IEEE SA
STANDARDS ASSOCIATION

IEEE P2814: RECOMMENDED PRACTICES ON TECHNO-ECONOMICS TERMINOLOGY FOR HYBRID ENERGY AND STORAGE SYSTEMS

IEEE SYSTEMS, MAN, AND CYBERNETICS SOCIETY/ STANDARDS COMMITTEE (SMC/SC)

AUGUST 24, 2020

TIME: 01:00 PM (UTC+1)

Teleconference: Cisco Webex

IEEE

AGENDA

1. Call to Order
2. Roll Call & Declaration of Affiliation
3. Approval of Agenda
4. IEEE Patent Policy: https://mentor.ieee.org/myproject/Public/mytools/mob/slideset.ppt
5. IEEE Copyright Policy: https://standards.ieee.org/content/dam/ieee-standards/standards/web/documents/other/copyright-policy-WG-meetings.potx
6. Approval of the minutes of the last meeting
7. Framework and methodology
8. AOB
9. Future Meetings
10. Meeting Adjourned

IEEE PATENT POLICY

Speak up now and respond to this Call for Potentially Essential Patents

If anyone in this meeting is personally aware of the holder of any patent claims that are potentially essential to implementation of the proposed standard(s) under consideration by this group and that are not already the subject of an Accepted Letter of Assurance, please respond at this time by providing relevant information to the WG Chair

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  - http://standards.ieee.org/develop/policies/best_practices_for_ieee_standards_development_051215.pdf
- Distribution of Draft Standards (see 6.1.3 of the SASB Operations Manual)
  - https://standards.ieee.org/about/policies/opman/sect6.html

WORKING GROUP COMMITTEE

Sponsoring Society and Committee:

IEEE Systems, Man and Cybernetics Society

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WG Vice Chair: Dr Dongxiao Wang (Australia)

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IEEE Program Manager: Mr Tom Thompson (USA)

Approval of the minutes of the last meeting

https://sagroups.ieee.org/2814/

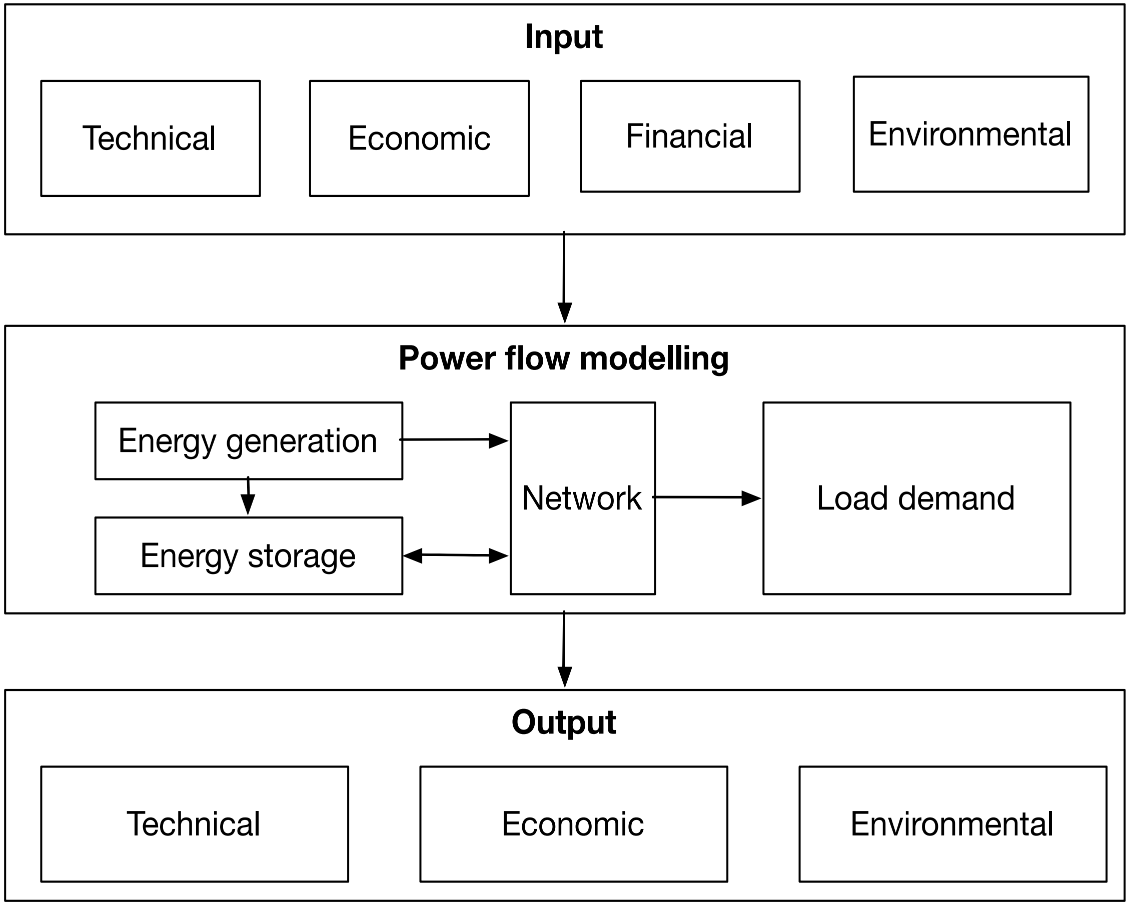
SCOPE

This standard defines techno-economic terminologies used in the development, construction, and operation of renewable energy and electrical energy storage systems

