CREATORS

SUSTAINABLE PLACES 2022

Sep. 6 - Sep. 9, 2022 | Nice, France

Electric energy utilization in modern industrial environments

Outline

- Facilities for electric energy production
- Facilities for energy storage
- Electric energy management

Paper result of: **CREATORS H2020 project**
https://www.creators4you.energy/

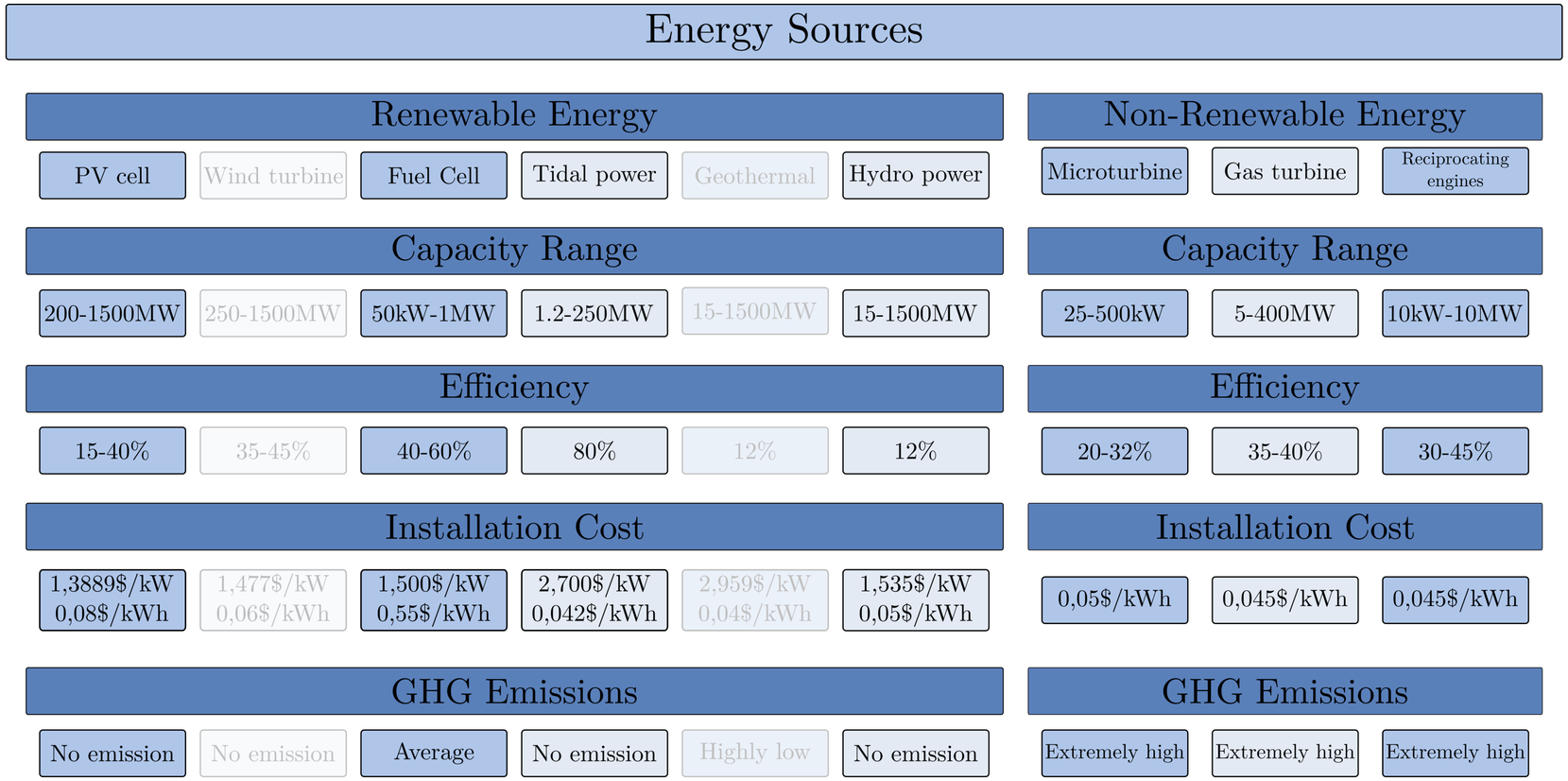
Speaker: **Ivan Todorović**
https://www.typhoon-hil.com/

