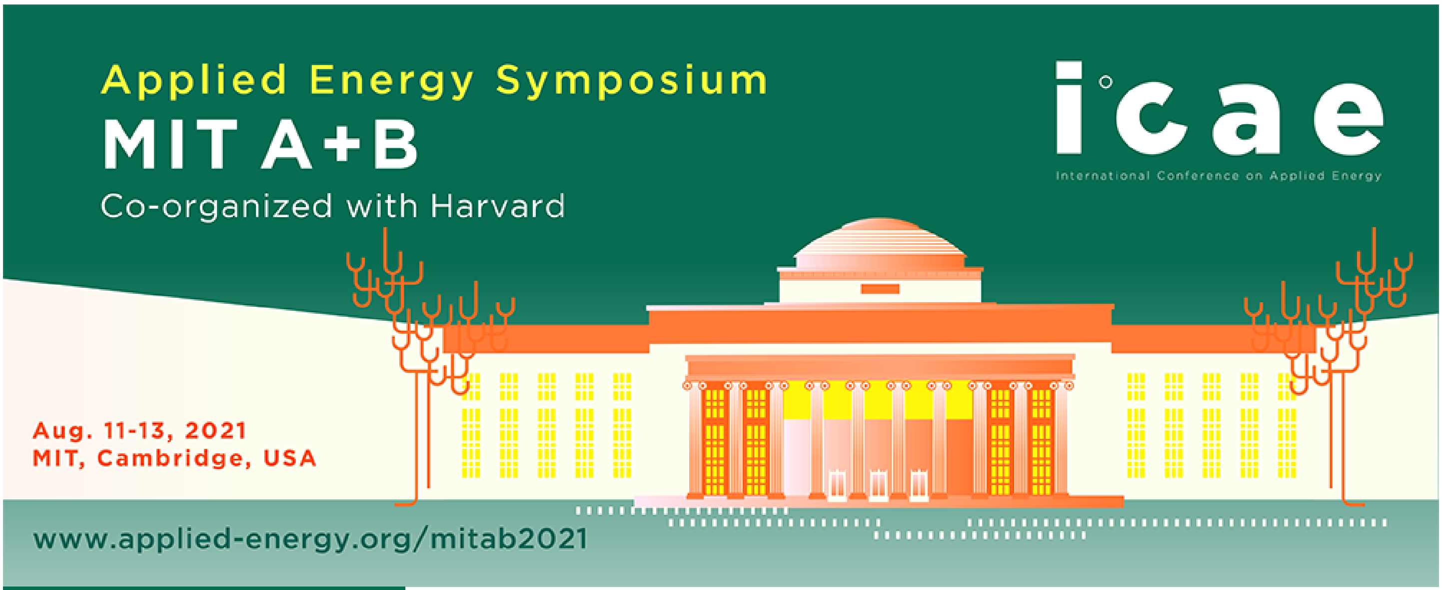

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Welcome to the Applied Energy Symposium：MIT A+B.

The IPCC report “Global Warming of 1.5°C” (Oct. 2018) issued a dire warning that unless CO2 emissions are halved by 2030, devastating changes, which will be sooner than expected and irreversible, will occur in ocean and on land. Time is running out for transitioning to new energy systems globally. Logic and numbers show that the world must take a two-step approach: (A) deploy existing, industrially proven technologies, namely solar, wind and nuclear base load at an unprecedented scale and pace, from now to 2050 -- when a house catches fire, firemen must run to the closest hydrants and stop disputing which water stream would be purer; and (B) develop new concepts and technologies that may replace the dirtier parts of (A) post-2050, at terawatt scale.

The Applied Energy Symposium: MIT “A+B” (MITAB) is dedicated to the accelerated deployment of (A), and new concepts and emerging technologies for (B). For (A), reducing capital and operating costs, managing social dynamics, and minimizing environmental impact while maintaining extreme productivity are key; automation, artificial intelligence, social mobilization, governmental actions and international coordination will provide essential boosts. For (B), we seek new concepts and emerging technologies (e.g. fusion power engineering, superconducting transmission, etc.) that stand a chance to scale to terawatts after 30 years, i.e. “baby technologies” can grow to adulthood in 20-30 years.

MITAB 2021 consists of a three-day symposium on August 11-13, 2021, virtually. All presentations (with the author’s permission) will be video recorded and posted on YouTube or other open sources for public dissemination. Outstanding presentations will be recommended by the session chair and scientific committee to be further considered for publication in a special issue of Applied Energy (journal Impact Factor 8.8, please find more information at https://www.journals.elsevier.com/applied-energy). .

