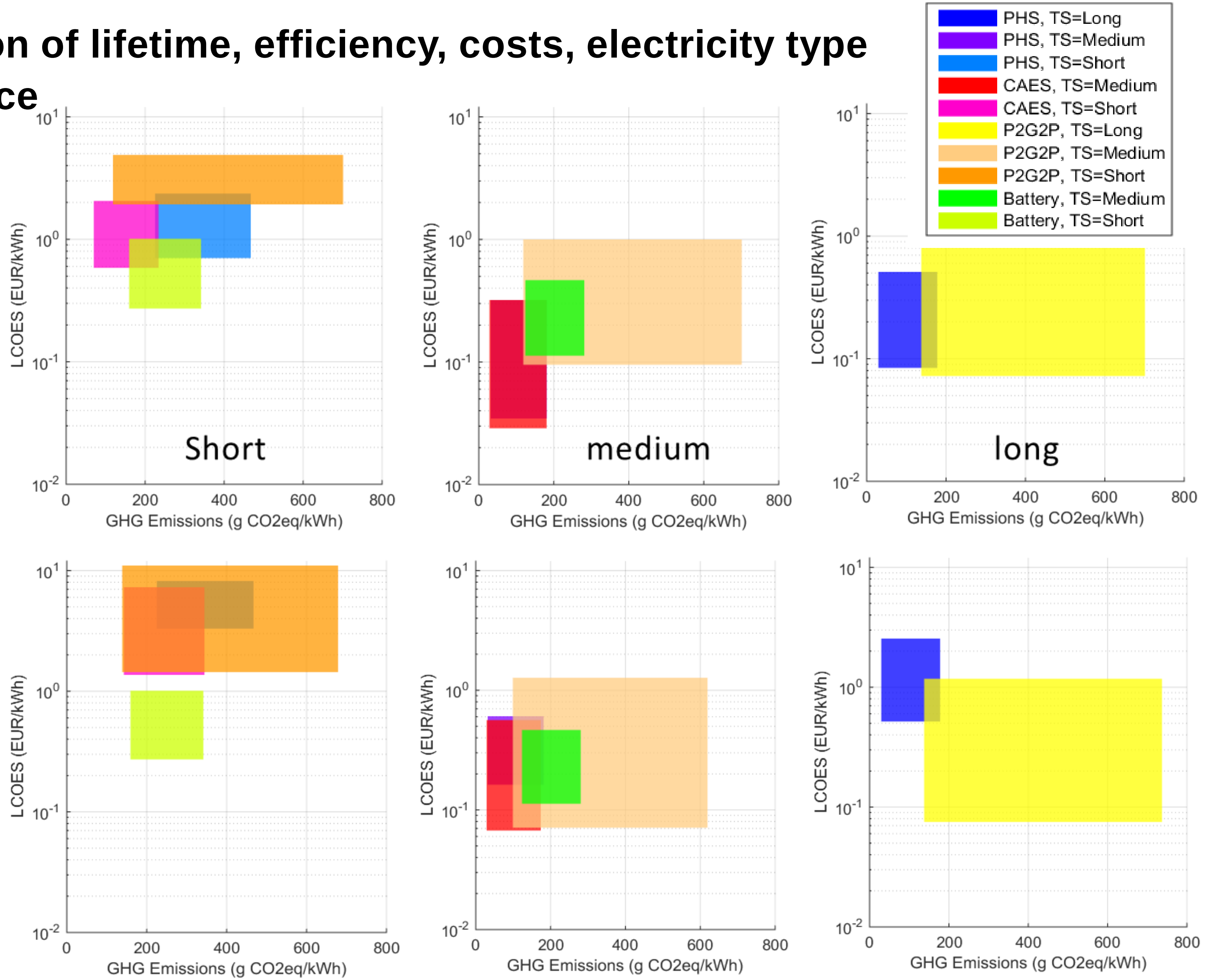


Focus: stationary electricity storage

Target of assessment: 1 kWh of electricity supply from storage

Performance Indicators: life cycle GHG emissions, levelized cost of electricity

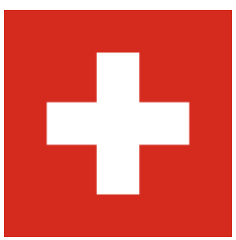
Variation of lifetime, efficiency, costs, electricity type and price



Parra et al., 2017, Energy

Battery technologies

Abbr.	Application	Site	Power [kW]	Energy [kWh]	Energy-to-Power Ratio	Usage [#cycles p.a.]	Energy delivered [kWh p.a.]
WA	*Wholesale Arbitrage*	*Generation/ Grid site*	10,000	60,000	6	365	21,900,000
AF	*Area & Freq. Regulation*	*Generation/ Grid site*	10,000	5,000	0.5	176	880,000
TD	*T&D Upgrade Deferral*	*Grid site*	10,000	50,000	5	250	12,500,000
PS	*Demand Peak Shaving*	*C&I sites*	125	250	2	104	26,071
SC	*Increase of Self-Consumption*	*Residential end-consumer*	2.5	5	2	250	1,250



