

Comparative techno-economic assessment of redox flow batteries and diesel generators for emergency power supply

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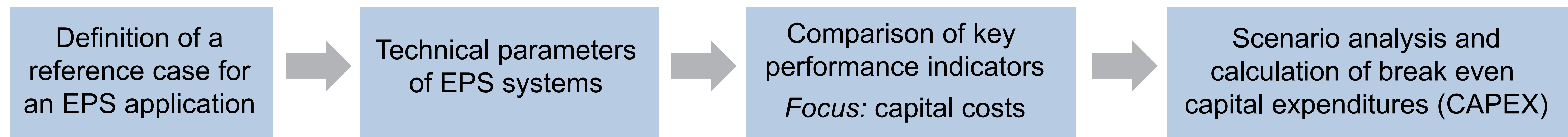


Research Topic

Emergency power supply (EPS) systems are applied to secure electricity supply for critical infrastructures (e.g. data centres, hospitals, airports, industry) in case of a blackout. The state of the art EPS solution is a system combination of lead acid batteries and diesel generators. The batteries are designed to bridge the gap between the blackout and the net power operation of the generator to guarantee an uninterruptible power supply (UPS). Here we consider redox flow batteries (RFB) in combination with ultracapacitors as an alternative EPS system.

Methodology

Comparative techno-economic assessment of emergency power supply (EPS) systems



Basis data

Reference case: 1 MW, 24 h emergency power supply for a data processing center with no interruption time

Typical hours of operation < 100 h/a (incl. test operation during maintenance)

Conventional system

Combination of battery system (UPS) and diesel generator

Redox flow system

Combination of ultracapacitor (UPS) and RFB

Lead acid batteries (UPS)		4 x Alpha Technologies TRI-Power X33 IGBT 120 kVA
Operation time	17 min	<i>Specific system costs:</i> 625 €/kW; 2,275 €/kWh (UPS electronics, battery rack, batteries incl. exchange, ventilation) [ATECO EDV GmbH, 2013]
System power	400 kW	
System capacity	110 kWh	
System lifetime	20 a	
Battery lifetime*	10 a	