To be invited to present at this symposium, please upload one of the following: a .zip file (<20MB) containing a video or voice file (≤10 min), or a Powerpoint presentation (≤20 slides), or an abstract (≤2 pages) or a conference paper (≤6 pages), which explain how and why your work matters to A or B. The manuscript will be reviewed by symposium organizers for acceptance to the conference. Examples of topics include, but are not limited to, the following:

- Renewable energy: solar energy (A or B), wind energy (A), bioenergy (A or B), and other renewables.
- Clean energy conversion technologies: fuel cells and electrolyzers (A or B), conversion of petroleum/gas/coal to high-valued materials and chemicals (A), hybrid energy systems, such as the combination of intermittent renewable energies and nuclear heat storage for load following, chemicals/materials/fuel production (A or B), multi-energy carrier energy systems (A or B).
- Energy storage: grid-scale batteries (A), battery management systems (A), fuel cell/ electrolyzer management systems (A), pumped hydro/compressed air (A), thermal energy storage (A or B), distributed energy storage (A).
- Nuclear energy: innovative concrete solutions and civil constructions (A), application of robotics and AI (A), shipyard constructed floating reactors (A), small modular reactors and micro-reactors (A or B), fast neutron reactors (B), fusion reactors (B).
- Mitigation technologies: Carbon capture and sequestration (B), nuclear waste (A), solar waste (A), battery waste (A), reduced-CO2 production of cement, bulk metals and chemicals (A or B).
- Intelligent energy systems: smart grids (A), ultra-efficient/superconducting power transmission (B), wireless power transmission (B); electrification of transportation and industrial production, such as electric cars/trucks (A or B), electrified air flight (A or B), microwave/plasma/electrochemical processing (A or B).
- Sustainability of energy systems: Environmental monitoring (A), social mobilization (A), consensus building (A), governmental policy making (A), international coordination (A).
- Sustainable geoenergy: geothermal (A or B), gas hydrate (A), unconventional natural gas (A), LNG, reducing methane and CO2 emission (A) of oil and gas sector, sustainable geoenergy development and management (A).
- Food, water and air: water and air treatment (A), reduced-CO2 production of food (A), Water-Food-Energy Nexus (A).

Given the grave urgency of our mission, we ask authors to be earnest, practical and in a problem-solving mode in their presentations. Creativity will be highly valued.

Details and updated information are available at www.applied-energy.org/mitab2021. If you have questions regarding this conference or submission, please contact Conference Organization Chair Dr. Ray (Zhenhua) Rui at MIT (mitab2021@applied-energy.org).

Important Dates

Submission starts: Jan 10, 2021
Extended Submission Deadline Apirl 26, 2021
Notification of acceptance: May 31, 2021
Conference: August 11-13, 2021
Conference Registration and MIT Campus Tour: August 11, 2021

We look forward to meeting you at MIT in Boston, USA.
Chairs of MITAB2021

Prof. Ju Li, Massachusetts of Institute of Technology
Prof. Michael J. Aziz, Harvard University
Prof. Jerry Yan, Editor-in-chief of Applied Energy

Innovations Now

8:45 a.m. – 9:37 a.m., Thursday, August 19, 2021 (Boston Time)

Zoom Room B: https://us02web.zoom.us/j/89194758601?pwd=UUVOWEJUdkNiREFBT0dZRTNhRFNjQT09