33 g CO2/kWh

485 g CO2/kWh

770 g CO2/kWh

Different battery chemistries

Schmidt et al., in preparation

Battery technologies

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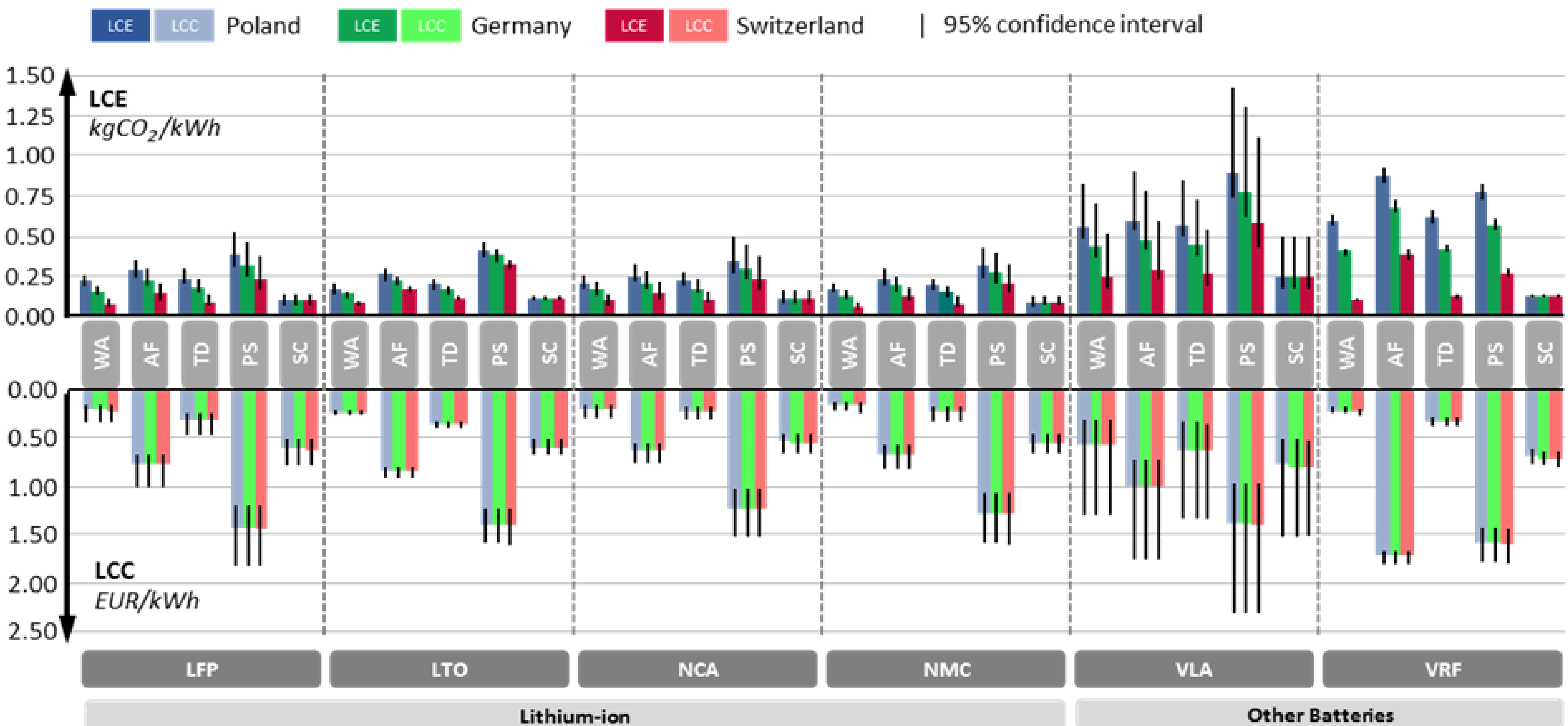

Findings

- Li-ion is the benchmark battery technology
- The life cycle cost of batteries depends on the system cost, while the life cycle emissions depend on the geography
- There are not trade-offs between the climate and economic dimension

Schmidt et al., in preparation

UNIGE's research

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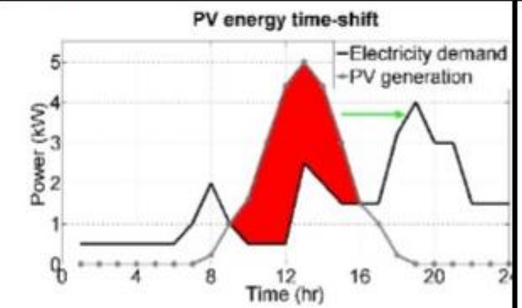
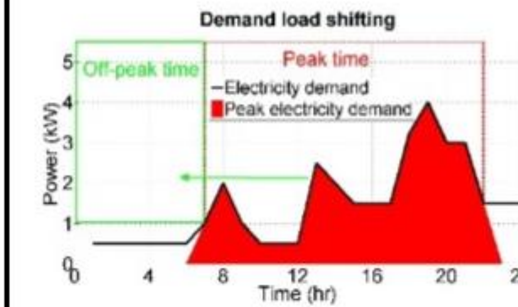
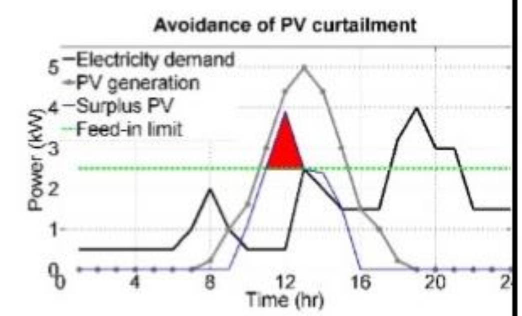
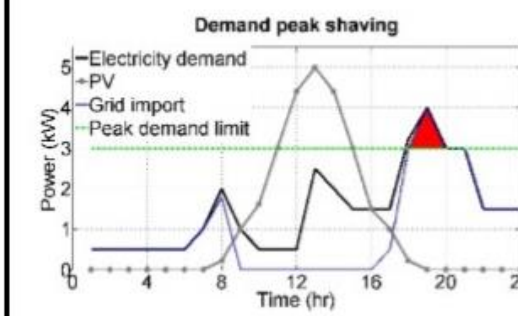
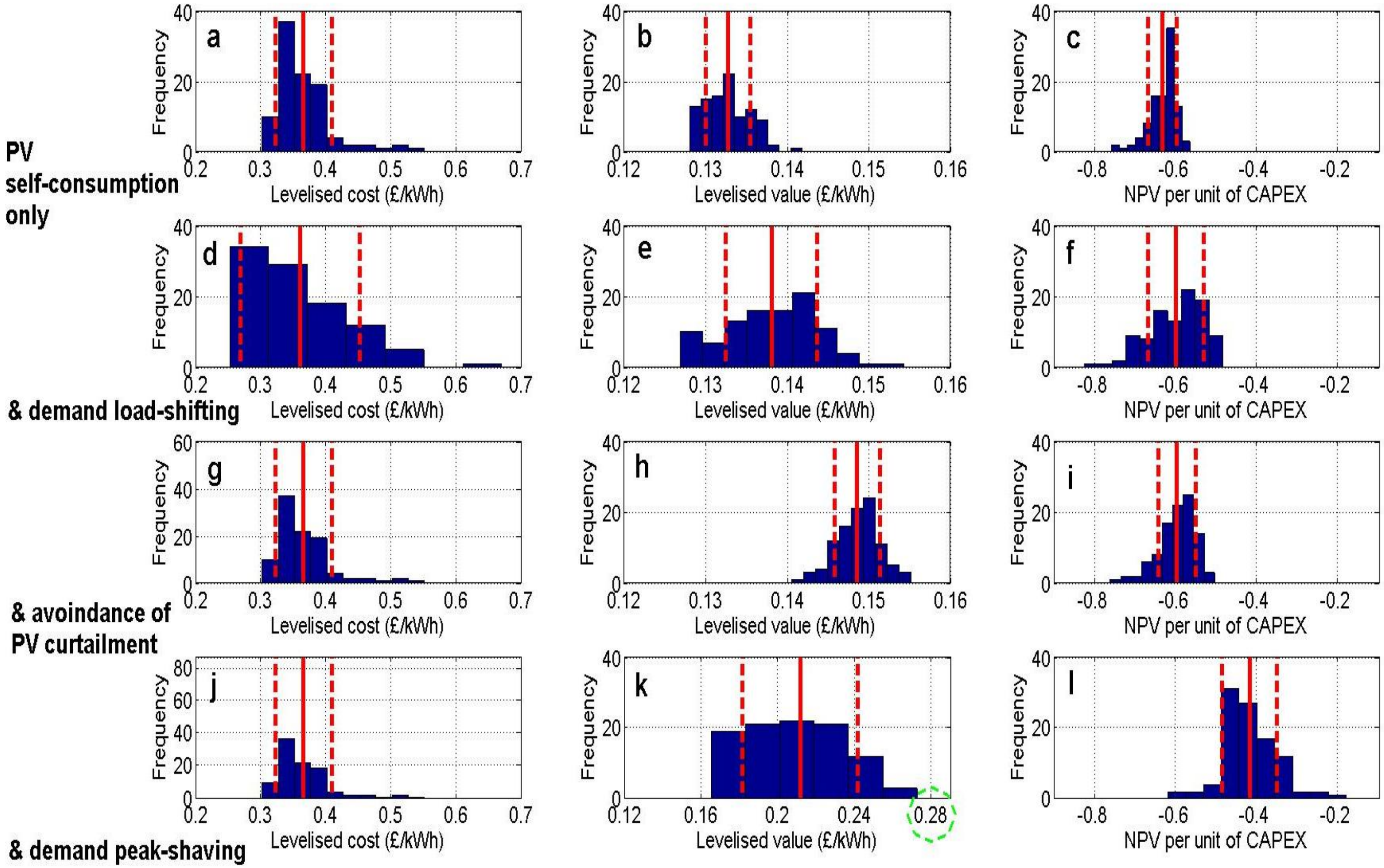
Combination of applications