Facilities for electric energy production*

Energy Sources								
Renewable Energy						Non-Renewable Energy		
PV cell	Wind turbine	Fuel Cell	Tidal power	Geothermal	Hydro power	Microturbine	Gas turbine	Reciprocating engines
Capacity Range						Capacity Range		
200-1500MW	250-1500MW	50kW-1MW	1.2-250MW	15-1500MW	15-1500MW	25-500kW	5-400MW	10kW-10MW
Efficiency						Efficiency		
15-40%	35-45%	40-60%	80%	12%	12%	20-32%	35-40%	30-45%
Installation Cost						Installation Cost		
1,3889$/kW 0,08$/kWh	1,477$/kW 0,06$/kWh	1,500$/kW 0,55$/kWh	2,700$/kW 0,042$/kWh	2,959$/kW 0,04$/kWh	1,535$/kW 0,05$/kWh	0,05$/kWh	0,045$/kWh	0,045$/kWh
GHG Emissions						GHG Emissions		
No emission	No emission	Average	No emission	Highly low	No emission	Extremely high	Extremely high	Extremely high

*Generally in use

Facilities for electric energy production*



*Generally in use in industrial facilities

Facilities for electric energy production*

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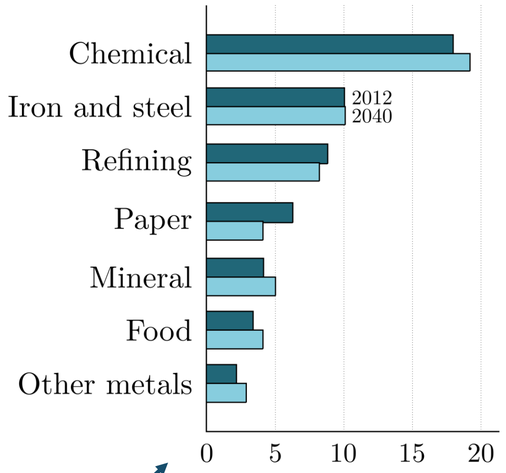

Percent of the 7× 10^{10} liters (daily)

*Generally in use in industrial facilities

Facilities for electric energy production*

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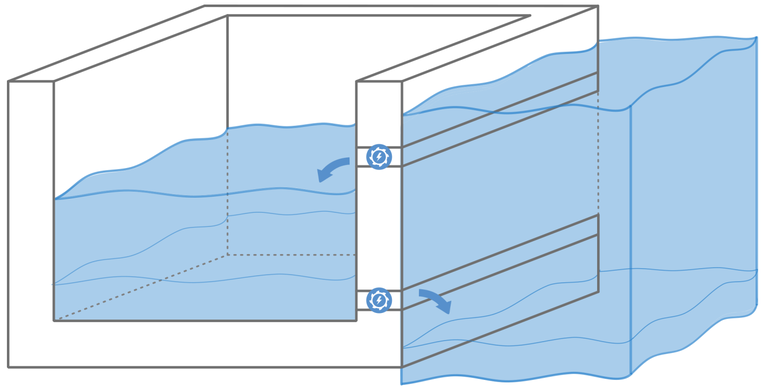