Meeting ID: 891 9475 8601

Passcode: 413766

Q&A Time (a.m.)	I.D.	Authors	Title
8:45	24	Sebastian Zwickl-Bernhard, Hans Auer	Green hydrogen from hydropower: A non-cooperative open-source modeling approach assessing the profitability gap and future business cases
8:48	25	Alvaro Moreno Soto, Jack Lake and Kripa Varanasi	Transient effects caused by gas depletion during carbon dioxide electroreduction
8:51	35	Matthew Blubaugh, Ali Razban and Jie Chen	Demand-controlled ventilation energy savings for air handling units
8:54	38	Juner Zhu and Martin Bazant	Mechanical safety of Li-ion batteries: physics-based models, data-driven approaches, and their intelligent combinations
8:57	52	David Keisar and David Greenblatt	Direct wind-energy based water desalination with reinforcement learning control for off-grid applications
9:00	63	Changyu Qiu and Hongxing Yang	Numerical evaluation and sensitivity analysis on dynamic heat transfer of a novel CdTe-base vacuum PV glazing
9:03	68	Jinbo Kim, Cheolhyon Cho, Hwandong Jang and Eunkyoung Kim	Photo rechargeable energy saving smart windows for high light transmission control
9:06	77	Arvind Srinivasan, Raphael Wu and Giovanni Sansavini	Flexibility and reliability optimization of multi-energy systems
9:09	96	Paolo Giani, Marc Genton and Paola Crippa	Addressing key challenges of high-resolution numerical weather prediction models for wind energy
9:12	97	Mehdi Jafari, Apurba Sakti and Audun Botterud	Understanding technology tradeoffs — An optimization algorithm for flow battery capacity restoration
9:15	162	Marui Li, Chaoyu Dong, Qian Xiao, Xiaodan Yu, Zhe Wang and Hongjie Jia	Reinforced temperature prognosis of energy storage system based on two-node electrothermal model and integrated long and short-term memory network
9:18	173	Marco Molinari, Jonas Anund Vogel and Davide Rolando	Using living labs to tackle innovation bottlenecks: the kth live-in lab case study
9:21	181	Huaiyu Wang, Changwei Ji, Yunshan Ge, Cheng Shi, Shuofeng Wang, Jinxin Yang and Hao Meng	Machine learning model-based investigation and prediction of combustion parameters of the pure hydrogen Wankel rotary engines
9:24	202	Sayanthan Ramakrishnan, Shravan Muthukrishnan and Jay Sanjayan	An innovative method of integrating phase change materials in buildings for thermal energy storage via additive manufacturing
9:27–9:37	**Group Discussion**		

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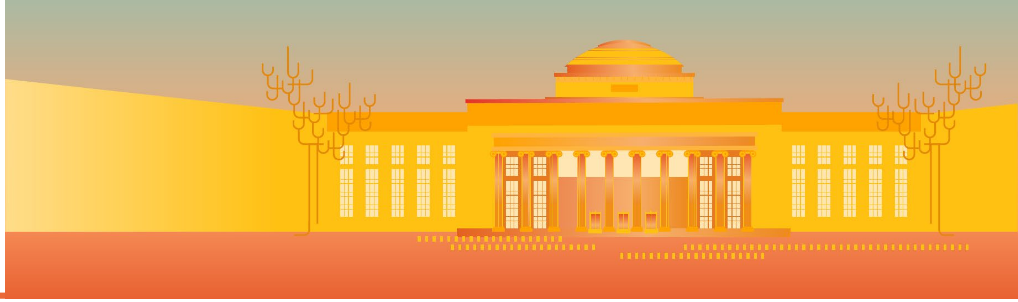

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Green hydrogen from hydropower: A non-cooperative open-source modeling approach assessing the profitability gap and future business cases

Sebastian Zwickl-Bernhard*, Hans Auer
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https://github.com/sebastianzwickl GitHub

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Introduction and motivation

- Hydrogen can play a pivotal role in the sustainable energy system transformation
  - Offers the opportunity to decarbonize the provision of numerous energy services and sectors
  - Adds additional integrated flexibility options, which can be used cross-sectoral and system-overarching
- Hydrogen deployment is also essential in most of the decarbonization pathways and sustainable economy/society storylines
- The crucial questions remain
  - (i) How is hydrogen produced in practice (primary fuels)?
  - (ii) How does the corresponding profitability look like?
  - (iii) How may various business cases succeed, taking into account the individual objectives of the agents involved?

Core objective and main research question of this work

- The core objective is to investigate a possible **future business case** for **green hydrogen production from hydropower**.
- In particular, the main research question is to find the **trade-offs** for a **run-of-river hydropower plant** owner between **trading of electricity** (e.g., forward/future electricity contracts or at the day-ahead spot market) and, alternatively**, production of green hydrogen**.
- The optimal exploitation and **allocation** of hydropower **resources** play a key role in the analysis.
- Equally important is the impact of different **CO2 prices** on the **profitability** of electricity trading and green hydrogen production.

Methodology applied

- Development of a non-cooperative optimization model (Stackelberg game).
- Thereby, the bi-level optimization framework is implemented with a single leader (H2 producer) and follower (H2 consumer).
- Both agents are profit oriented. Their objectives are maximizing revenues and minimizing total costs, respectively.
- H2 producer is the price setter and H2 consumer is the price taker for green hydrogen.

