MASTER OF SCIENCE
IN LIFE SCIENCES

Hes·so
Haute Ecole Spécialisée de Suisse occidentale
Fachhochschule Westschweiz
University of Applied Sciences Western Switzerland

Project: From Food Wastes to Biohydrogen - Dark Fermentation as A Circular Energy Solution

Candidates	:	
Duration	:	16 weeks – one semester
Report	:	12.12.2025, 11.59pm
Advisor	:	Thierry Chappuis, Fabian Fischer, David Singer
Additional Advisors HES	:	
Expert / Company	:	
Abbreviation	:	FW^2H_2
Key Words	:	food waste valorization, dark fermentation, renewable hydrogen, circular economy

1. Description

Food production generates large volumes of organic waste, much of which is still under-utilized or costly to dispose of. In Switzerland, fruit processing generates substantial waste, notably from wine production, which produces viticultural residues such as grape skins, seeds, stems, and lees.. Others dairy by-products such as whey permeate – around 9 litres for every kilogram of cheese produced – also pose a significant treatment challenge in wastewater plants. These streams contain sugars and other fermentable compounds that could be converted into clean energy instead of being discarded. At the same time, Switzerland's National Hydrogen Strategy (adopted in 2024) and long-term climate goals for 2050 call for a transition toward renewable hydrogen to decarbonize transport, industry, and energy storage [1, 2]. This creates an opportunity to connect waste valorization with national energy priorities.

Dark fermentation [3] is a biological process in which microorganisms convert carbohydrates from organic wastes into hydrogen gas, without the need for light. It operates continuously day and night and can be applied to many waste streams, including grape pomace, fruit pulps, and dairy permeates. To reduce the impact of seasonal availability of specific residues, the project will consider combining several waste sources to ensure year-round feedstock supply. The hydrogen produced can be used directly as a clean fuel or as a feedstock for other renewable energy systems. In this project, students will investigate how dark fermentation could be applied to local food and agricultural wastes, and will compare its performance, benefits, and drawbacks with conventional anaerobic digestion (methanisation), which produces biogas rich in methane. Understanding the trade-offs between these two routes – in terms of energy yield, conversion efficiency, greenhouse gas impact, and end-use – will be key to identifying the most promising pathway.

Working in interdisciplinary teams, students will build a complete project proposal that combines scientific and economic objectives, a detailed plan of human and material resources, a timeline, and an analysis of project risks. This risk analysis will identify possible causes of premature project failure (e.g., unrealistic goals, underestimated costs, lack of technical feasibility) and propose mitigation measures. Students will draw on literature, case studies, and their own preliminary design ideas to propose a feasible process concept for biohydrogen production from selected wastes. The proposal should also consider how such a process could integrate into existing waste management systems and contribute to Switzerland's hydrogen roadmap.

2. Objectives

1. **Literature review**

   1.1. Current methods for treating and valorizing viticultural, fruit, and dairy wastes.

   1.2. Principles, advantages, and limitations of dark fermentation compared to anaerobic digestion.

   1.3. Overview of Switzerland's 2024–2050 hydrogen policy and potential markets for renewable hydrogen.

   1.4. Case studies of successful hydrogen or methane production from similar waste streams.

2. **Feedstock selection and evaluation**

   2.1. Identify at least three representative waste streams (e.g., grape pomace, apple pulp, whey permeate, others).

   2.2. Assess composition, availability, seasonality, and handling/storage requirements.

3. **Process concept development**

   3.1. Outline a lab-scale dark fermentation process for the selected wastes, including pre-treatment, fermentation conditions, and gas handling.

   3.2. Develop a simple mass- and energy-balance estimate for hydrogen production.

   3.3. Compare the same feedstocks under anaerobic digestion, estimating methane yield and total energy output, from literature data.

4. **Economic and environmental assessment**

   4.1. Estimate potential capital and operating costs for both processes at a small scale.

   4.2. Compare greenhouse gas reduction potential and integration into local energy use.

5. **Project planning**

   5.1. Define the team structure, roles, and responsibilities.

   5.2. Identify material and equipment needs, including analytical tools. Maximal budget for the project: 250 kCHF

   5.3. Prepare a timeline with milestones and a risk analysis covering technical, economic, and environmental factors.

3. Starting bibliography

[1] Federal Office of Energy. *Hydrogen and Power-to-X*. The Federal Council adopted the national hydrogen strategy in December 2024. Bern, Switzerland: Swiss Confederation; 2024. Available from: https://www.bfe.admin.ch/bfe/en/home/supply/hydrogen-and-power-to-x.html

[2] Enerdata. *Switzerland adopts its national hydrogen strategy*. Enerdata News; 2024 Dec 18. Available from: https://www.enerdata.net/publications/daily-energy-news/switzerland-adopts-its-national-hydrogen-strategy.html

[3] Albuquerque MM, Zanganeh J, Moghtaderi B. A review on biohydrogen production through dark fermentation, process parameters and simulation. *Energies*. 2025;18(5):1092. Available from: https://www.mdpi.com/1996-1073/18/5/1092

4. Remarks

Templates for the report and additional information will be provided by the advisor.