STRUCTURE OF STANDARD

1. Overview (recommended practices), scope and purpose
2. Normative references (related standards)
3. Definitions (terms and nomenclature)
4. Need for the Recommended Practice, context of problems, outline of the recommended practice
5. Methodology
6. Examples of application of the methodology
7. Bibliography

TEA FRAMEWORK FOR P2814



INPUT

- Define unit of analysis: Storage or generator? Or combination of both?
- Define cost types (examples from literature, capital cost, operating cost, decommissioning cost)
- Define technical types (efficiency, power rating, energy rating)
- Library of energy storage options for study
- General financing conditions to be considered to calculate discount rate from cost of debt, cost of equity (examples from literature)

METHODOLOGY

- **Recommended Practices for techno-economic analysis**
- **Timeframe for the analysis (recommended practices for different sampling interval in techno-economic studies e.g. context)**
- **Define the power flow modelling approach (distribution network) for techno-economic studies**

OUTPUT

- **Focus on techno-economic metrics**

- **Technical metrics**
  - Resilience,
  - Loss of load probability,
  - Power quality（voltage and load management）,
  - Reliability etc.

- **Economic metrics**
  - LCOE
  - NPV

CASE STUDIES

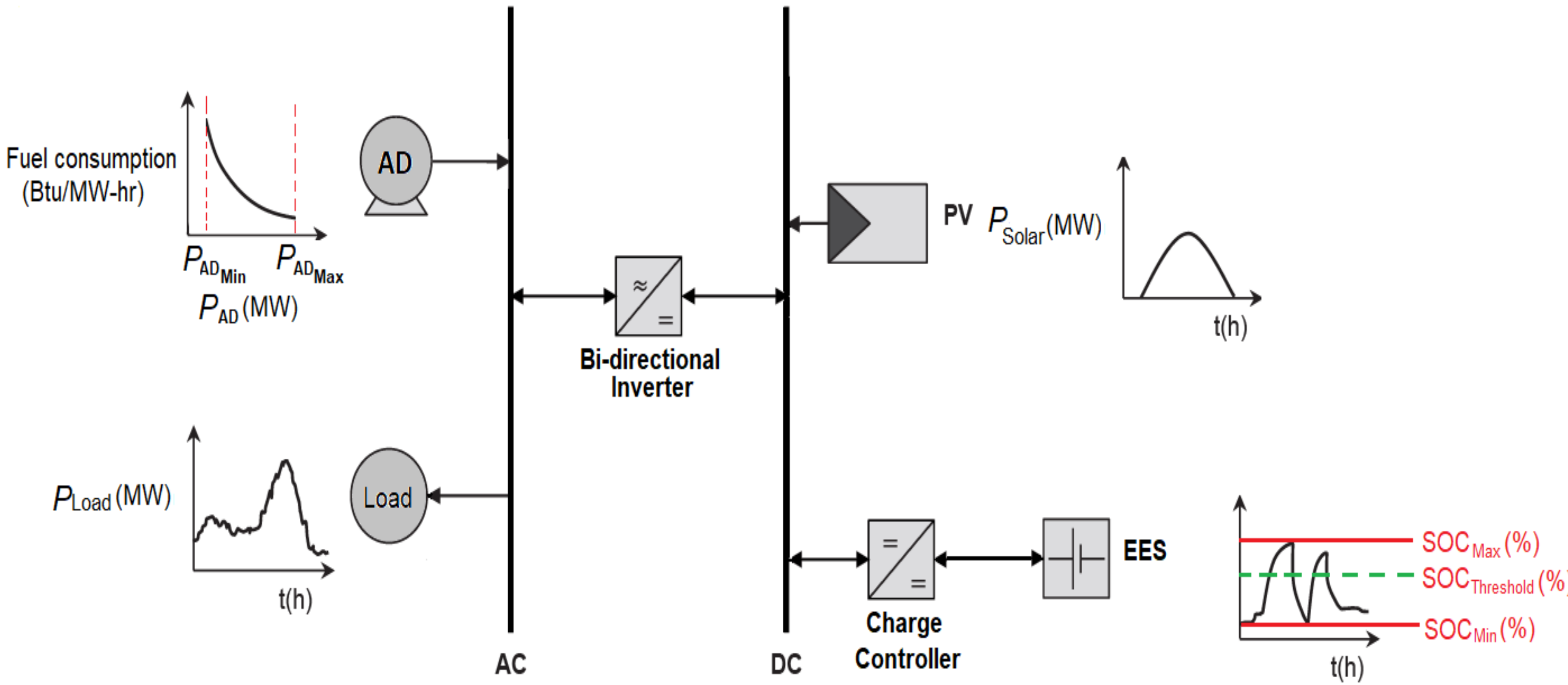
1. EV charging
2. Comparison of energy storage methods (e.g. generation integrated energy storage)
3. Virtual power plant
4. Controllable load and demand response programs, e.g. air conditioners and heat pumps
5. Multi-vector energy systems

