P+D 1

sweet swiss energy research for the energy transition

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Reserve Power Plants

Goal: The P+D project 1 aims to study use cases for the **auxiliary power plants** running on sustainable fuels for a **seasonal** strategy and **self-sufficiency** considerations. Potentially, a promising use case is studied **hardware-in-the-loop** by relying on different installations both from private partners and consortium members.

Team

Team PSI-LEA

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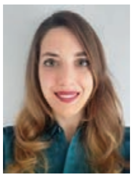
Team ETH-EPSE

André Bardow



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Team EMPA-UES

Robin Mutschler

Who wants to join?

Your picture

Your picture

Your picture

Partners interested in contributing:

PSI-LEA ETH-EPSE

EMPA-UES

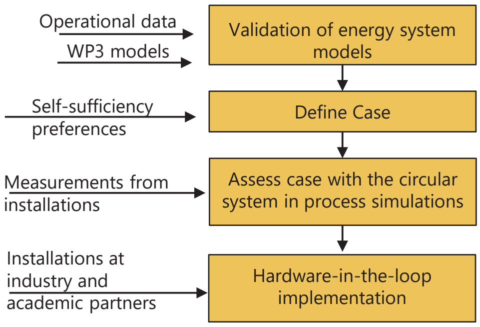
Concept

Available inputs from reserve power plants & GE:

- Input/ output data, e.g., efficiencies (without interference with plant operation
- Experimental data from test benches on different fuels

Expertise from reFuel.ch:

- Modeling of the Swiss energy system with a focus on robustness (WP3)
- Understanding of national policy and public acceptance, especially concerning self-sufficiency (WP1, roundtables)
- Power-to-X installations



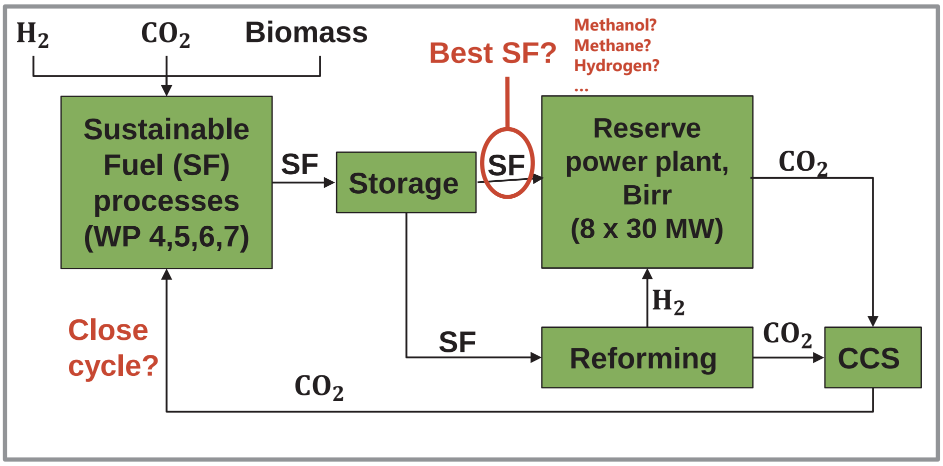


Figure: Concept to integrate the reserve power plant in Birr with sustainable fuel production processes, seasonal storage and carbon capture and storage (CCS)

Research questions

- What role can a reserve power plant play in achieving a **robust and sustainable** (reFuel.ch Objective 1) energy supply?
- **Which fuel** is most suited for such a reserve power plant?
- Can we integrate such a reserve power plant with seasonal storage?
- Should we **close the carbon cycle** on-site?

Timeline and Milestones

Case study definition:

- Defining a potential role considering self-sufficiency

Detailed demonstrator concept:

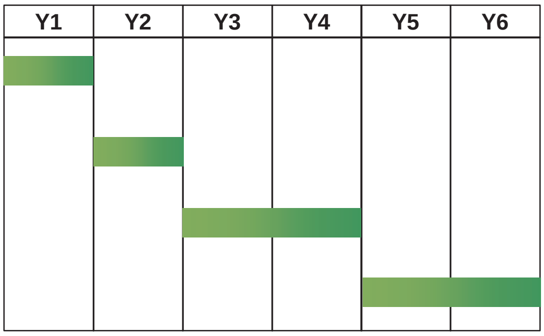
- First assessment of concept based on energy system models