Application	Remarks	Application	Remarks
	- Energy application - Supply side - PV charging - Driver: difference between retail price and feed-in tariff - We focus on the UK		- Energy application - Demand side - Grid charging - Driver: varying-price tariffs - We use a 2-period time-of-use tariff: Economy 7 [22]
	- Power application - Supply side - PV charging - Driver: regulation (e.g., Germany) or capacity-based tariffs - We use a feed-in limit of 50% of PV capacity [24]		- Power application - Supply side - PV or grid charging - Driver: capacity-based tariffs - We use a value of 8 £/ kW_{peak}·month [26]

Parra and Patel, under review

Combined applications



Parra and Patel, under review

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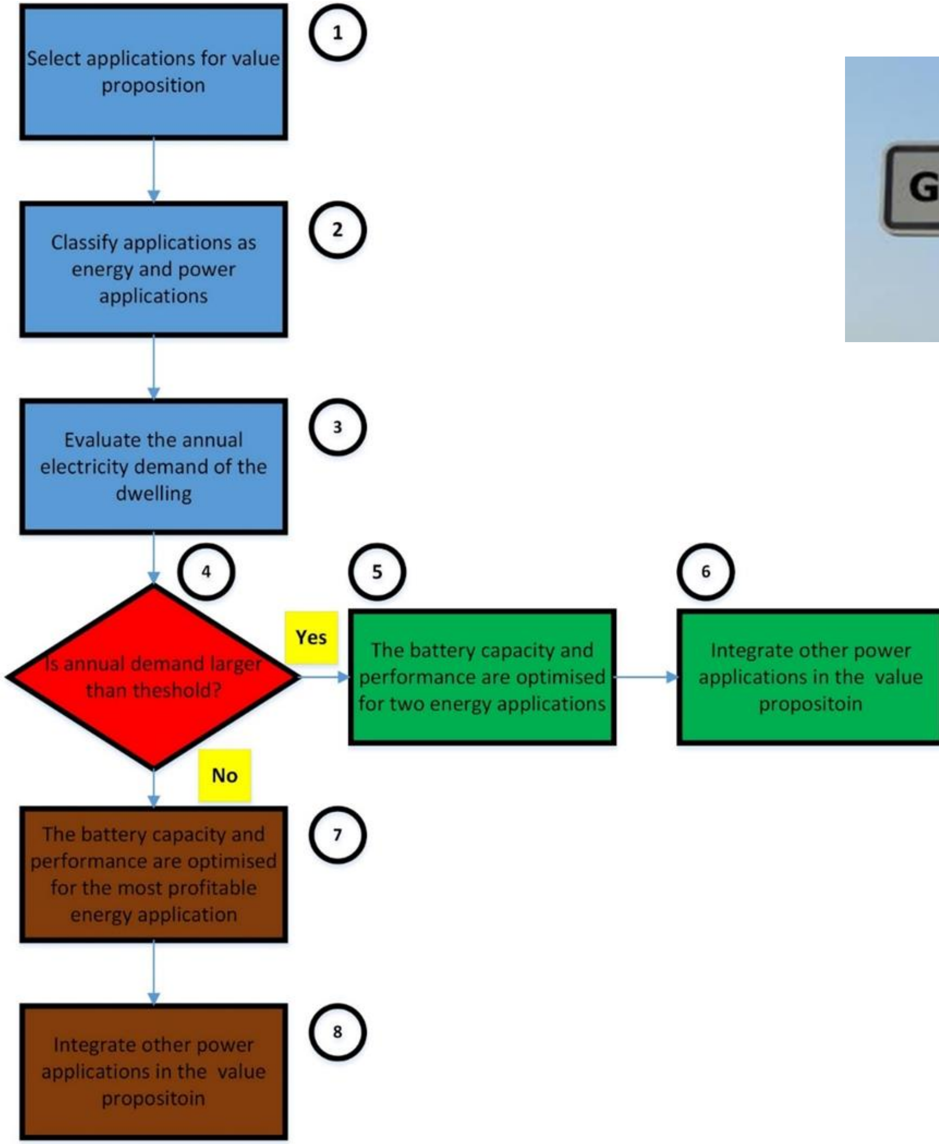