TECHNO-ECONOMIC STUDIES

	This work	Berrada et al. [11]	Shaw-Williams et al. [34]	Locatelli et al. [12]	Guinot et al. [54]
Country considered	Kenya	Spain	Australia	U.K.	Ilorin, Nigeria
Research context	Presenting a financial model for EES coupled with PV and AD biogas power plant . A DCF model for the Li-ion storage is introduced.	A cost-benefit analysis is performed to determine the economic viability of energy storage used in residential and large-scale applications.	Evaluating the scope for promoting distributed generation and storage from within existing network spending.	Examining the value of real options valuation on the development of the ESS project.	The techno-economic feasibility of a hybrid solar energy system, including lithium batteries and a hydrogen chain for an off-grid application.
Financial and economic indicators examined	NPV, IRR, Debt duration, LCOE, and LCOS	NPV	NPV, IRR, LCOE, value of deferred augmentation, value of customer reliability	NPV	LCOE
Types of storage	Li-ion	Gravity storage	Batteries	Compressed air energy storage and pumped hydro storage	Li-ion
Storage degradation	Yes (cycle degradation considers the change in SOC)	No	Yes (as a percentage per year)	No	Yes, (cycle degradation and calendar degradation) DOD only
Findings	The existing market is unprofitable to use Li-ion when the capital cost is at 1500 $/kWh, unless participating in grid services with high payments.	Storage is unprofitable for residential applications except if it is used as a stand-alone system.	There are power network benefits with a more rapid adoption of distributed generation and residential battery storage.	Real option analysis increases the economic performance of ESS.	Not considering battery degradation leads to significant difference in estimating system size and LCOE values.

C. S. Lai, G. Locatelli, A. Pimm, Y. Tao, X. Li, and L. L. Lai, "A financial model for lithium-ion storage in a photovoltaic and biogas energy system," *Applied Energy*, vol. 251, p. 113179, 2019.

SYSTEM CONTEXT



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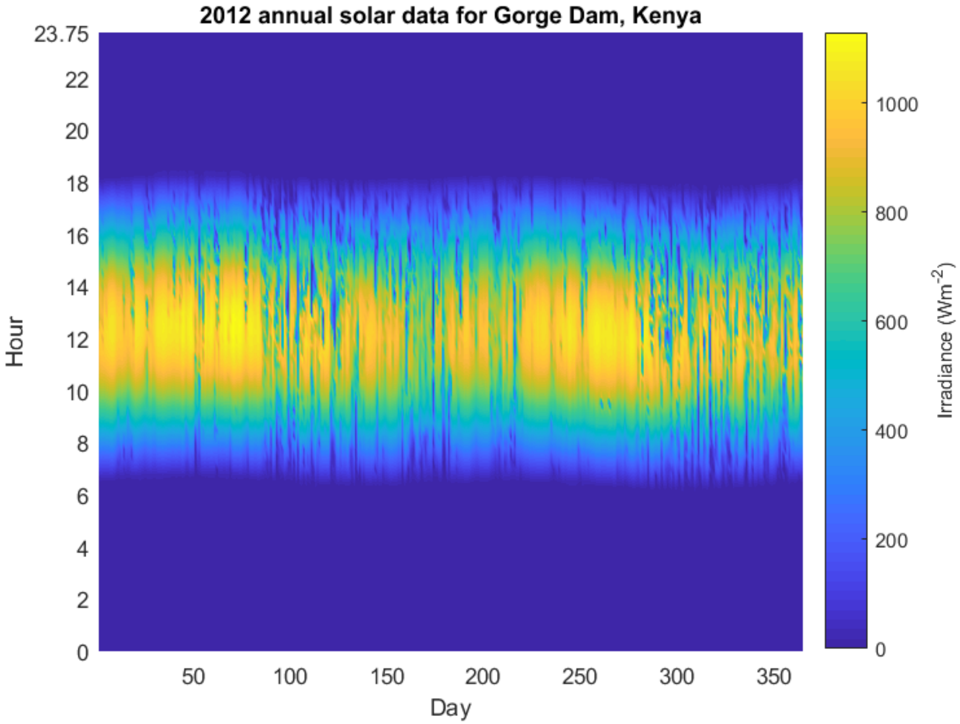
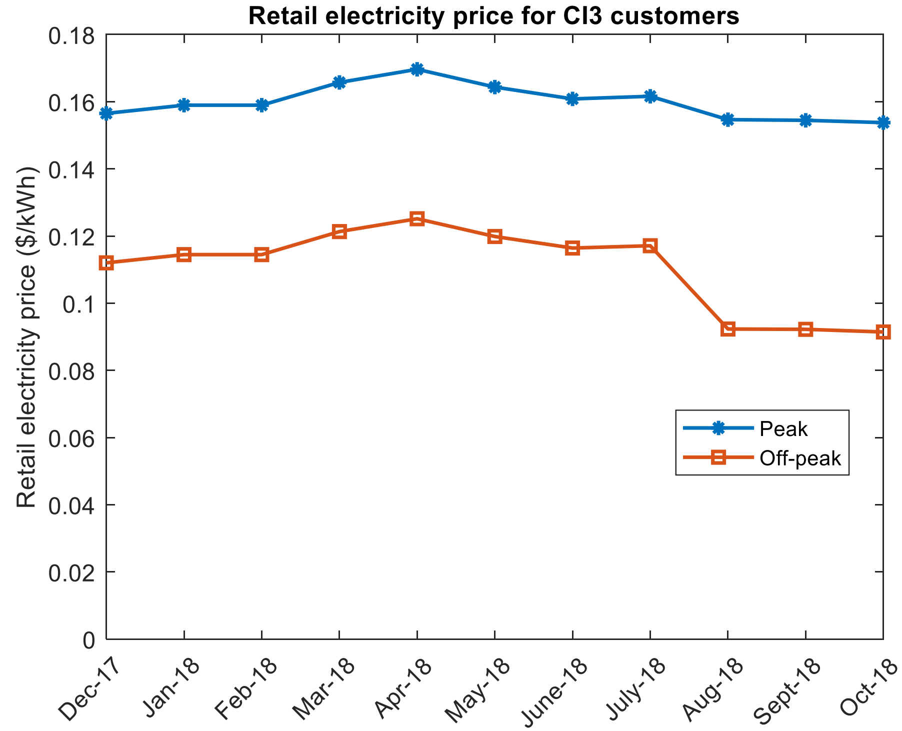
DATASET