Tidal storage system

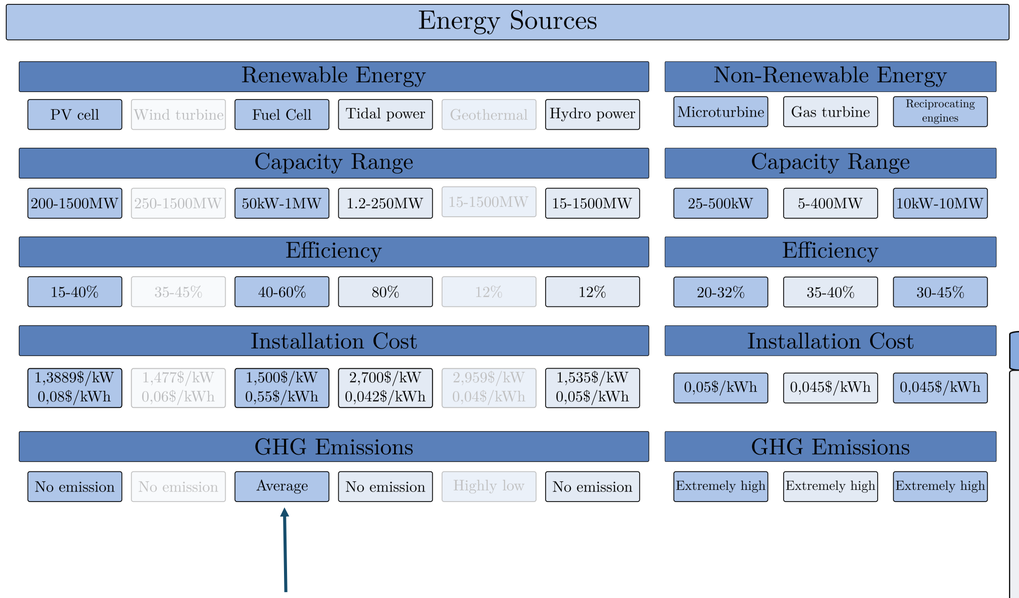
Tidal energy systems

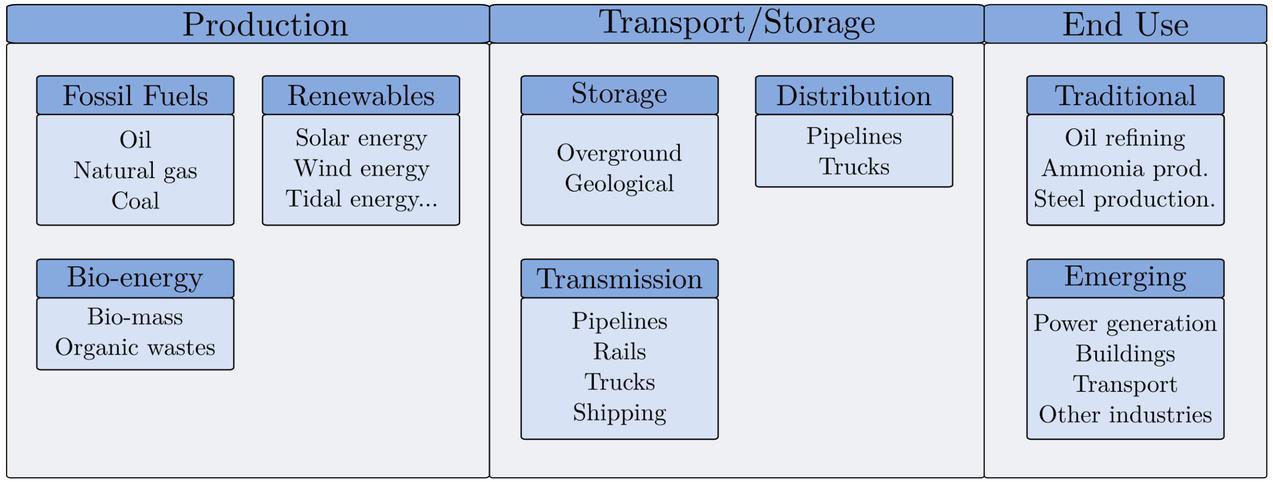
Energy islands:

- Tidal + PV
- Offshore wind + PV
- Wave + PV
- Offshore wind + Wind
- …

*Novel energy sources for industrial applications

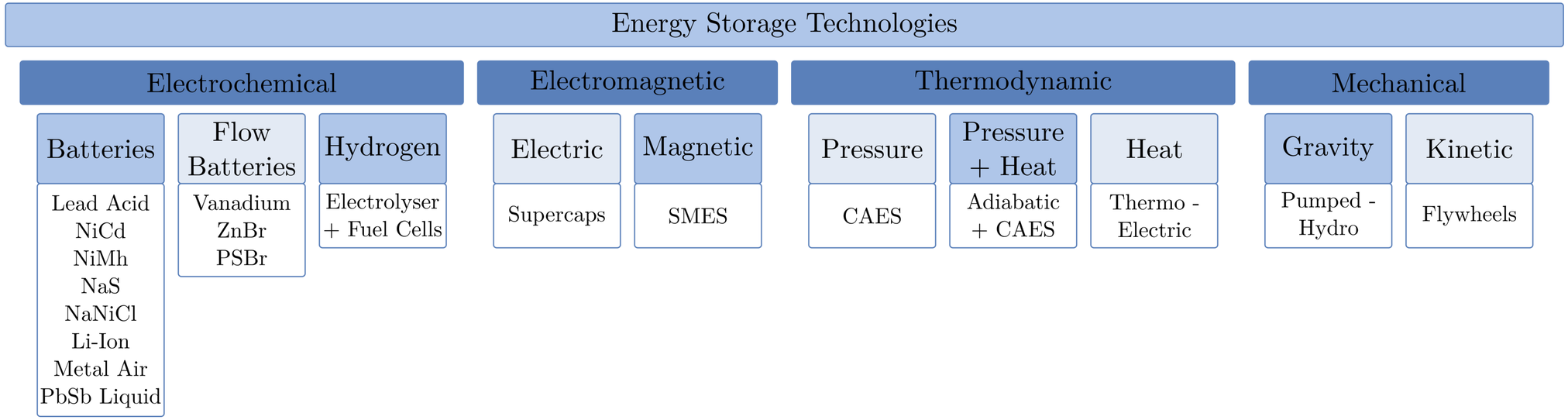
Facilities for electric energy production*





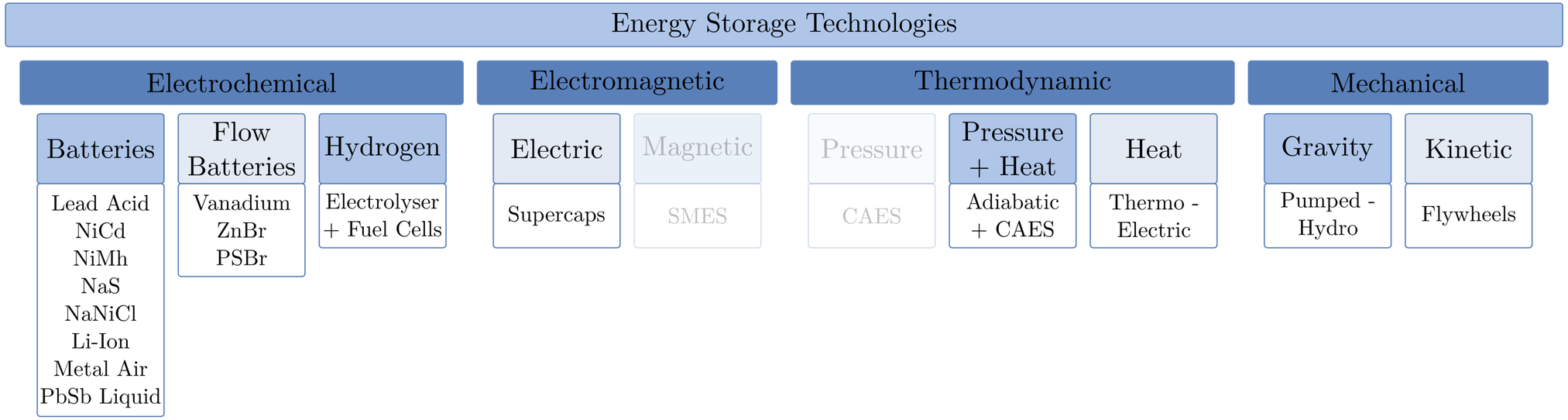
*Novel energy sources for industrial applications