Optimization problem of the H2 consumer (follower)

$$\min_{\underline{x}} \sum_t q_t^{con} \cdot p_t^{con} + q_t^{H_2} \cdot p_t^{H_2} + q_t^{CO_2} \cdot p_t^{CO_2}$$

(1) Objective function

$$\underline{x} = [q_t^{con}, q_t^{H_2}, q_t^{CO_2}]$$

(2) Decision variables

$$\underline{d} = [p_t^{con}, p_t^{H_2}, p_t^{CO_2}, \alpha^{con}, \beta^{con}, q_t^{load}]$$

(3) Parameters

$$q_t^{load} - \beta^{con} \cdot q_t^{con} - q_t^{H_2} = 0 \quad : \lambda_t^{load} \quad (\forall t)$$

(4) Constraint - load

$$q_t^{CO_2} - \alpha^{con} \cdot q_t^{con} = 0 \quad : \lambda_t^{CO_2} \quad (\forall t)$$

(5) Constraint - emissions

Optimization problem of the H2 producer (leader)

$$\max_{\bar{y}} = \sum_t q_t^{spot} \cdot p_t^{spot} + q_t^{future} \cdot p_t^{future} + q_t^{H_2} \cdot p_t^{H_2}$$ (1) Objective function

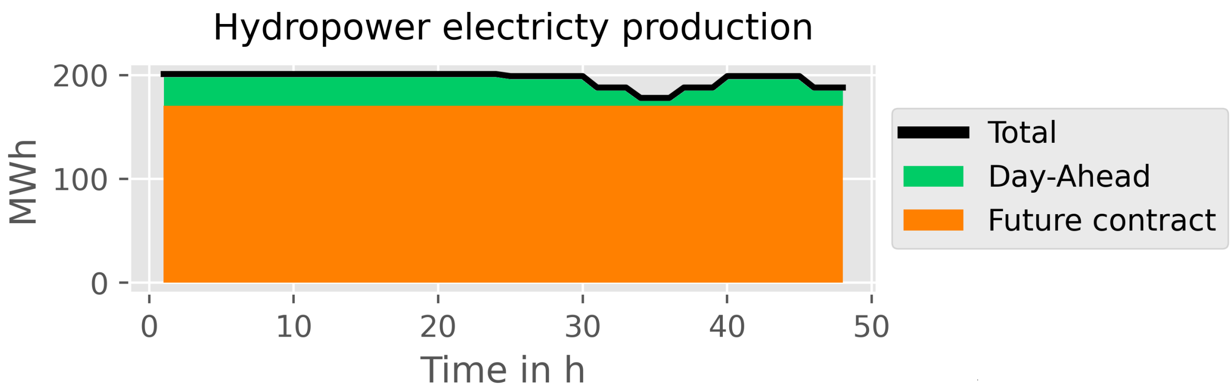
$$\bar{y} = [q_t^{spot}, q_t^{future}, q_t^{Curtail}, p_t^{H_2}]$$ (2) Decision variables

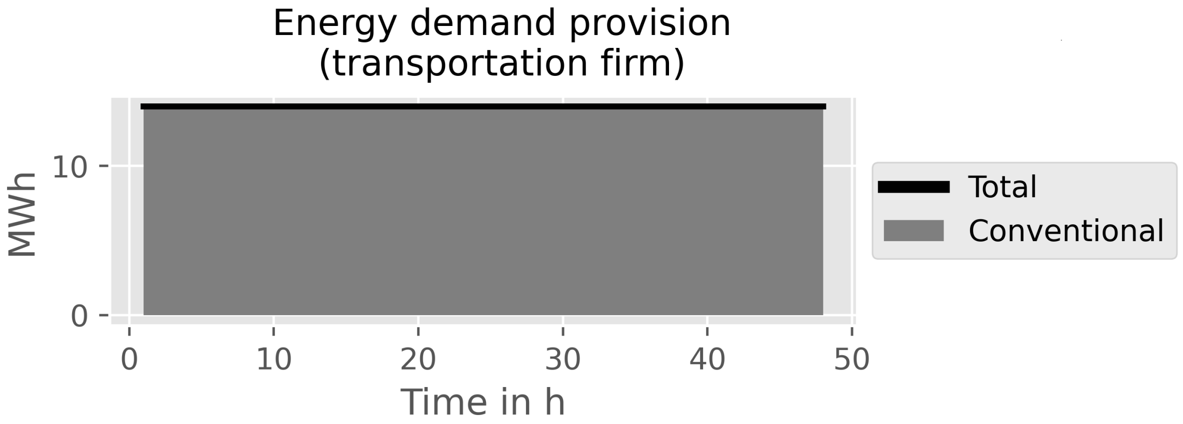
$$\bar{d} = [p_t^{spot}, p_t^{future}, q_t^{gen}, \tilde{q}_t^{base}, \eta^{H_2}]$$ (3) Parameters