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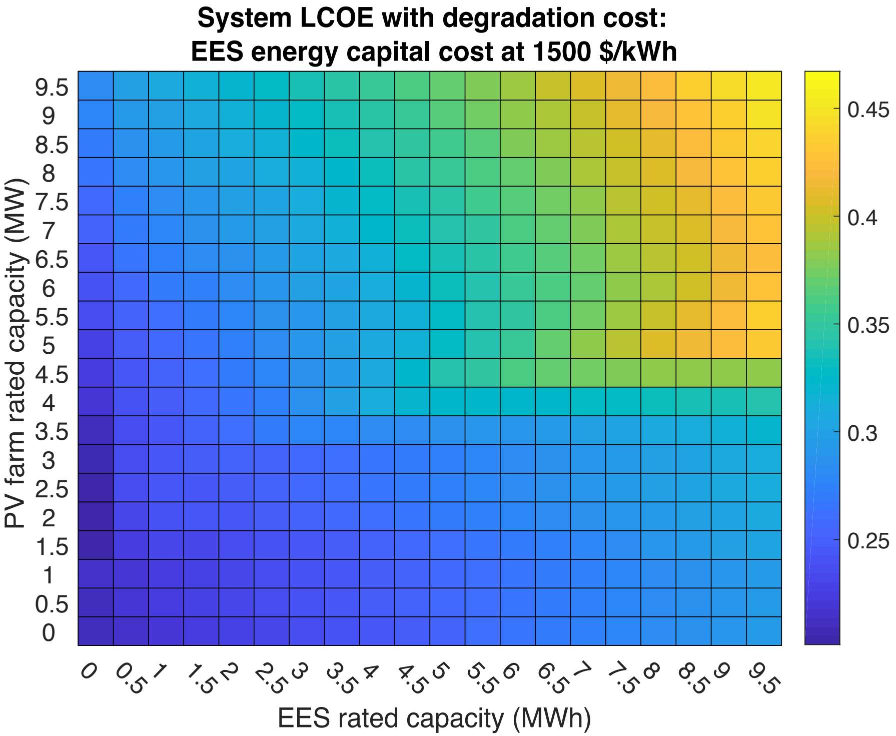
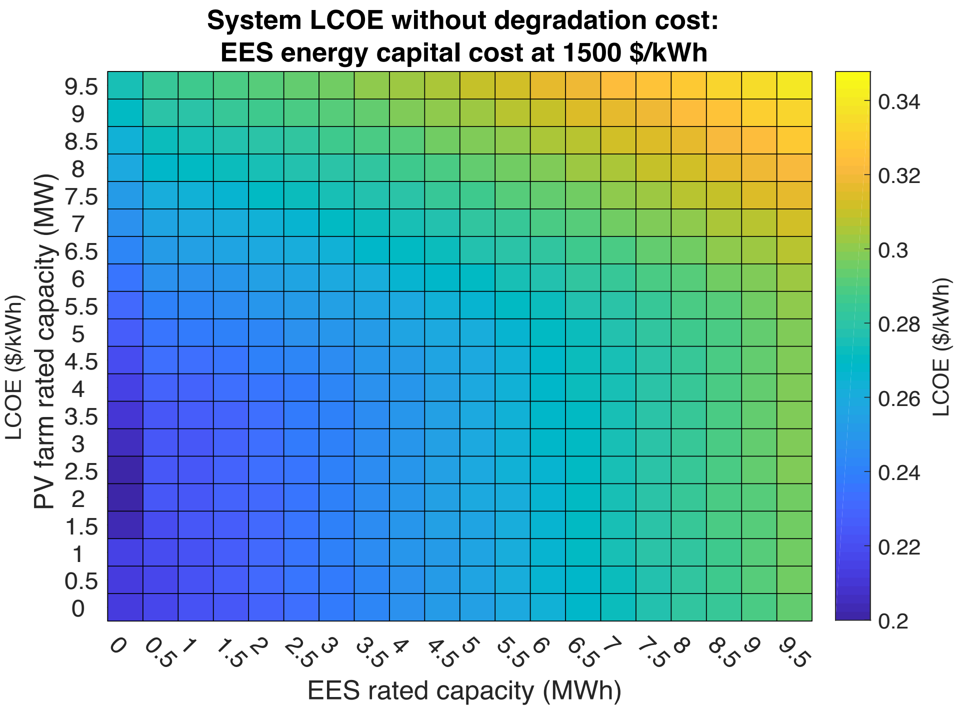
DEGRADATION EFFECT ON SYSTEM LCOE