Parra and Patel, under review

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Power-to-gas

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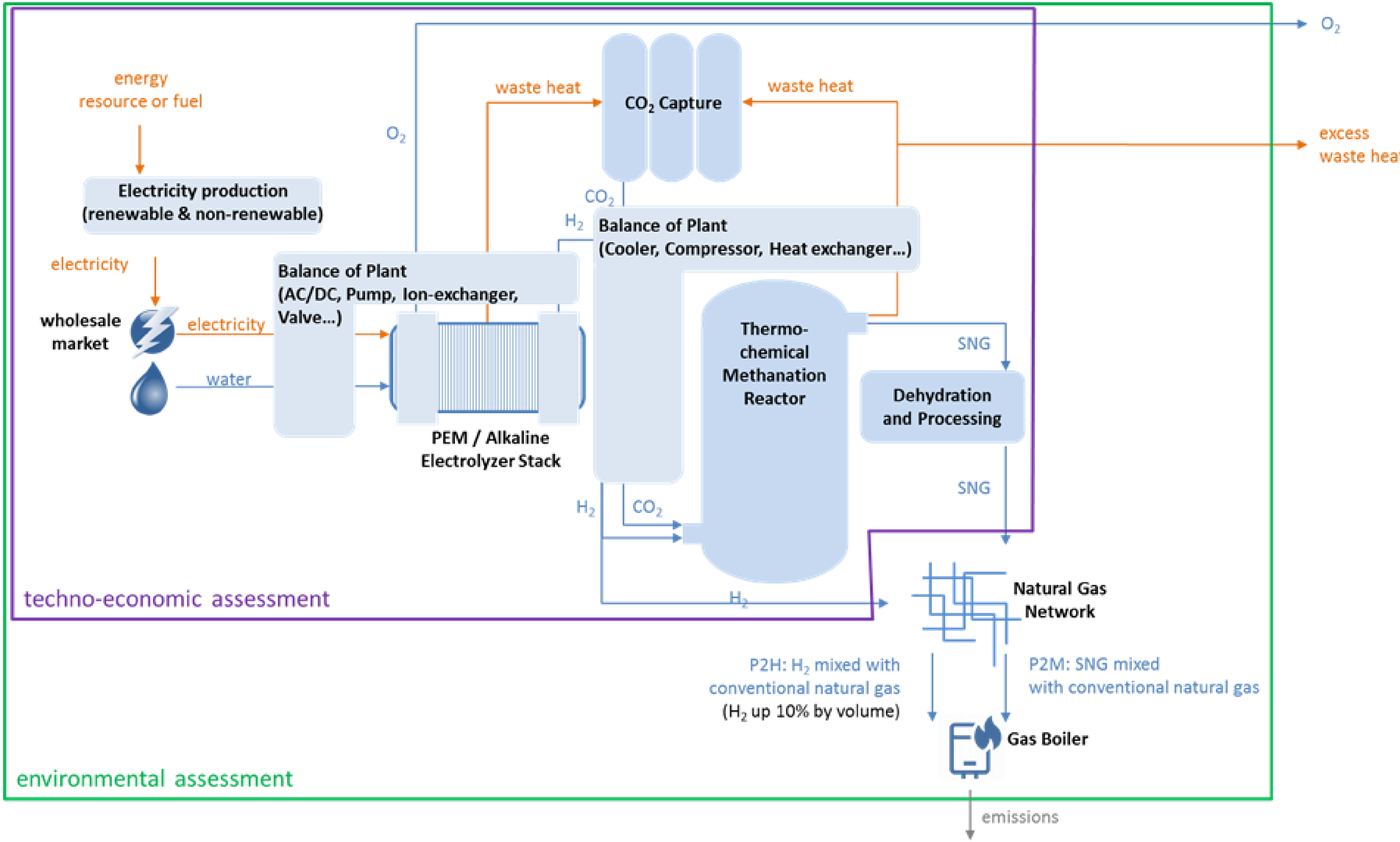
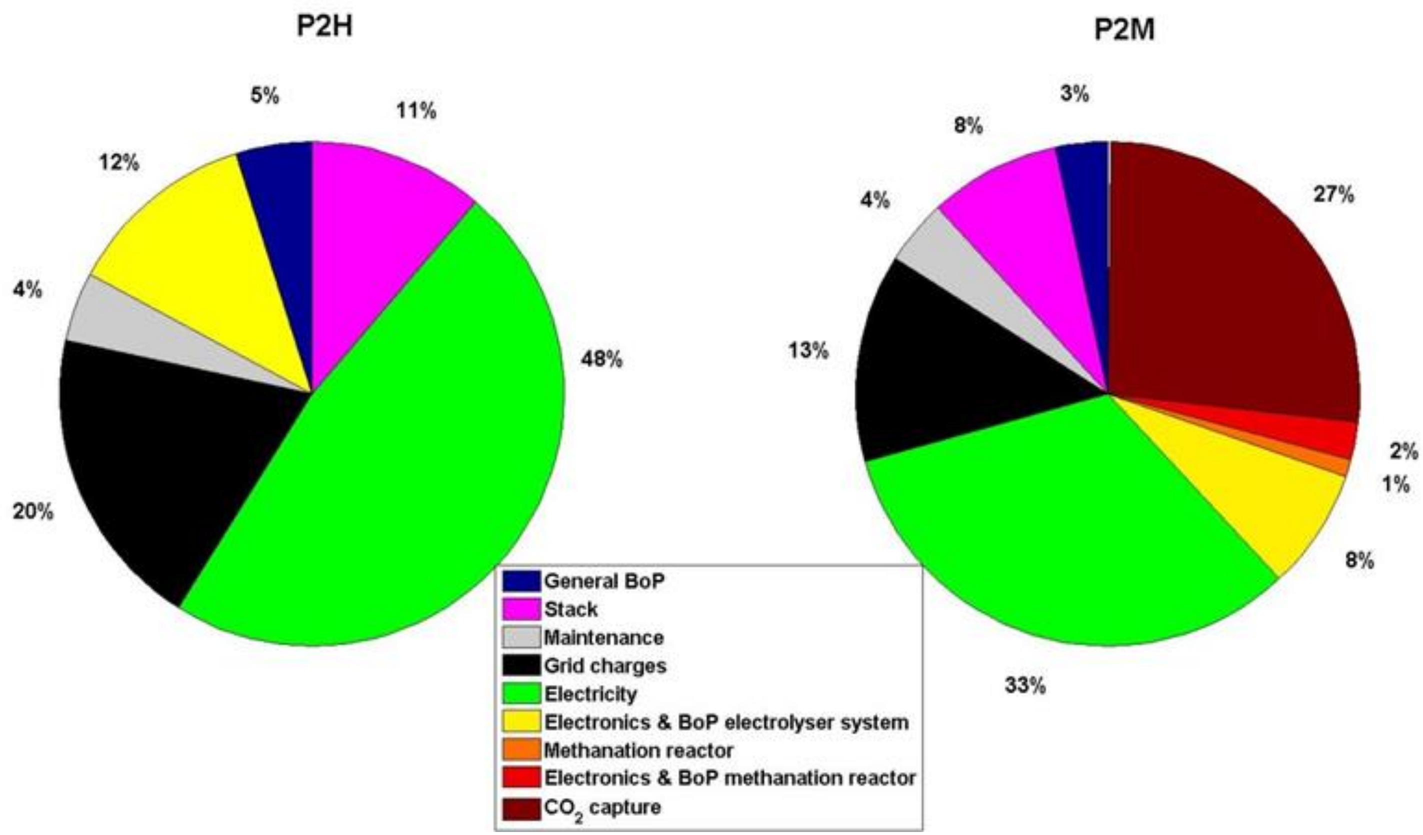