Process simulation:

- Development of detailed simulation models for all components

Hybrid system hardware-in-the-loop:

- Virtual connection of installations a different locations



reFuel.ch – **Re**newable **Fuel**s and **Ch**emicals for Switzerland

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PuD 2

Case Study: Sustainable Fuels and Chemicals Import from the Iberian Peninsula

sweet swiss energy research for the energy transition

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Concept

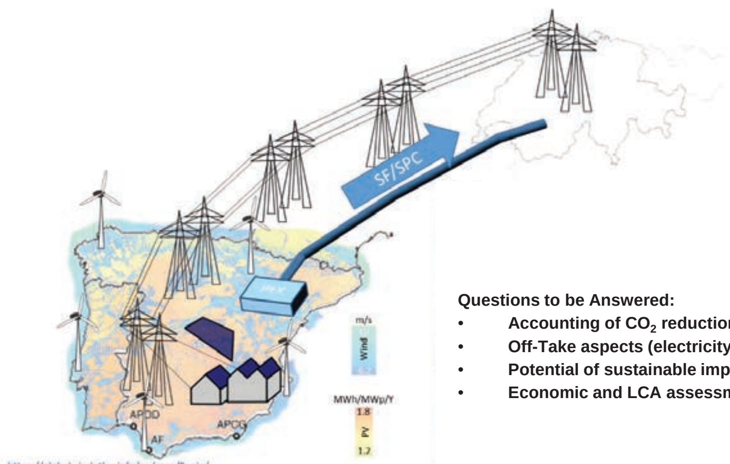
Explore the potential of energy trade between Spain and Portugal, as examples of EU countries, and Switzerland

Imports of energy in the form of electricity, SAF, and SPC will play a decisive role in the future Swiss energy system, while other countries can export renewable energy.

Spain and Portugal, with their renewable energy potential (solar Direct Normal Irradiance between 1730 and 2310 kWh/m2 [REF]), are promising partners, seen as the future powerhouse of Europe [REF].

Essential Aspects:

- **The potential of renewable energy generation**
- **Policy and legal questions**
- **Economic and ecologic characteristics**
- **Social acceptance within Spain and Portugal (domestic energy requirements, land use, etc.)**
- **Networks and storage for reliable energy import**
- **Challenges and opportunities, regulatory framework**



https://globalwindatlas.info/en/area/Spain/
https://globalsolaratlas.info/map?c=44.276671,-15.073242,6

Questions to be Answered:

- **Accounting of CO_2 reduction credits**
- **Off-Take aspects (electricity and gas grid, fuel logistics)**
- **Potential of sustainable imports**
- **Economic and LCA assessment**

Impact

The stakeholders get information required to negotiate obstacles and develop **future business models**.

For the upstream market:

- **Energy providers** in the exporting region
- **Regional governments** in the exporting region,
- Process **engineering** and **refinery business**

For the down-stream market:

- Local **energy distributors** and
- **Service providers** (Airlines, logistics…)

In general, the **financial sector** and **insurance** business.

Timeline and Milestones

P+D2			Year 1				Year 2				Year 3			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task		**Teams**	M01-03	M04-06	M07-09	M10-12	M13-15	M16-18	M19-21	M22-24	M25-27	M28-30	M31-33	M34-36
T0	Coordination	*P+D lead*												
T1	Pre-Feasibility RT and stakeholder onboarding	*Members*						M1.1						
T2	Pre-Feasibility literature search and assessment	*Members*											M2.1	D2.1
T3	P+D application for feasibility study	*Members*												

			Year 4				Year 5				Year 6			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task		**Teams**	M37-39	M40-42	M43-45	M46-48	M49-51	M52-54	M55-57	M58-60	M61-63	M64-66	M67-69	M70-72
T0	Coordination	*P+D lead*												
T3	P+D application for feasibility study	*Members*	M3.1											
T4	Feasibility study	*Members*								D1.4				

P+D 3

Sustainable Fuels and Chemicals Import from Oman

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reFuel.ch

Team

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Objectives

Objective 1 of the Oman sustainable fuel case is to evaluate how existing technologies for the production of sustainable fuel in desert regions should be combined and operated to meet high sustainability metrics as required, for example, by the European "Renewable Energy Directive" (RED-III).