$$q_t^{spot} + q_t^{curtail} + q_t^{future} + q_t^{H_2} // \eta^{H_2} - q_t^{gen} = 0 \quad (\forall t)$$ (4) Constraint - generation

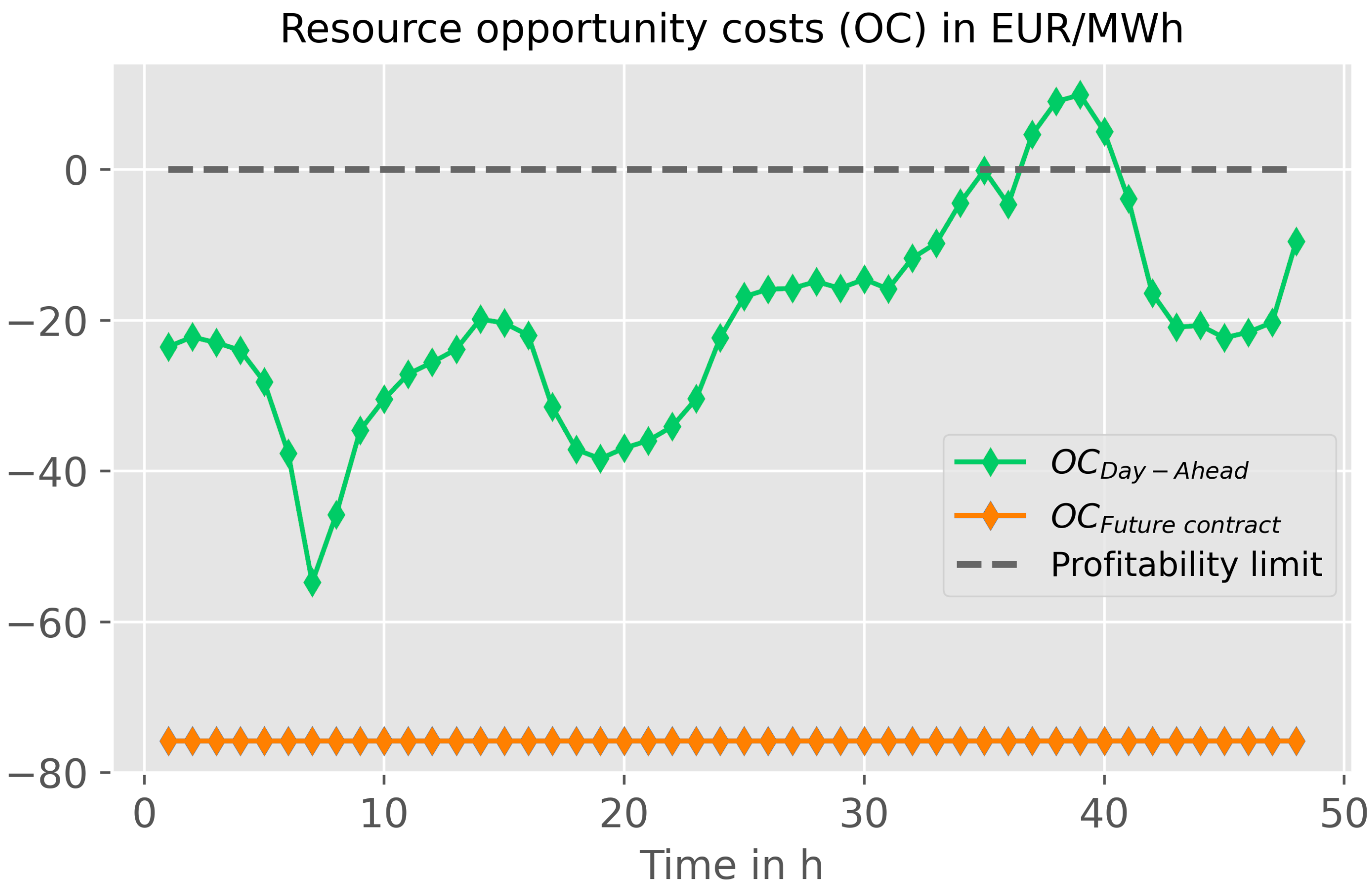
$$q_t^{H_2} / \eta^{H_2} + q_t^{future} - \tilde{q}^{base} = 0 \quad (\forall t)$$ (5) Constraint - constant