Power-to-gas



Levelised cost for different cost components (both CAPEX and OPEX) as a percentage of the total for a 1 MW P2H system and a 1 MW P2M system capturing CO2 from the air.

Parra et al., 2017, Applied Energy

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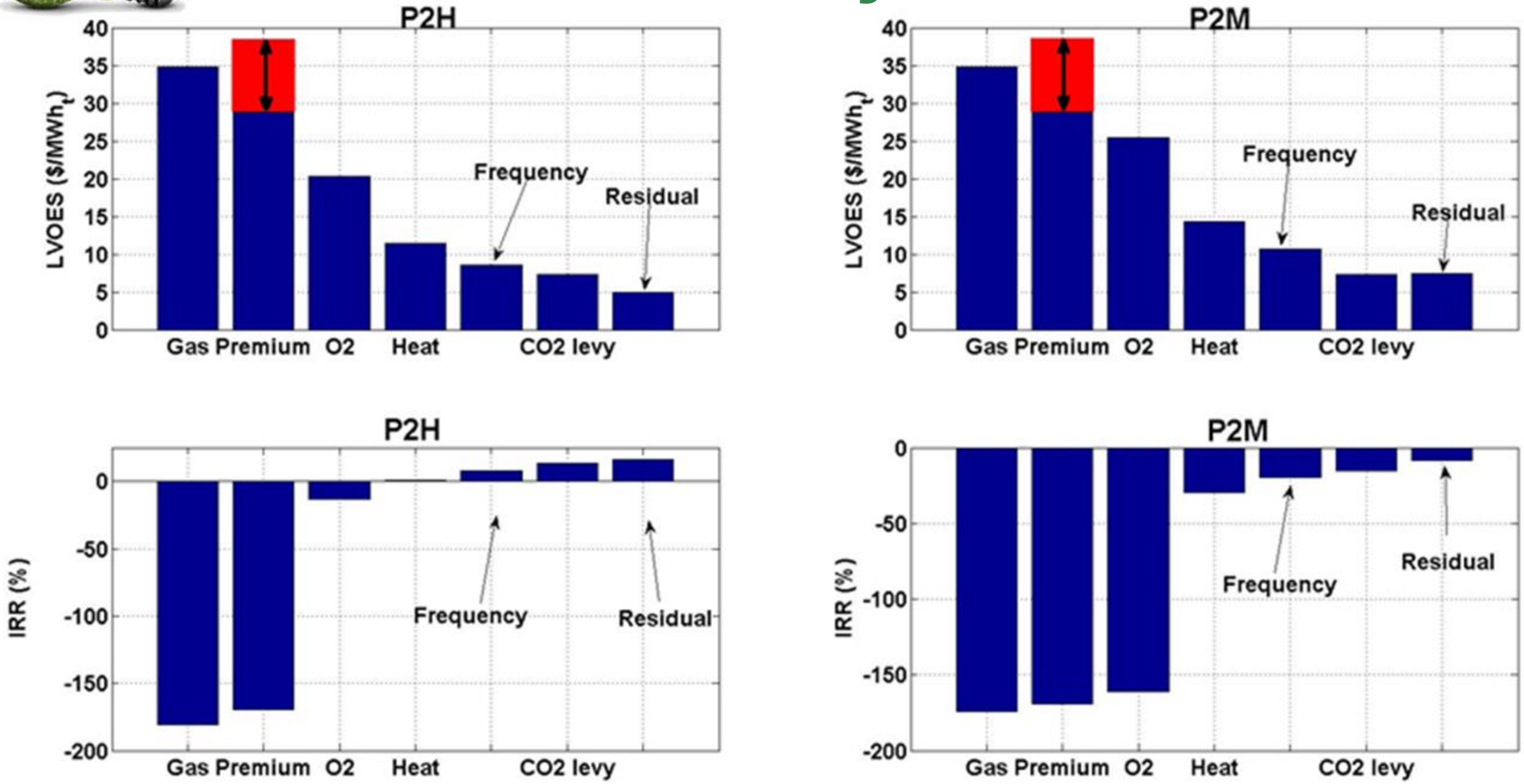
Cost benefit analysis



Levelised value (CHF/MWht) and internal rate of return (%) associated which services provided by a 1 MW P2H and a 1 MW P2M system with CO2 capture from air.