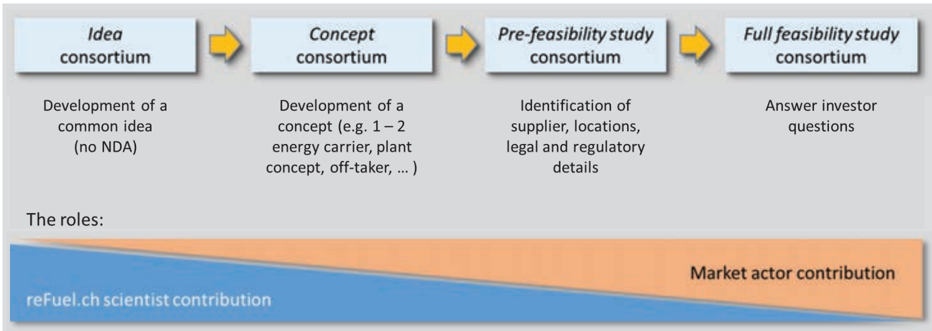
Desert regions for example have an enormous but fluctuating energetic potential and thus why conventional Power-Purchase-Agreement (PPA) approaches with assumed maximal hours at full-load fall short. In addition, the lack of water in combination with high CO_2 availability emphasizes the importance of Direct Air CO_2-Capturing in such regions.

Objective 2 is to evaluate the sustainability of synthetic fuels produced in desert regions. Sustainability is understood in this context on a broad sense, including social, technical, economic and political aspects for all involved parties.

Objective 3 is to identify the logistics of sustainable fuel delivery from Oman to Switzerland, for both the costs and the environmental impact.

Objective 4 aims to identify if a consortium (including investors in the up- and downstream market) for the further development of the case can be initiated (including the acquisition of the required funding).

Concept



Within a structured concept starting with an *idea consortium*, the processing of open questions (see objectives 1 – 4) and the development of an idea for the supply of sustainable fuels to Switzerland shall be developed towards realization.

In a first action, a delegation of the idea consortium joined the Green Hydrogen Summit Oman in December 2023 and gained many insights and information about the plans of Oman for sustainable fuels production.

Empa, zhaw, SUPSI, n|w Fachhochschule Nordwestschweiz, PSI, CASALE, EPFL, ETH zürich, Universität Basel

Impact

Deserts show a 2 – 2.5 times higher renewable electricity production potential and significant amounts of unused areas. Within the Oman sustainable fuel case, the production of sustainable fuels in deserts shall be investigated.

To cover the demand of sustainable fuels in Switzerland by 2050, large scale plants are required and a market-ramp-up must start soon! However, to comply with sustainability factors, such as a coupling with fluctuating renewable electricity production, load flexibility of large scale plants is crucial and will be investigated.

Combining the energetic potential and the advanced infrastructure of sustainable energy technology in Oman with the research competences of Switzerland could be of interest for both countries.

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P+D 4

Hydrogen for high-temperature processes

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Objectives

The overarching objective is to decarbonize industrial processes and materials. Thereby the focus is set on

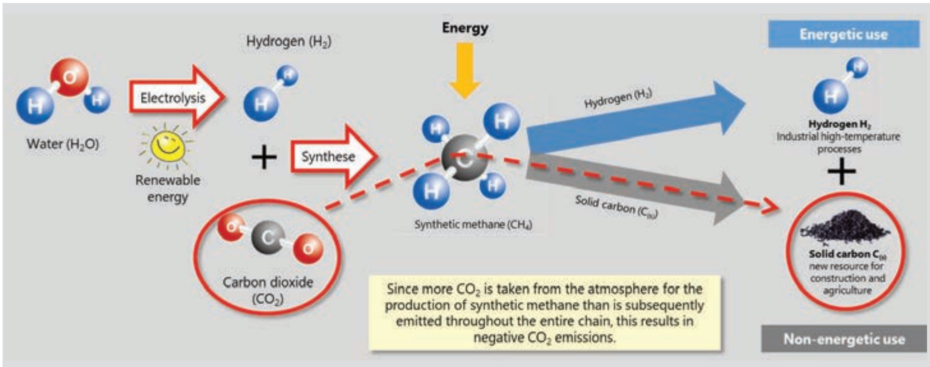
i) the decarbonization of high-temperature process heat

ii) the substitution of fossil energy based materials

The approach shall cover the entire energy chain and be compatible with the requirements of future energy systems (e.g. by avoiding an increase of electricity import during winter).