Results 1/5: Hydropower plant resource allocation and energy demand provision of the transportation firm

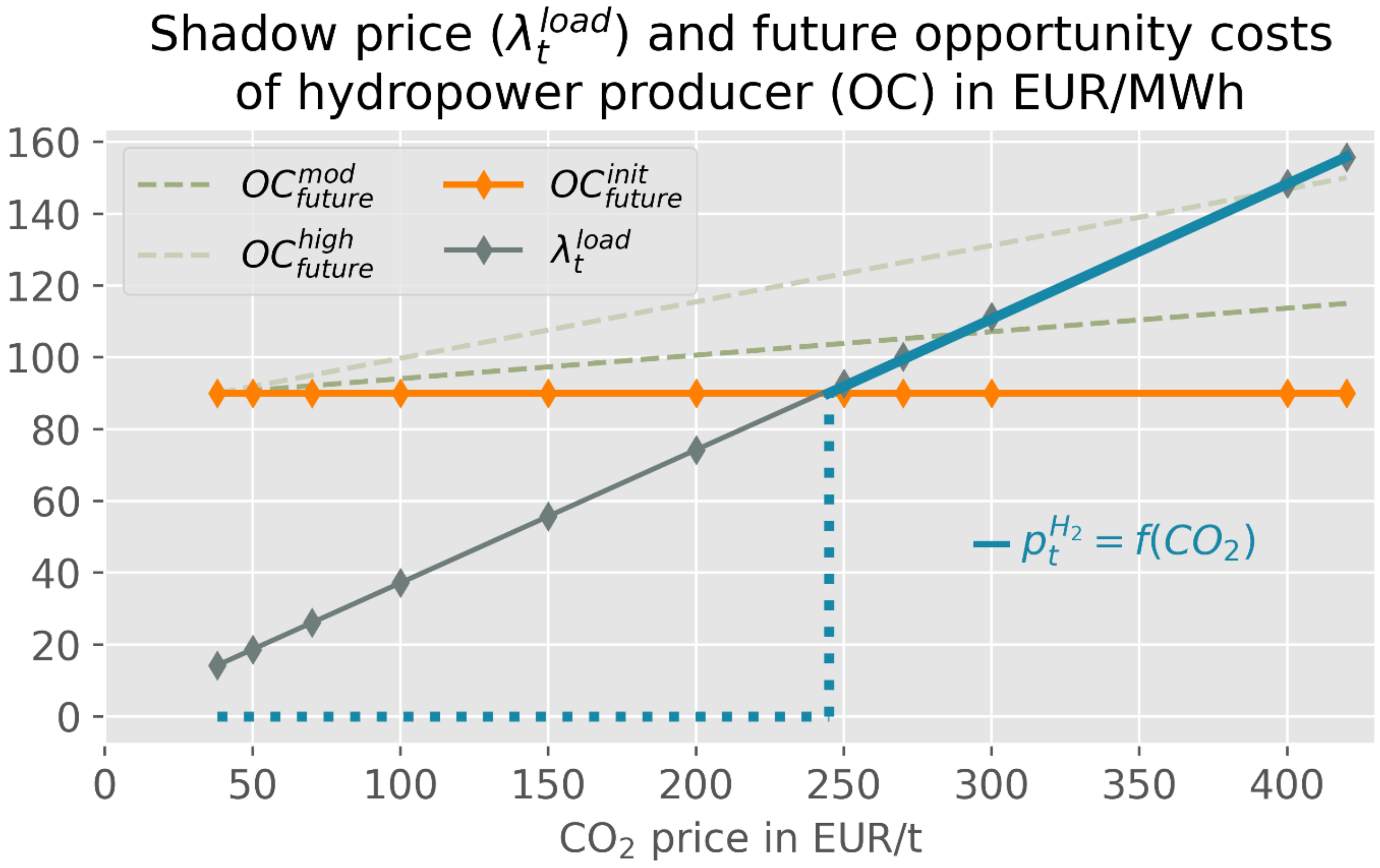




Results 2/5: Profitability gap for hydrogen production