Parra et al., 2017, Applied Energy

Storage
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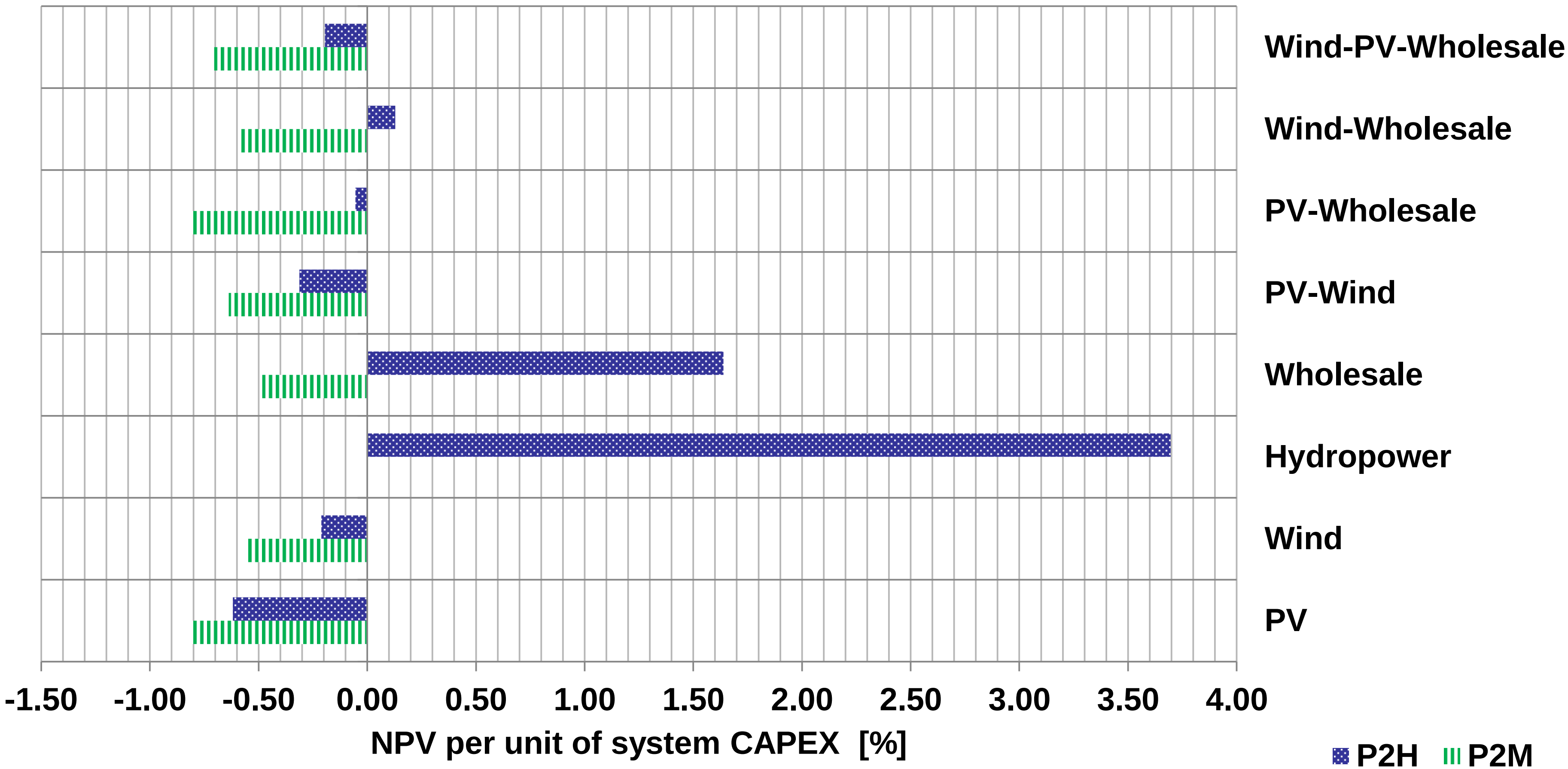
Power-to-gas



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Hassan et al., in preparation

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Role of energy storage at the national scale

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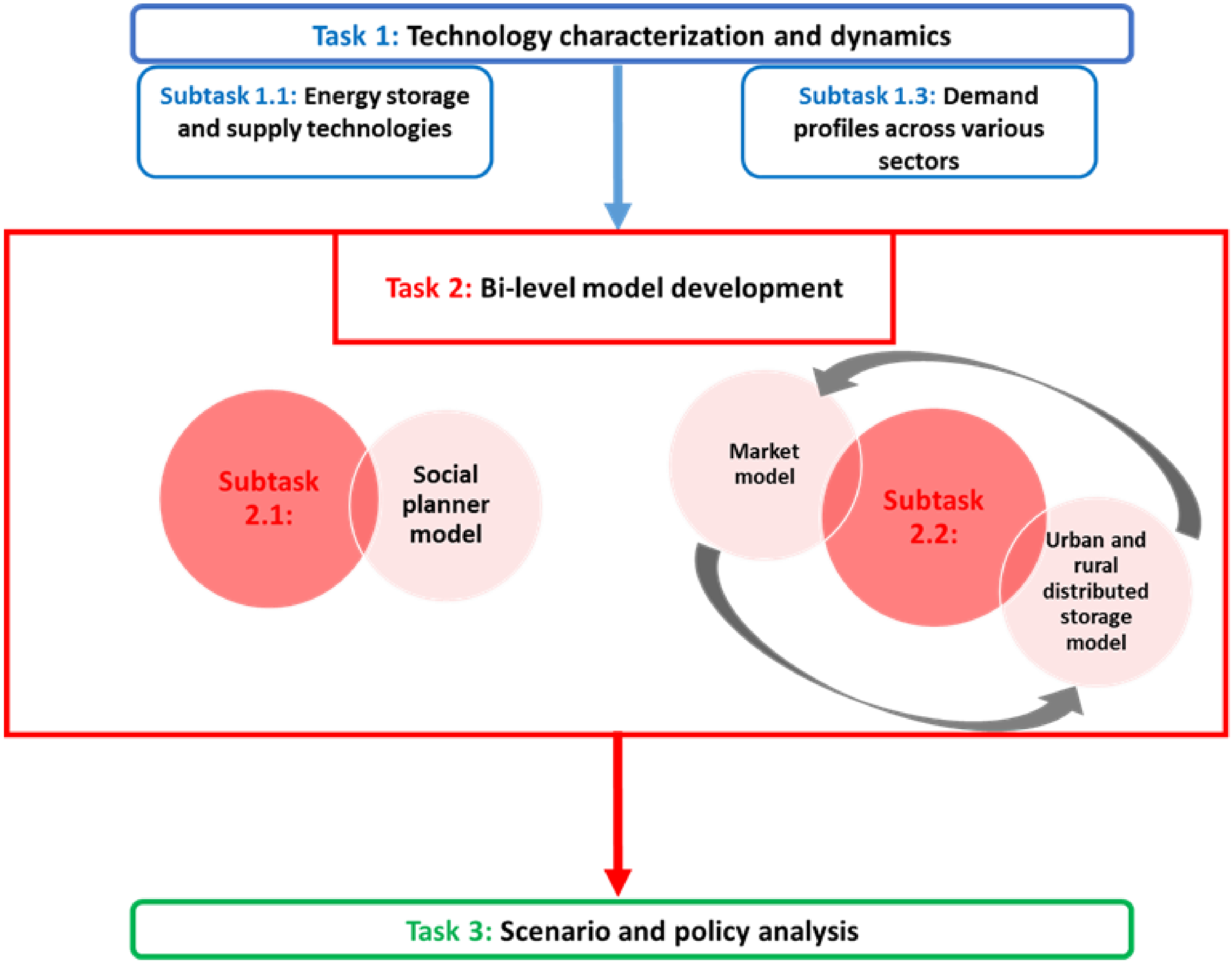