The technology shall be demonstrated in a real industrial environment.

Approach



Methane pyrolysis is often mentioned in literature among the most cost effective hydrogen production routes. However, sustainable decarbonization only occurs if renewable energy is used. This case may even result in the production of hydrogen with negative CO_2 emissions.

Furthermore, the pyrolysis of renewable (biogenic or synthetic) methane enables production of hydrogen for use in high-temperature processes as well as solid carbon as a substitute for fossil Carbon Black. Both are used in large scales.

While the use of hydrogen for the decarbonization high-temperature processes is quite clear and corresponding burner technologies are available, the processing of the solid carbon is more demanding since it may be contaminated with organic carbon and requires densification for further use.

Empa Materials Science and Technology · Tech Cluster Zug · Kanton Zug · AVAG · WWZ · V-ZUG · Partners Group · Accelleron · Sulzer · amag · VZ · Sika · swiss safety center · Metall Zug · Holcim · SHL Medical · sakowin · Siemens

Impact

Within this P+D project, a demonstrator with a hydrogen production capacity of 10 kg/h and a solid carbon production capacity of 30 kg/h shall be realized on the campus of the Tech Cluster Zug AG. The hydrogen shall be used in the high-temperature enameling oven and the carbon shall be used as carbon black substitute in member companies of the Association for Industry Decarbonization (see logos on the left side).

The further development of atmospheric carbon into a material shall be investigated. In a first stage, a substitute for fossil Carbon Black is the main focus. On a longer term, other carbon based materials such as carbon fibers of graphite shall be discussed.

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Power to SAF Demonstration Plant & Innovation Platform

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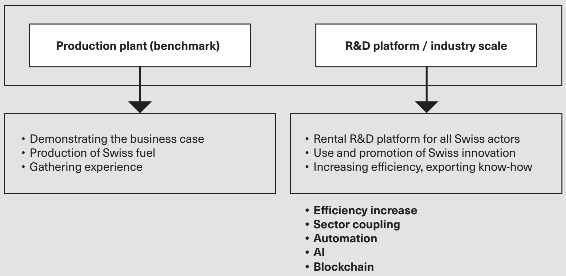
Concept

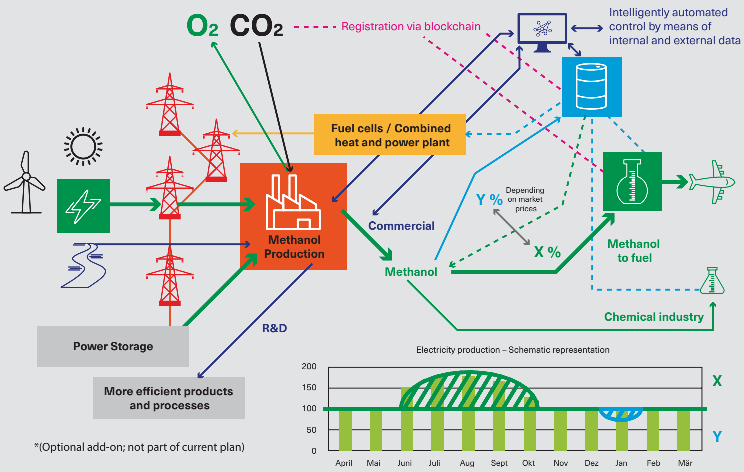
Commercial plant 2-10 MW
Bookable for R&D
Availability: 7'884 hrs (90% of the year) per year
Maturity: TRL > 4 for implementation
Integration: The technology shall be suitable to be integrated into the existing industrial environments.
Fuels: SAF and e-Methanol

Design: Modular design for easy integration, upscaling, improved QA/QC and fast installation on site.
Operation: Basically base load, but part-load (if required and/or cannot be avoided) Automated Data Management System using electricity market data to optimize the operation of the P2L facility

Dual Use Demonstration Plant



Dual Use Demonstration Plant (+ Sector Coupling)*



*(Optional add-on; not part of current plan)

Airborn Fuels Switzerland

To make synthetic SAF fly

airbornfuels.ch

Partners: engineering, power utilities, aircraft manufacturing, plant manufacturer and operator, power-to-methanol and methanol-to-JetFuel technology providers.
Information verbally only.