A draft report must be submitted on 11.11.2025 and will be discussed during an online session on 18.11.2025.

On the due date of the report, the following documents have to be provided by the candidates:

- Report in electronic form (Word and PDF) to the advisor and co-advisors
- The report can be written in English, French or German and should be limited to 20 pages in length (excluding appendices).

5. Evaluation

The final grade of the module will take into account the report (40%), the defense (30%) and an individual interview (30%).

The report will be evaluated according to the following criteria:

	Very good	Good	Slightly insufficient	Significantly insufficient
Context and objctives	Permanent vision of the project context, mastery of all objectives	Sufficient understanding of the context and main objectives of the project, with occasional refocusing required	Insufficient understanding of context and objectives, regular refocusing necessary	Constant reframing of context and objectives or ignoring context and objectives
State of the art	Relevant selection of existing resources, clear summary, clear positioning of the project	Selection of relevant resources, partial summary, positioning of the project presented but not very in-depth	Selection of irrelevant resources, unclear or non-existent project summary and positioning	Selection of irrelevant resources or missing state of the art
Research methodology	Appropriate and well-described research methods. The innovation sought will enable proven advances to be made	The research methods have minor shortcomings which impact the clarity of the research proposal. By large, the innovation actions will allow to fulfill the goals of the project.	The research methods have major shortcomings which significantly impact the clarity of the research proposal. By large, relevant parts of the proposal objectives will not be fulfilled.	Research methods are inappropriate or incomprehensible. The innovation sought will not lead to proven advances
Planification	Tasks and deliverables broken down and planned in a relevant and autonomous manner, realistic planning including resources and costs	Tasks and deliverables cut out and planned in a relevant way after a few modifications	Numerous corrections needed to arrive at a definition of tasks and deliverables and a workable schedule	Unworkable breakdown and planning despite multiple iterations
Clarity and legibility	Clean, concise writing, precise vocabulary, high-quality illustrations described in the text, attractive layout	Acceptable writing (a few spelling mistakes), generally appropriate vocabulary, mostly legible illustrations	Several spelling mistakes per page, often insufficient vocabulary, poor quality or inappropriate illustrations	Spellchecker not used, inappropriate vocabulary, poor quality/inappropriate illustrations, sloppy layout

The defense will be evaluated according to the following criteria:

	Very good	Good	Slightly insufficient	Significantly insufficient
Structured presentation and ability to summarise (15%)	Introduction of context, clear structure, clear, well-argued summary	Adequate structure, some awkward transitions, partial or unargued summary	Unconvincing structure, missing transitions, unconvincing synthesis	Context not introduced, lack of main theme and summary
Presentation materials (15%)	Clean, error-free and legible material, good linkage between presentation and material content	Appropriate support material, usually error-free and legible, used for the presentation	Loaded and illegible media or no control over media content	Overloaded and illegible media and no control over media content
Posture and oral expression (15%)	Open posture, captures the listener's attention, good elocution, appropriate and specific vocabulary	Open posture, lack of dynamism, adequate elocution, mostly appropriate vocabulary	Closed posture, limited contact with the public, limited and/or inappropriate vocabulary, poorly comprehensible oral expression	Closed posture with no contact with the audience, incomprehensible or inaudible speech
Technical depth of the presentation (15%)	Fully convinced of the quality and depth of the work carried out and of its original contribution to TM	Impression that the work carried out has an appropriate technical depth for a TM	The presentation does not allow us to assess the quality and depth of the work carried out	Impression of surface work, no new technical elements linked to TM, the presentation is a smokescreen
Presentation management (15%)	Time limit respected, prepared slides were all dealt with in the same level of detail, self-assessment included in 30 min.	Slight overrun (3 min max) or necessary acceleration during the presentation with a different level of detail for the last slides, self-assessment included in the 33 min.	Overrun of more than 3 minutes or necessary acceleration with more than 3 slides not dealt with or no self-assessment	Overrun of more than 6 minutes or necessary acceleration with more than 6 slides that are not processed or no reaction to the supervisor's warning.
Interacting with listeners and answering questions (25%)	Constructive attitude in discussions, clear answers in line with the questions asked	Constructive attitude in the discussion, imprecise answers in line with the questions	Lack of commitment to the discussion, answers not in phase with the questions	Defensive and/or negative attitude in the exchange, irrelevant responses (avoidance, deflection)

Plagiarism in any form is not accepted. Any case of plagiarism or professional misconduct will be prosecuted following the rules of the HES-SO.

XX.XX.2025, Sion

Advisor

Urban Frey
Head of Master HES-SO MLS

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