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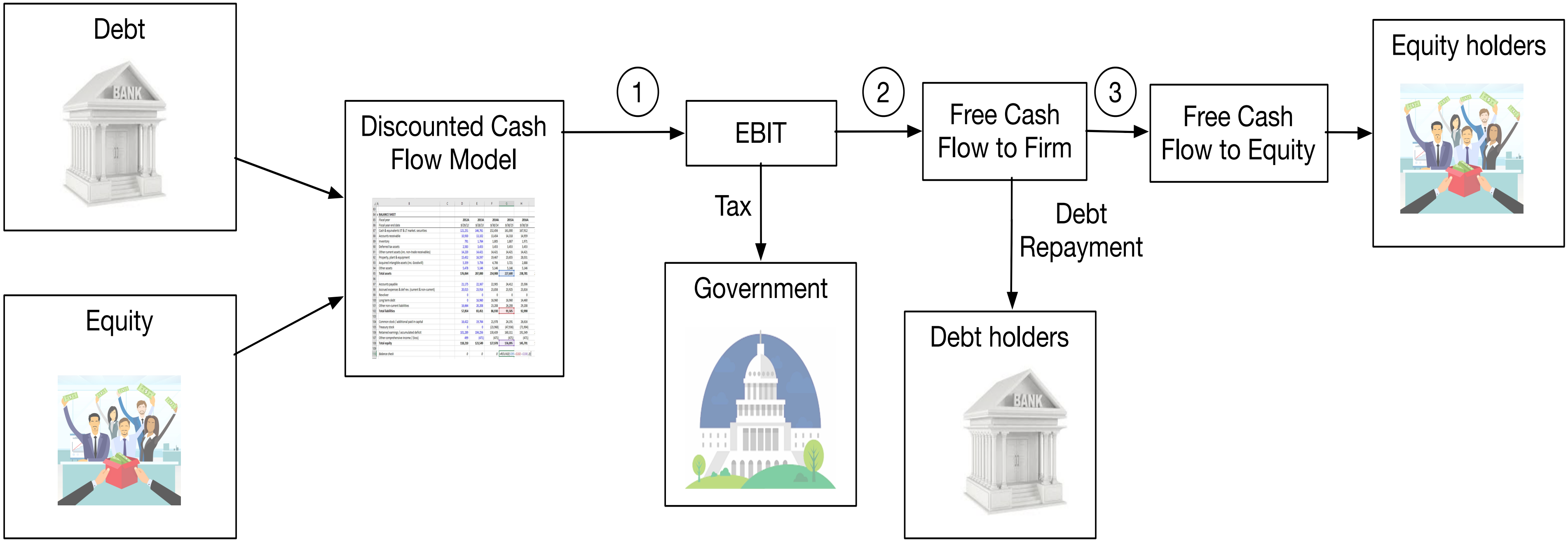
EXEMPLIFICATION OF THE FINANCIAL MODEL



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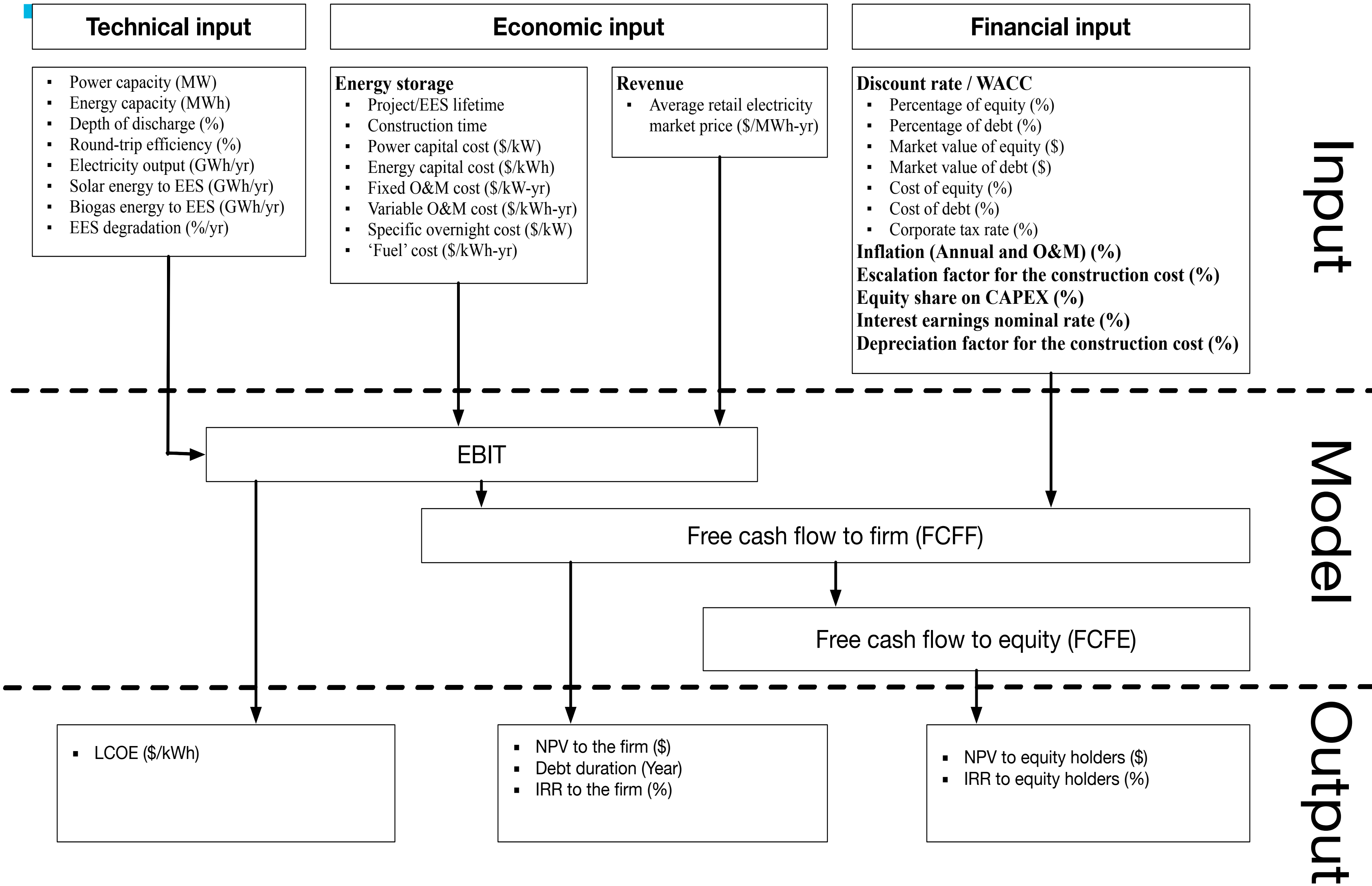
INPUTS FOR EES FINANCIAL ASSESSMENTS