*: Battery exchange after 10 years

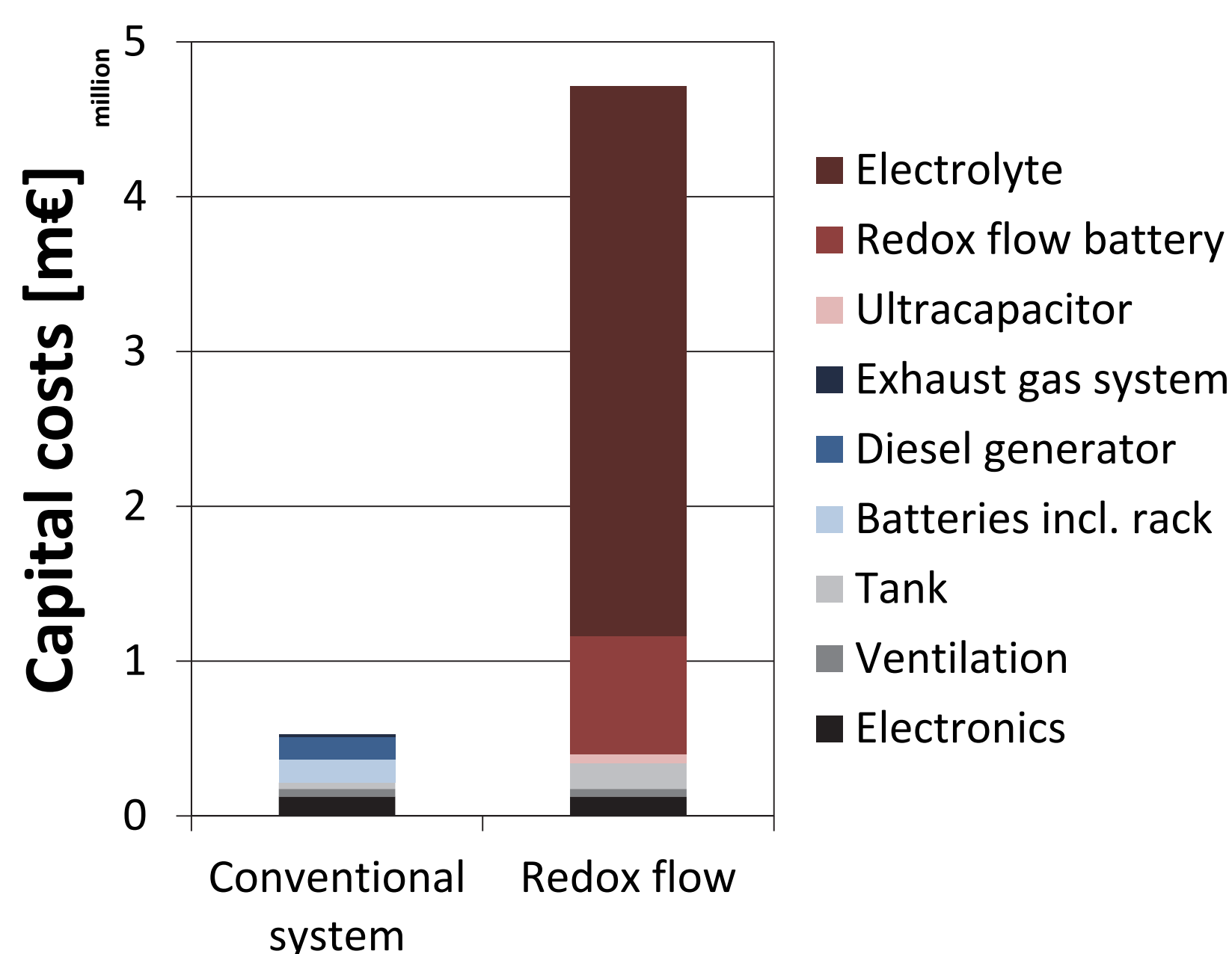
Ultracapacitor (UPS)		40 x Maxwell Technologies BMOD0130 P056 B03 56 V, 130 F
Operation time	15 s	<i>Specific system costs:</i> 400 €/kW; 96,000 €/kWh (ultracapacitor modules and rack, UPS electronics, ventilation) [MT, 2013], [Digi-Key, 2013]
System power*	400 kW	
System capacity	1.67 kWh	
Lifetime	20 a	
*: 40 modules with 10 kW each		

Diesel generator		1 x Diesel generator 1 MW
Operation time	24 h	<i>Specific system costs:</i> 270 €/kW; 12 €/kWh (motor, generator, electronics, tank, exhaust gas system, ventilation) [NE, 2013]
System power	1 MW	
System capacity	24 MWh	
Tank size	6 m ³	
Lifetime	20 a	

Redox flow battery		1 x All-Vanadium (V/V) RFB 1 MW
Operation time	24 h	<i>Specific system costs:</i> 835 €/kW (RFB, electronics, ventilation) <i>Specific electrolyte costs:</i> 155 €/kWh (vanadium electrolyte, tank) [Viswanathan et al., 2012]
System power	1 MW	
System capacity	24 MWh	
Lifetime	20 a	
Reaction time	< 60 ms	