Facilities for energy storage*



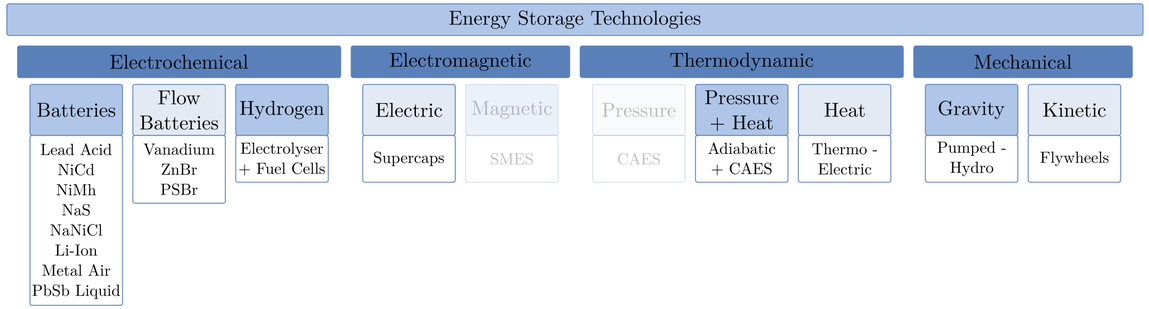
*Generally in use

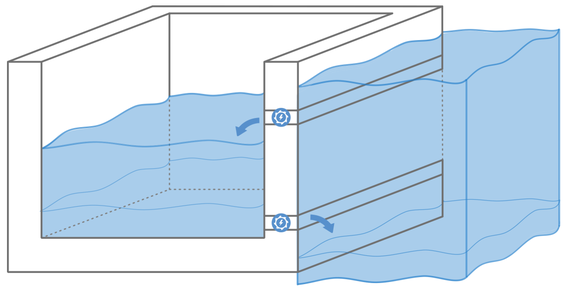
Facilities for energy storage*

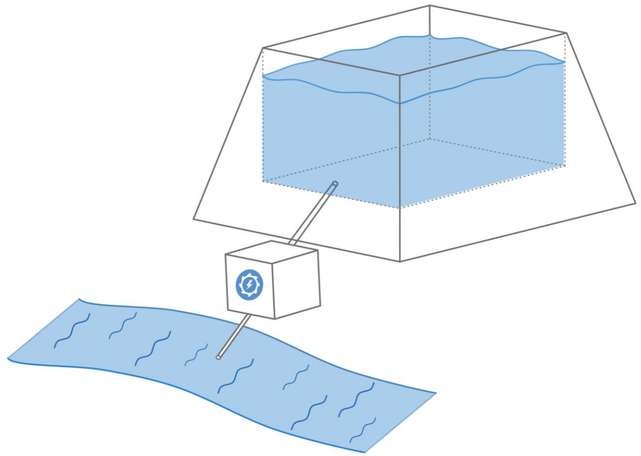


*Generally in use in industrial facilities

Facilities for energy storage*







Small-scale pumped-hydro systems

(Energy hill)

Other gravity-based storage systems:

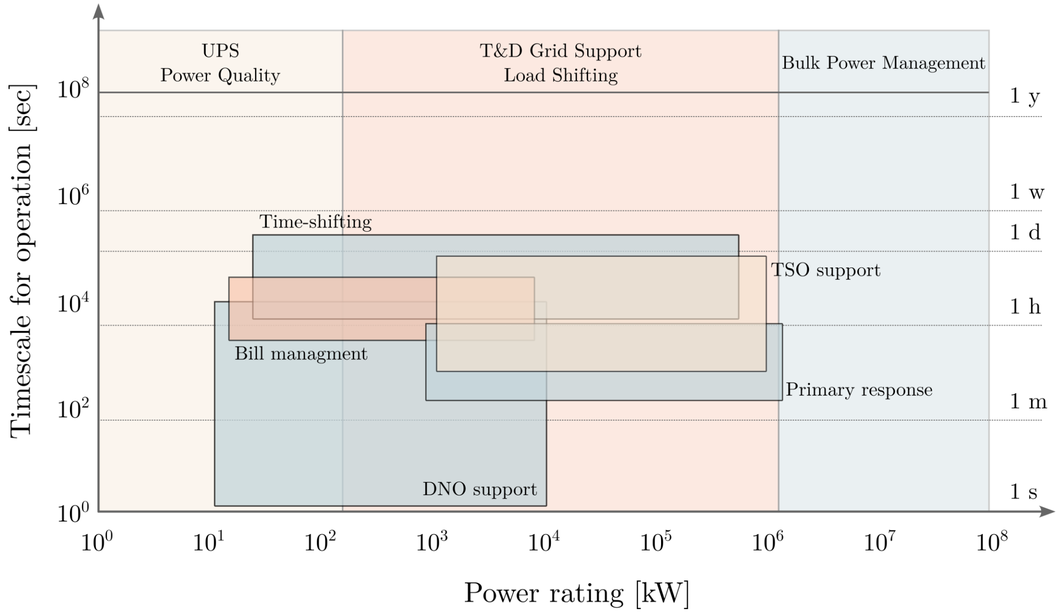
- Lagoon storage
- Deep shaft
- Artificial basin
- …

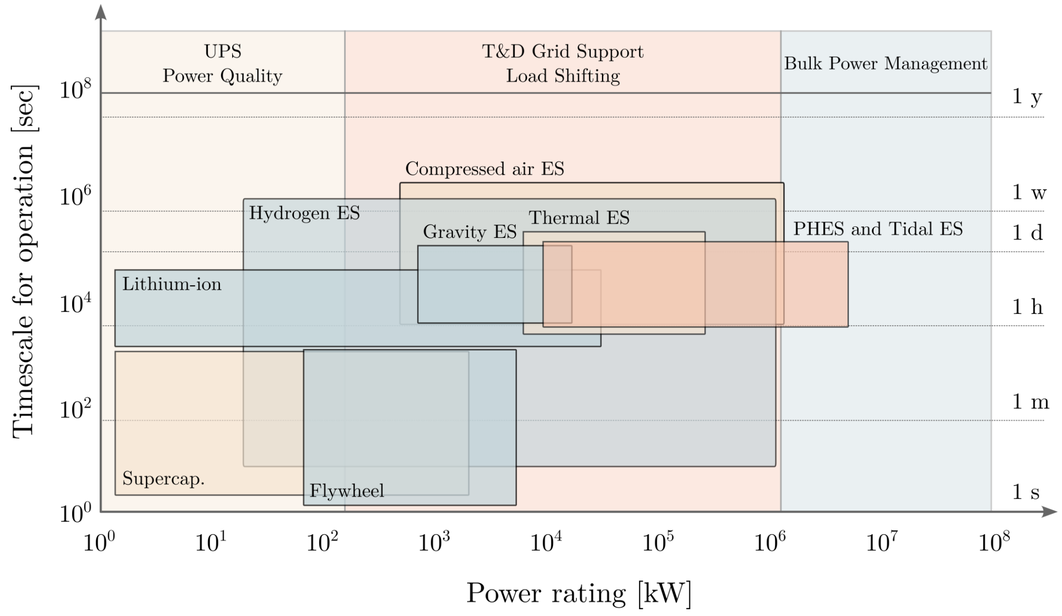
*Novel energy storage systems for industrial applications