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TECHNICAL AND ECONOMIC SPECIFICATIONS

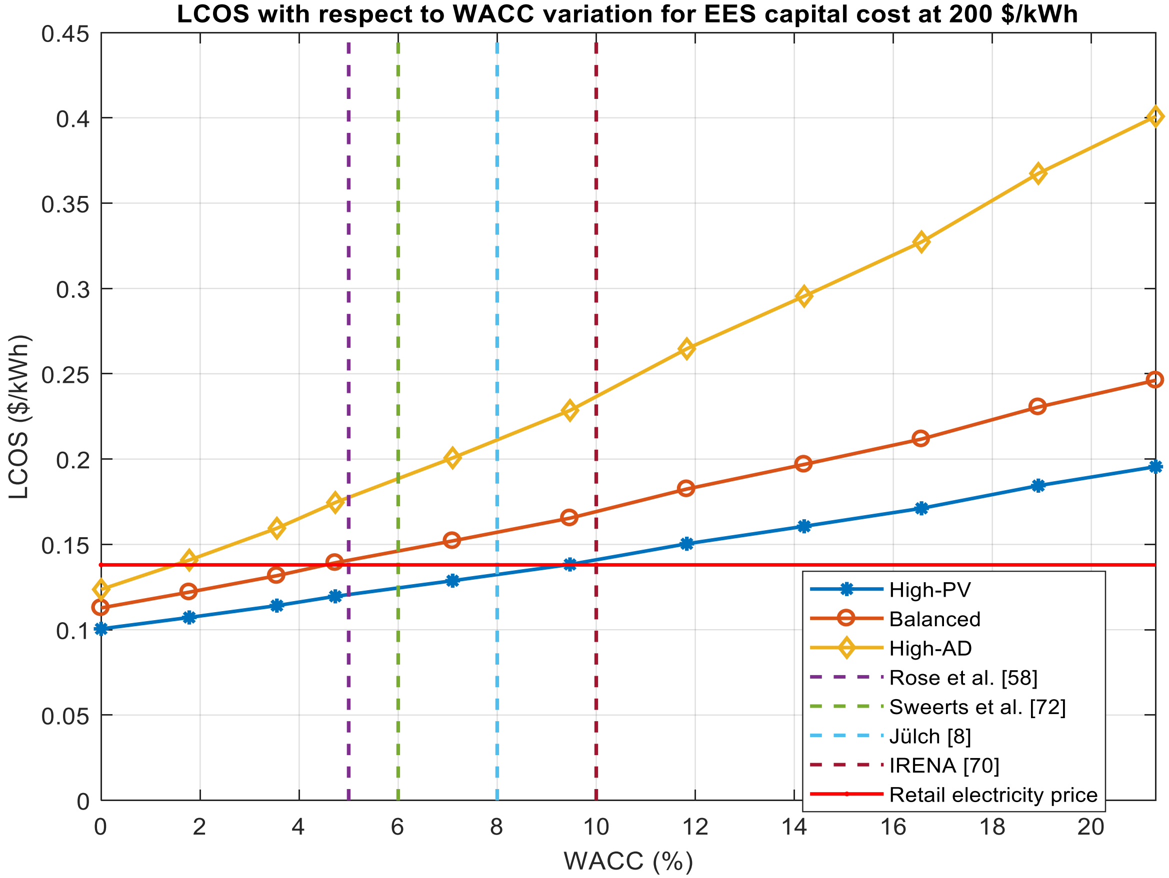
Index	Input	Scenario					
		1	2	3	4	5	6
A1	**$SOC_{Threshold}$ (%)**	**20**	**50**	**100**	**20**	**50**	**100**
A2	**EES capital cost ($/kWh)**	**1500**			**200**		
A3	**Energy capacity $E_{EES_{Rated}}$ (MWh)**	5 [30]					
A4	**Power capacity $P_{EES_{Rated}}$ (MW)**	2 [30]					
A5	**Construction time (Year)**	1					
A6	**EES operating lifetime (Years)**	8	9	18	8	9	18
A7	**EES energy output during first year of operation (GWh)**	1.56	1.14	0.61	1.56	1.14	0.61
A8	**Equivalent EES degradation cost (M$/yr)**	0.86	0.75	0.40	0.114	0.10	0.05
A9	**Round-trip efficiency (%)**	95 [22]					
A10	**EES fixed O&M costs ($/kW-yr)**	2.12 [10]					
A11	**Specific overnight cost ($/kWh)**	1500			200		
A12	**Total overnight cost (M$)**	7.5			1		
A13	**Biogas energy to storage (GWh/yr)**	0.12	0.014	0.005	0.12	0.014	0.005