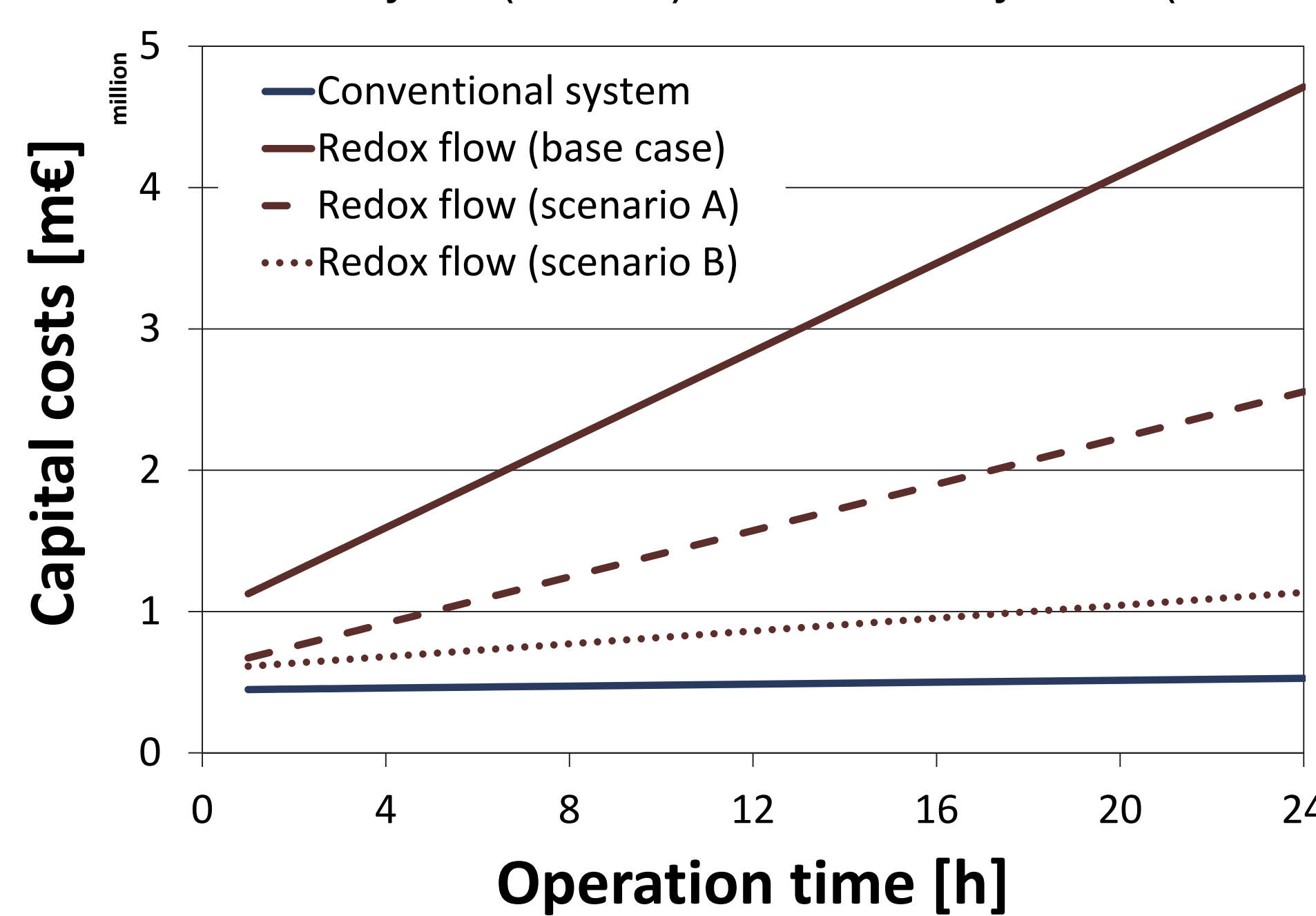
Results

Comparison of capital costs for reference case

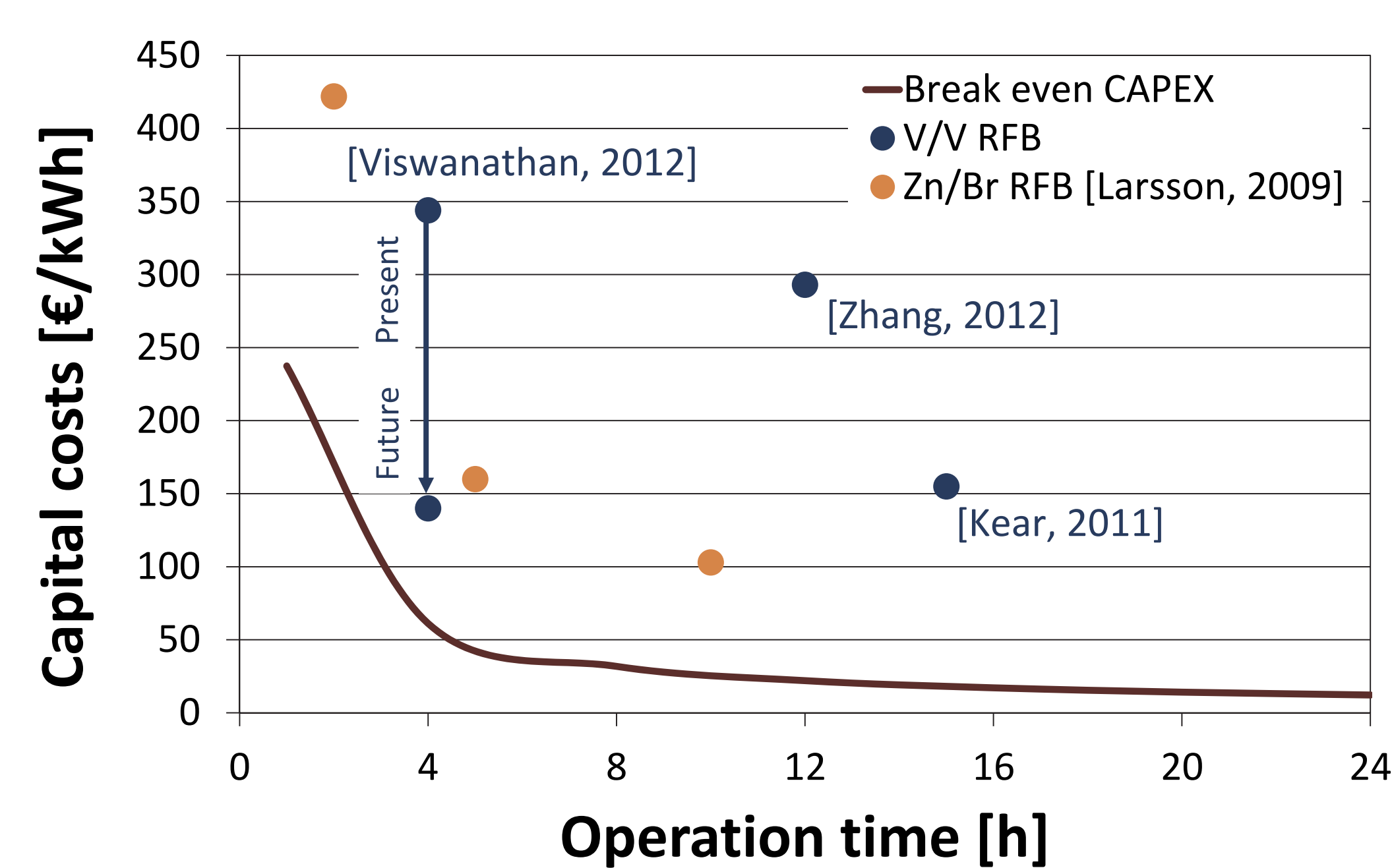


Scenario analysis

Scenario A: 50 % system (418 €/kW) and 50 % electrolyte costs (78 €/kWh)
Scenario B: 50 % system (418 €/kW) and 10 % electrolyte costs (16 €/kWh)



Calculation of break even CAPEX and comparison to RFB literature cost data



Comparison of key performance indicators

Category	Conventional system	Redox flow system
Stage of development	mature (kW to multi-MW systems)	first commercial systems (< 1 MW)
System suppliers	> 100	< 10
Service structure	established	developing
Max. operation time	dependent on tank volume	
Fuel	diesel	electricity; use of renewable energies possible
Emissions	CO ₂ and noise emissions	-
Energy density	11,000 - 12,000 Wh/kg (diesel)	15-25 Wh/kg (V/V electrolyte)
Space requirements	low	high
Site requirements	vibration tolerance	-
Maintenance	periodic maintenance and test operation	
Readiness after operation	short-medium (dependent on tank refueling time)	long (dependent on RFB recharge time)

Conclusion

- Significant cost decrease of RFB systems required
Focus: development of low-cost electrolyte systems (e.g. Fe/Cr)
- Low RFB operation costs not significant due to low hours of operation
- Use of renewable energies allows CO₂ and emission free operation
➔ RFB systems might be interesting for niche applications

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