Impact

e-Methanol and e-SAF for the industry
Acceleration of technological readiness
Demonstration of business case and Swiss innovation power
Supportive political framework conditions
Supportive public perception

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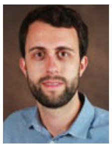
P+D 6

Swiss Methanol Platform

Team



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Other partners:

- Azienda Multiservizi Bellinzona (AMB)
- Divisione dell'ambiente del Canton Ticino
- Azienda Elettrica Ticinese (AET)
- Metanord

Concept

Project idea:

The idea of the project is to realize an industrial green methanol pilot. The plant will combine methanol production for seasonal storage and industrial customers with industrial demonstration, linked to joint research in the reFuel.ch project.

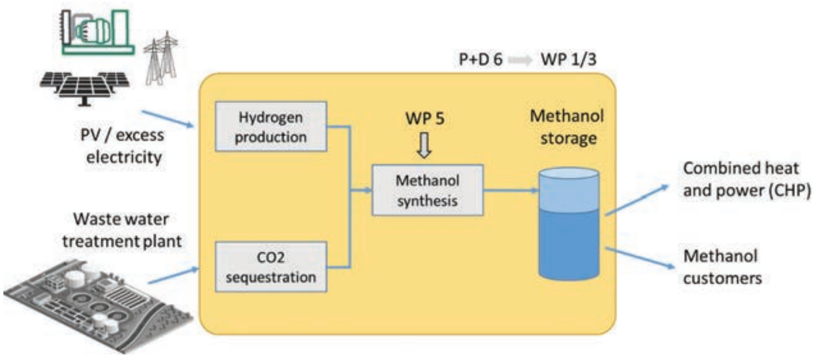

Figure: Project concept and integration into reFuel.ch

Project boundary conditions:

The project builds on the unique setup with three CO_2 sources:

- Biogas plant (CO_2: 1400 t/a)
- Wastewater treatment plant (CO_2: 800 t/a)
- Waste incineration plant (CO_2: 180 000 t/a)

Furthermore, an on-site electricity production 100 GWh p.a. allows for high full-load hours necessary at the current technology and market readiness level.

The project will take into account the specific location in canton TI considering the geographical boundary conditions and existing infrastructure.

Current status:

Pre-feasibility study concluded

Goal

- The goal is to integrate the Biogas and Wastewater treatment plant in a first project step to build up experience for potential scale-up to including the waste incineration plant.
- The project focuses on technology demonstration and validation, aiming to provide a platform for component testing for industrial partners.
- The project integrates research activities from the reFuel.ch project on component development and system level.

PuD 7

Synergistic Methanol and Methane from Decentral and Domestic Biomass Sources

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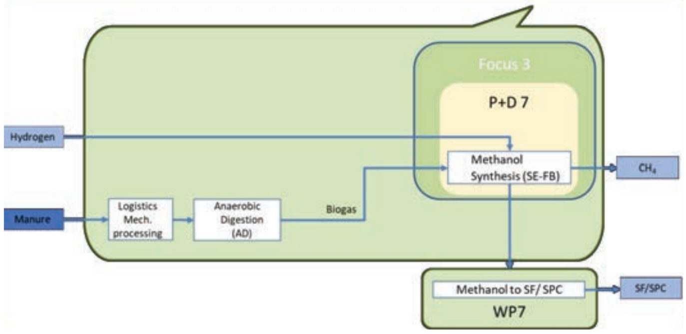
AlphaSYNT®
Swiss SynFuels