Results 3/5: Hydrogen price set depending on shadow price and opportunity costs



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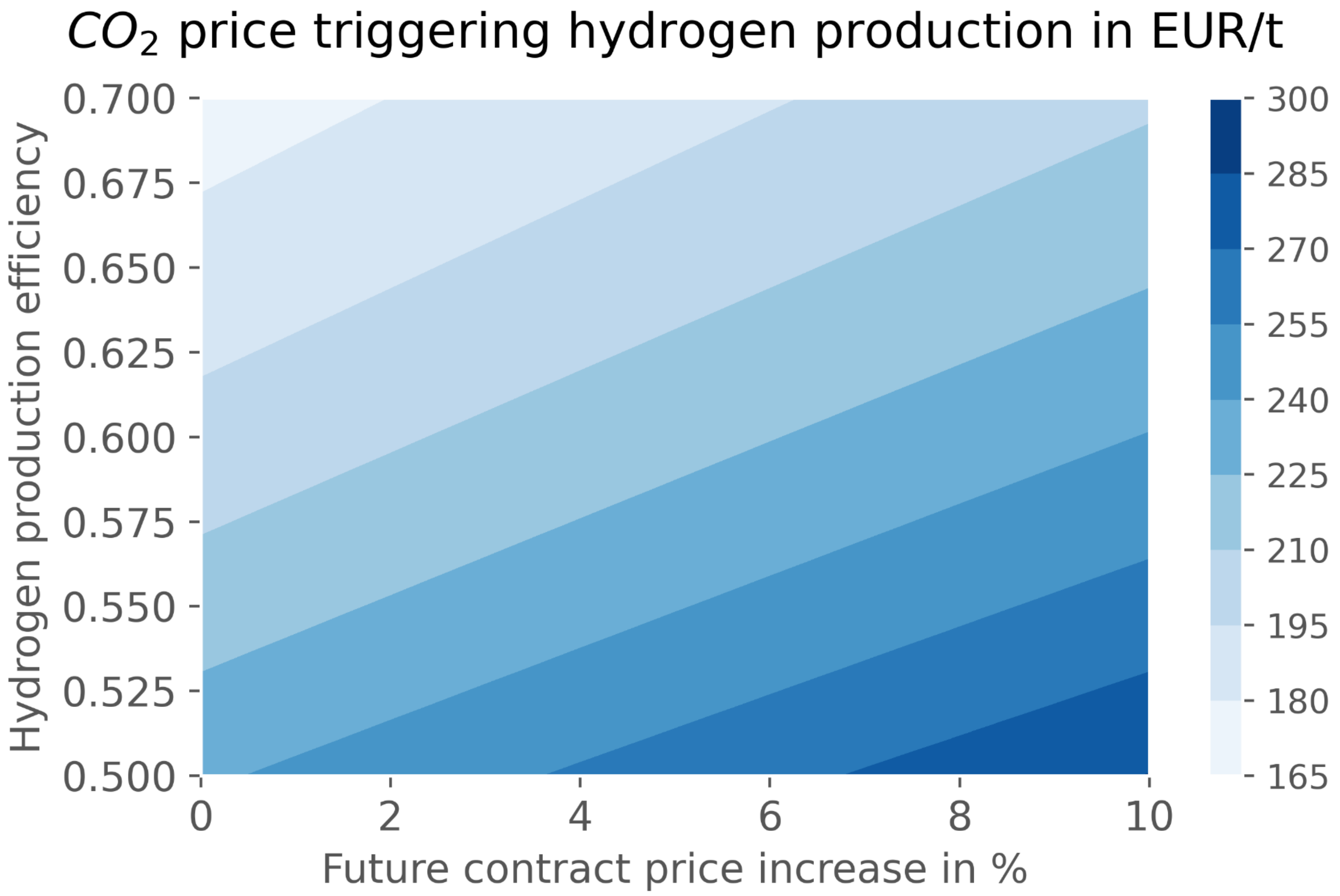