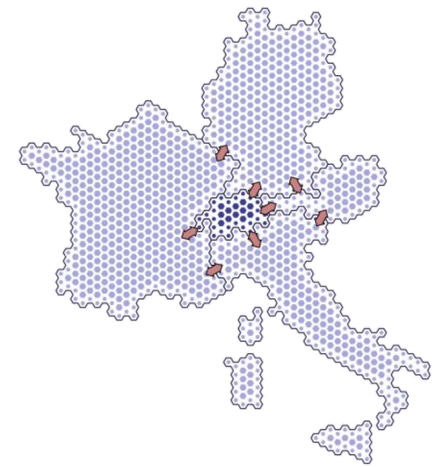
Storage
Swiss Competence Centers for Energy Research

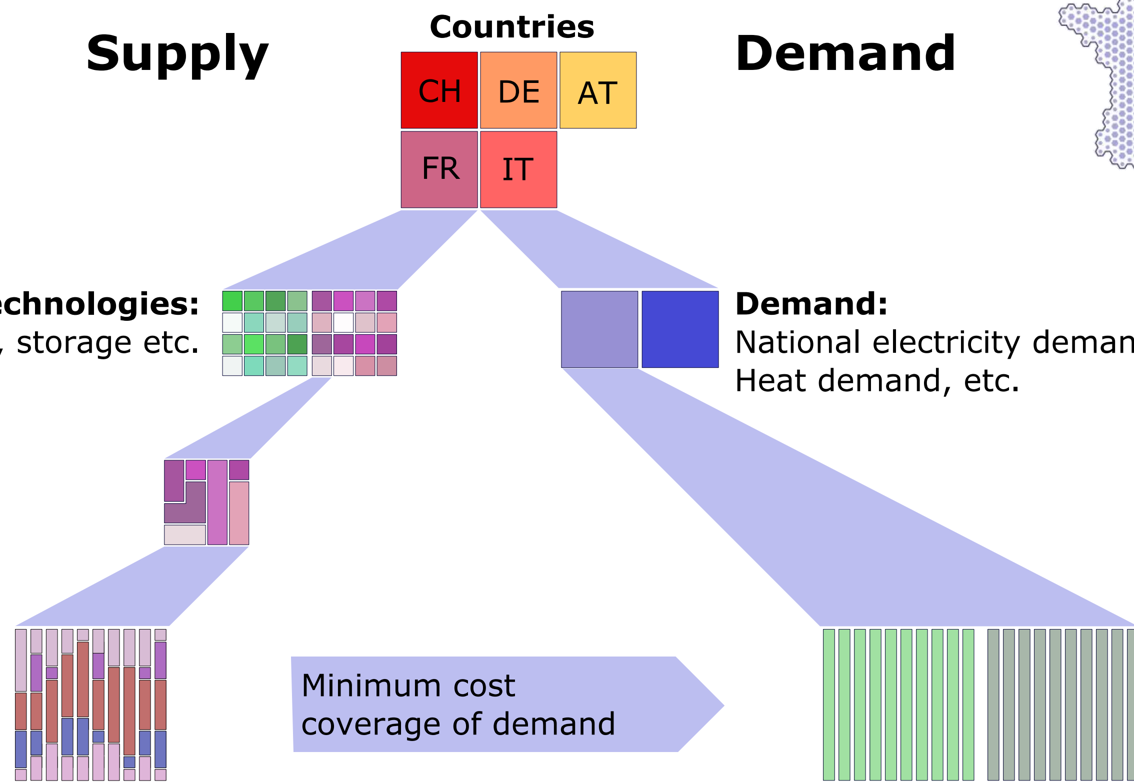
SCCER CREST

Heat demand

Technology characterisation

National-scale linear optimization model to in Switzerland (and neighbors)





M- Soini, in preparation

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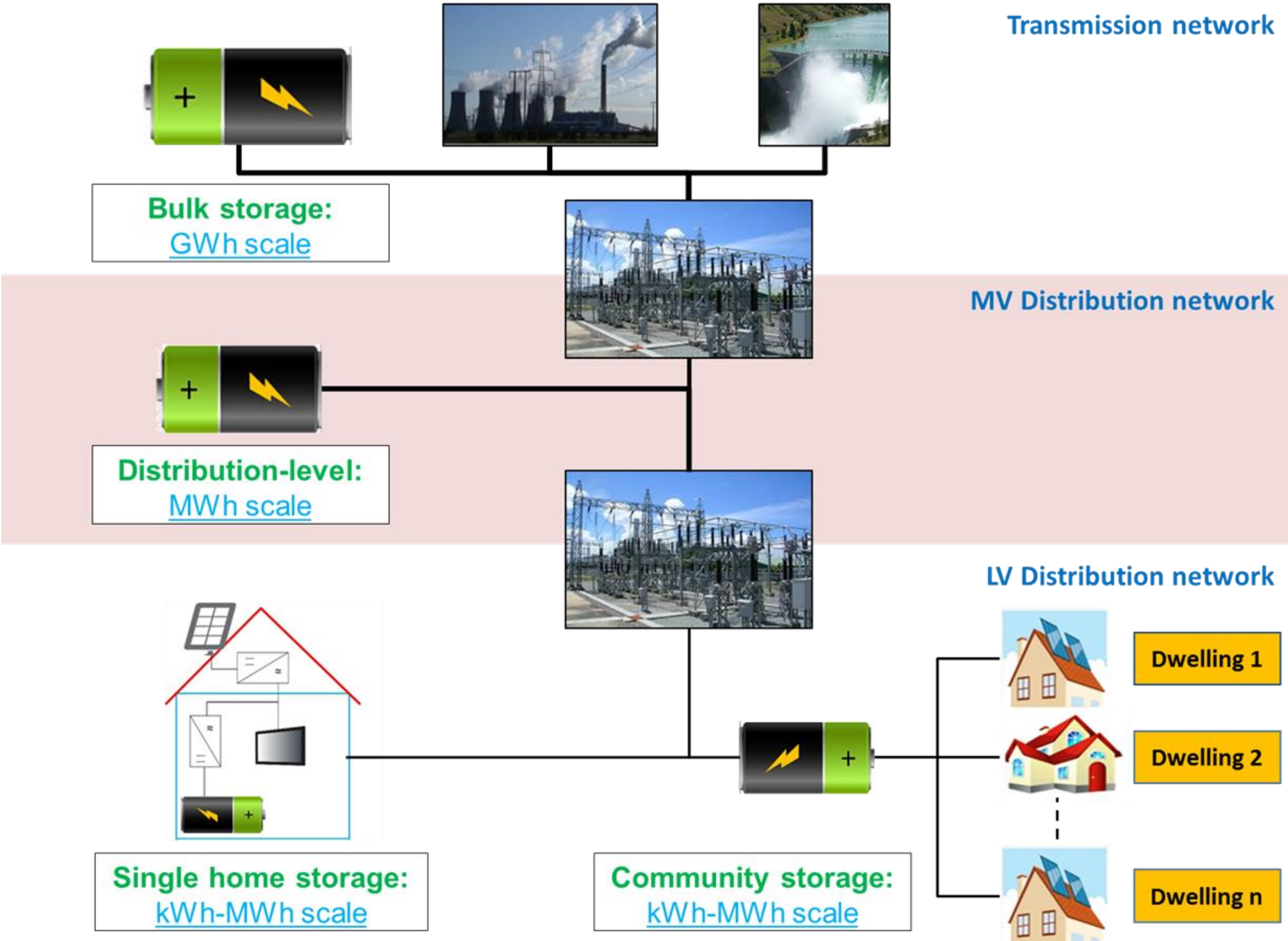
Energy storage