C. S. Lai, G. Locatelli, A. Pimm, Y. Tao, X. Li, and L. L. Lai, "A financial model for lithium-ion storage in a photovoltaic and biogas energy system," *Applied Energy*, vol. 251, p. 113179, 2019.

INFLUENCE OF WACC ON EQUITY NPV AND LCOS

$\text{WACC} = D.K_\text{d}.(1 - t) + E.K_\text{e}$

D and E are percentage of debt (%) and percentage of equity (%) respectively, and sum to 100%. K_d and K_e are cost of debt (%) and cost of equity (%) respectively. t is the corporate tax rate (%).



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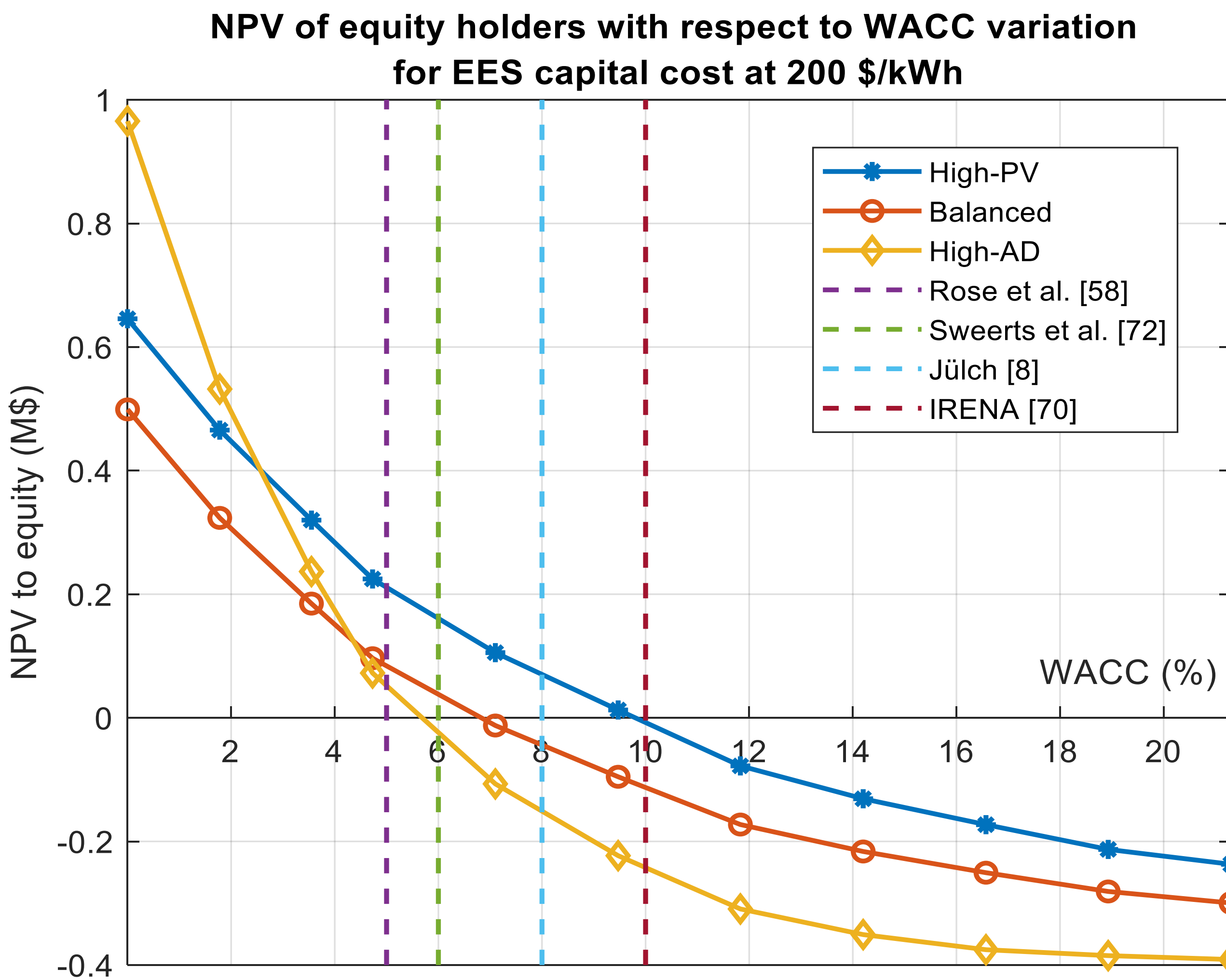
EQUITY NPV WITH RESPECT TO VARIOUS WACC