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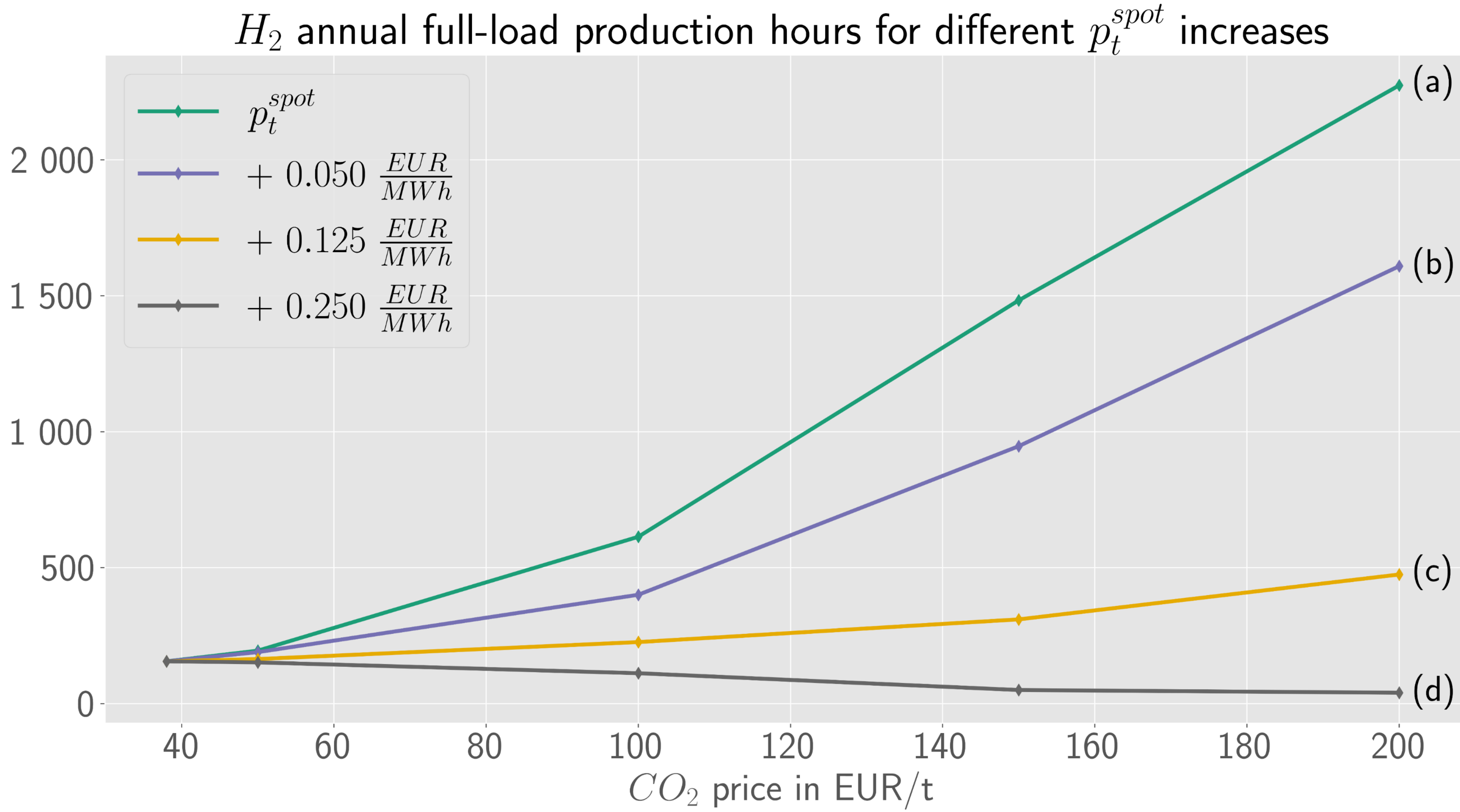
Green hydrogen from hydropower
Sebastian Zwickl-Bernhard



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Conclusions and outlook

- Current market environment and price setup do not allow for profitable green hydrogen production as yet.
- An Increasing CO2 price, as the key determining parameter, leads to improved competitiveness along with the emerging market penetration of hydrogen.
- In the numerical example examined, a CO2 price above 245 EUR/t triggers a profitable business case.
- Hydrogen deployment may also significantly depend on the price development on the wholesale electricity markets with underlying driving factors in both directions, supporting and limiting green hydrogen deployment.
- Future work may address, among others, the investigation of the impact on green hydrogen production from hydropower in a predominantly renewable energy-based power plant portfolio.

Acknowledgements

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This work has received funding from the European Union's Horizon 2020 research and innovation programme undere grant No. 835896