Parra et al., 2016, Renewable & Sustainable Energy Reviews

Community scale

Massachusetts Institute of Technology

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Table 2
Comparison of community batteries to households batteries.

	Individual household batteries	Community batteries
Total demand (MWh)	3244	3244
Solar generation (MWh)	851	851
Base imports	2523	2523
Base exports (MWh)	130	130
Total storage capacity (MWh)	13.0	8.5
Average IRR (%)	8.0	9.3
Imports with storage (MWh)	2464	2432
Exports with storage (MWh)	49.5	27.8
Import reduction per kWh storage (kWh per kWh storage)	4.6	10.7
Export reduction per kWh storage (kWh per kWh storage)	6.2	12.0

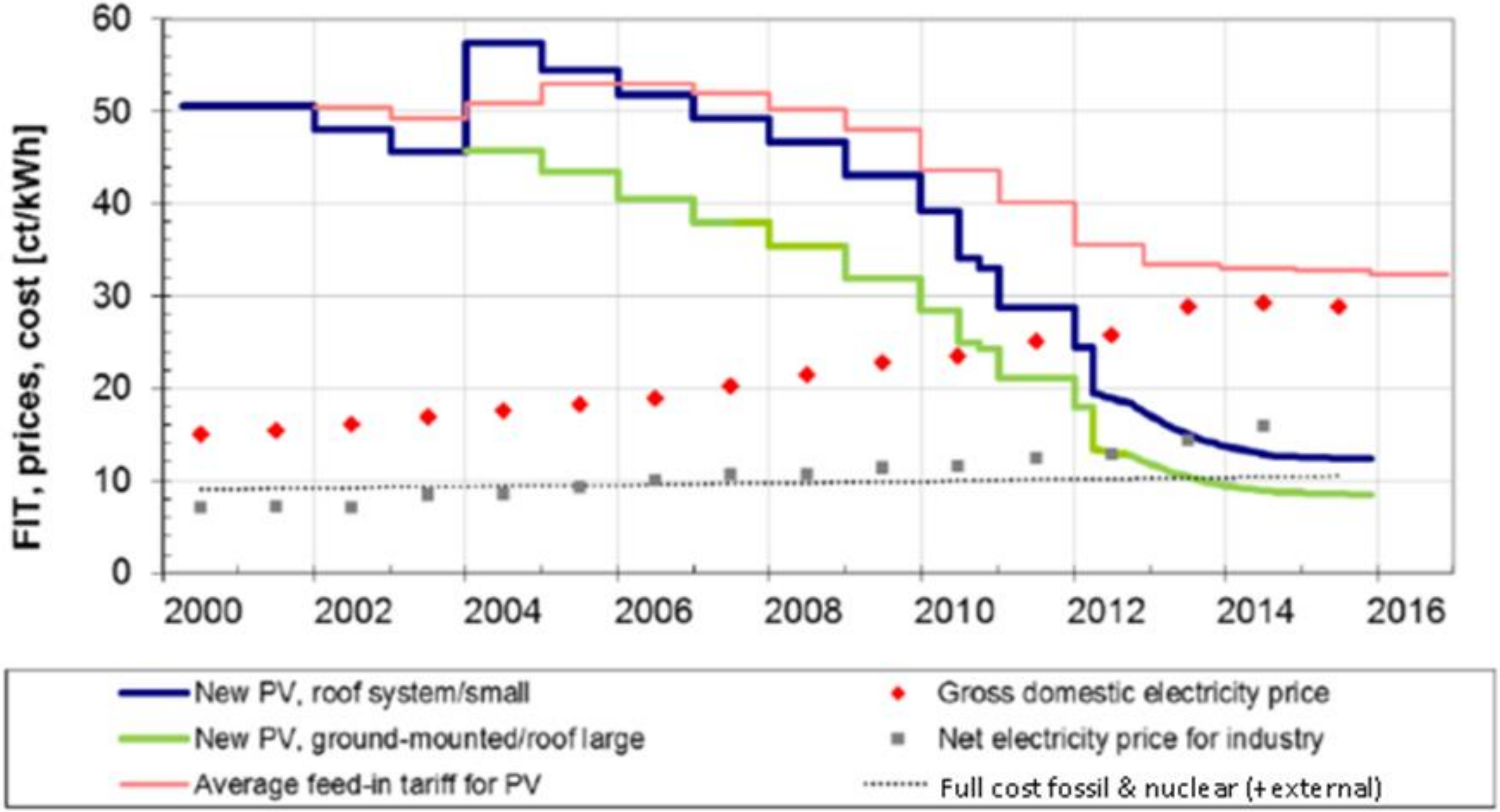
Longitude

Storage team





Outlook



- Virtual storage-incentives
- Battery storage

Conclusions and discussion

1. The transition to a renewable-based energy system is possible
2. Interdisciplinary challenge
3. Energy storage development in the next decade key for renewable energy penetration and climate change mitigation
4. Further system integration with policy coordination to reduce uncertainty
5. Level the playing field for technologies
6. Stationary batteries are very close to profitability
7. Stakeholder involvement and trade-offs for accelerating acceptance

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https://www.unige.ch/efficience/efficiency/team/parra/

https://david-parramendoza.net/

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Merci beaucoup