Facilities for energy storage

Applications of ESS	Minimum Response Time	Minimum Discharge Duration
	Generation	
Uninterrupted and stable power flow	s	10 min – 2 h
Peak shaving	min – h	s – 10 h
Black-start	s – min	1 h – 6 h
Mobile applications	ms – s	s – h
	Transmission	
Postponement of infrastructure upgrades	min	1 h – 6 h
Voltage regulation	ms – s	6 min – 1 h
	Distribution and end-user services	
Power quality	< 5 ms	ms – 1.2 min
Reliability	5 ms – s	5 min – 5 h
Voltage support	< 5 ms	15 min
Postponement of infrastructure upgrades	min	2 h – 8 h
Ride-through support	< 5 ms	10 s – 15 min
Transportation applications	ms – s	s – h

Facilities for energy storage





Energy management schemes

Energy Management Schemes

Classical Optimization Methods	Heuristic and Metaheuristic Methods	Intelligent Methods	Emerging Methods
Dynamic programming	Genetic algorithm	Neural networks-based approaches	Game theory-based
Linear programming	Particle swarm optimization algorithm	Fuzzy-logic controllers-based algorithms	Deep learning-based
Nonlinear programming	Differential evolution algorithm	Model predictive algorithms	Deep reinforcement-learning-based
Mixed-integer linear programming	Adaptive differential evolution algorithm	Multi-agent systems schemes	...
Mixed-integer nonlinear programming	Whale optimization algorithm	...	
Mixed integer quadratic programming	Grey wolf optimization algorithm		
Adaptive multi-clustering alghorithm	Evolutionary algorithm		
Stochastic programming	Non-dominated sorting genetic algorithm		
Rule-based alghorithm	Artificial bee colony		
...	Pareto concavity elimination transformation		
	...		

Energy Management Schemes

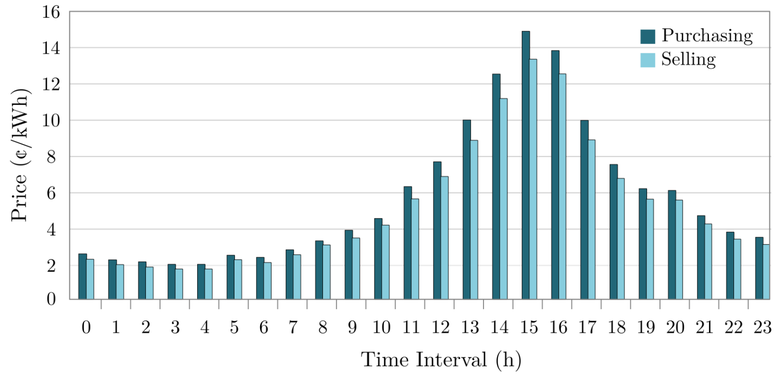
Centralized	Distributed
Equivalent consumption minimization strategy	Multiagent systems
Model predictive control	Distributed model predictive control
Sequential function method	Alternating direction method of multipliers
Hierarchical control	...
Sensitivity function method	
Recursive searching algorithm	
Artificial intelligence algorithm	
...	

Energy management schemes

Optimization methods goals*

Optimal storage management
Demand response program
Vehicle-to-grid system (V2G)
Cost minimization
Energy scheduling
Operating time
Reliability of operation
Losses minimization
Generate energy with lower emissions
Uninterrupted power flows
Stable power flows
Peak shaving

Load shedding
Black-start
Postponement of infrastructure upgrades
Maintenance costs
Voltage regulation
Power quality
Reliability
Voltage support
Frequency regulation
Ride-through support
Transportation applications
...



*With even more constraints…

Energy management schemes

- Scalability
- Applicability
- Standardization
- Development
- Testing
- Implementability
- …

Energy management schemes

- Scalability
- Applicability

Scientific problem

- Standardization
- Development
- Testing

Technical problem

Thank you!

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