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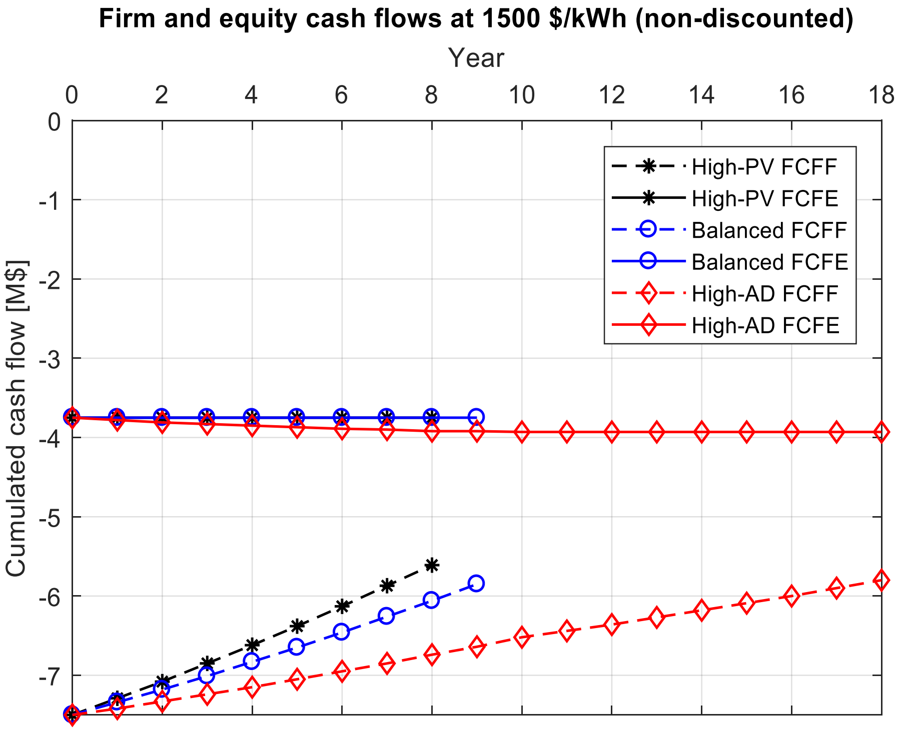
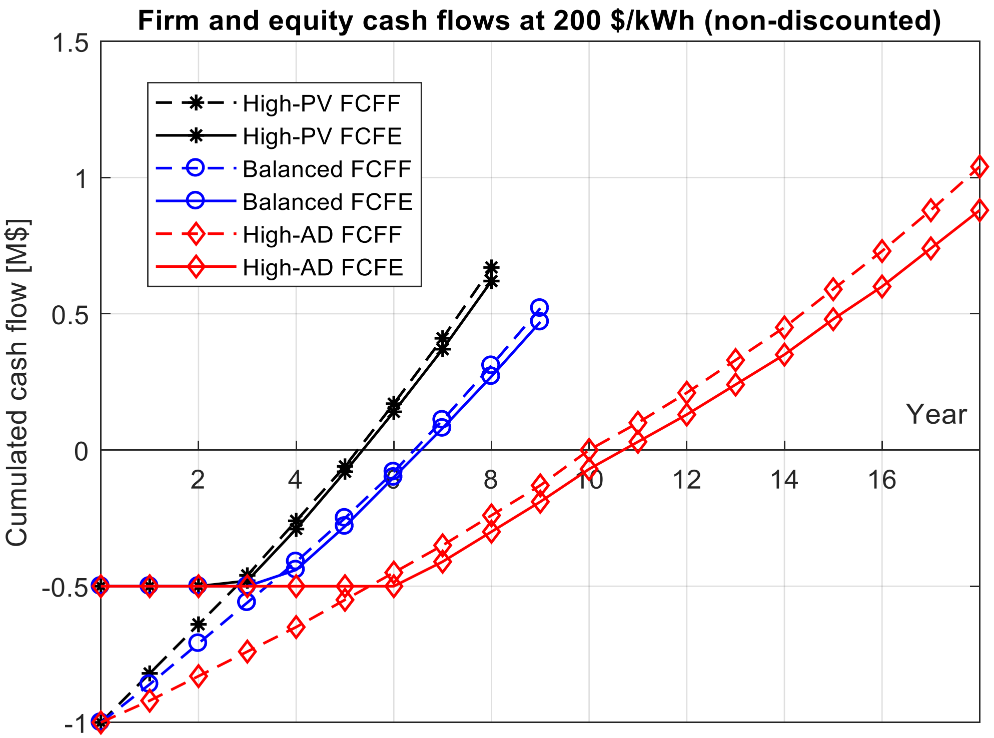
CUMULATED CASH FLOW TO THE FIRM AND CUMULATED CASH TO EQUITY FOR THREE OPERATING SCENARIOS





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SUMMARY OF RESEARCH

- The economics for EES with and without the degradation can be very different;
- The EES capital cost plays an important role in the financing. It constitutes the majority of the lifecycle cost.
- The EES is unprofitable under most operating situations when the capital cost is at 1500 $/kWh.
- When the capital cost drops to 200 $/kWh, the EES becomes profitable when it operates more frequently with a reduced lifetime
- Open for discussion

TASKS

- Begin data collection and confirming the methodology
- Initial Draft document
- Meeting (Webex, approx. every 1-2 months)
- Schedule of the next teleconference: Oct. 2020, Time TBD

IMPORTANT DATES

PAR Request Date:14 Feb 2019

PAR Approval Date: 21 May 2019

PAR Expiration Date: 31 Dec 2023

THANK YOU

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