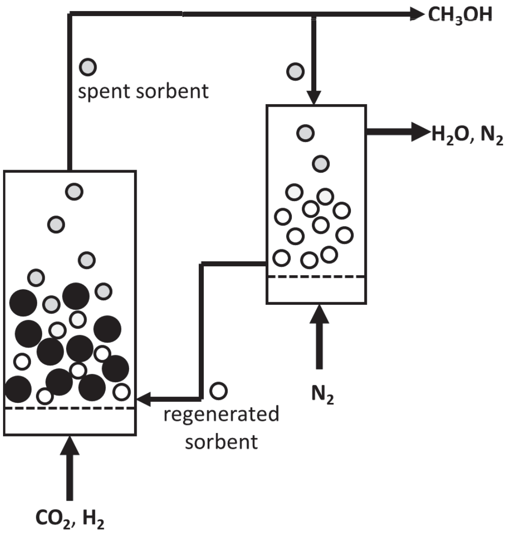
Concept

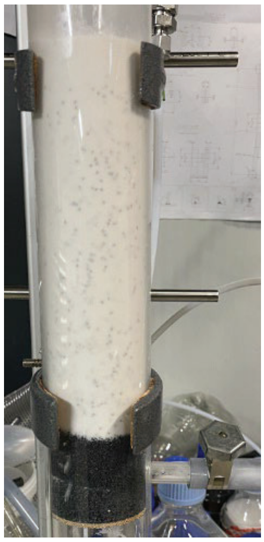
Challenges for methanol synthesis: Strong thermodynamic limitation; compression for state-of-the-art high pressure operation is too expensive in PtX.

Approach: Shift equilibrium by in situ product removal with continuous sorbent circulation to regenerator. Techno-economic estimation shows potential for reduced capital cost and higher efficiency

Goal: Based on the results of WP6, including fluid dynamic research and TEA (techno-economic assessment), a pilot plant TRL 7 is planned for the second project half.







Impact

- Results from WP6 (plant operated at TRL 4) will be upscaled
- Technical experience from bringing fluidized bed methanation to commercial scale limits the scale-up risk
- Technology aims at lower OPEX and CAPEX in methanol synthesis and thus at facilitating decentral plants
- Besides CO_2 from digestion, also producer gas from biomass gasification or CO_2 from biomass-based flue gas or air can be used as carbon source to obtain renewable methanol, even according to the expected new RED III rules.

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PuD 8

Manure-Based Bio-Crude

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WIN GD

BFH

Concept

Background: Manure holds an unused energy potential of 25 PJ/a and could be used as renewable energy source. Technical challenges include the low energy density of manure.

Goal: Demonstrate the technical feasibility of converting manure to a storable fuel. Use the fuel for electricity generation. Power a internal combustion engine with the resulting bio-fuel.

Task 1: Demonstrate the Manure handling and pre-processing

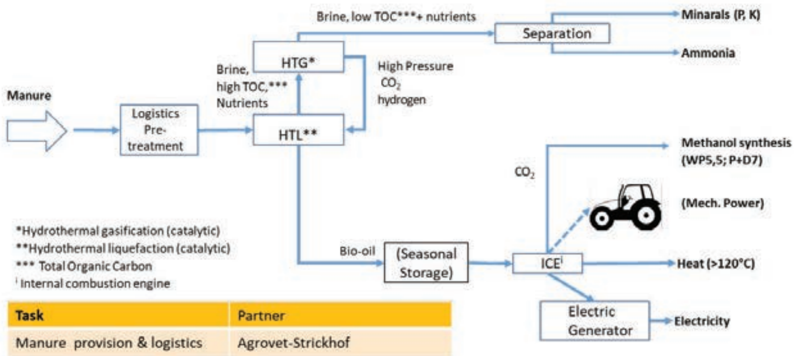
Task 2: Catalytic hydrothermal liquefaction (HTL of manure to bio-oil in fuel quality

Task 3: Testing and qualification of the bio-oil for use in internal combustion engines

Task 4: Gasify the process water which is loaded with organics into CO_2 and hydrogen

Task 5: Routing the CO_2 towards the mrethanol synthesis in P+D 6

Task 6: Extraction of ammonia and minerals to complete the process chain



Task	Partner
Manure provision & logistics	Agrovet-Strickhof
Manure pretreatment	BFH
HTL plant	FHNW (rented)
Catalyst system	FHNW (with cat. manufacturer)
HTG	PSI-LBK
Fuel qualification for ICE	WinGD
Nutrient separation	TBD
Assessment	ETHZ
Implementation (business case, farm fueling)	Agricultural cooperative fuel distributor

Impact

- Realize the energy potential and regenerate the nutrients in the process water
- Create new renewable energy source for electricity generation
- Seasonal energy storage to bridge the winter months with less solar energy
- Additional prospect of powering tractors and other heavy machinery
- Contribute to Switzerland's self-sufficiency

Timeline and Milestones

Not yet defined

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SFLV1

Methanol-type SAF emissions from jet aircraft ground tests (MESAGROUND)

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metafuels

PILATUS

PSI zhaw UNI FR

Concept

Methanol-to-jet (MtJ)

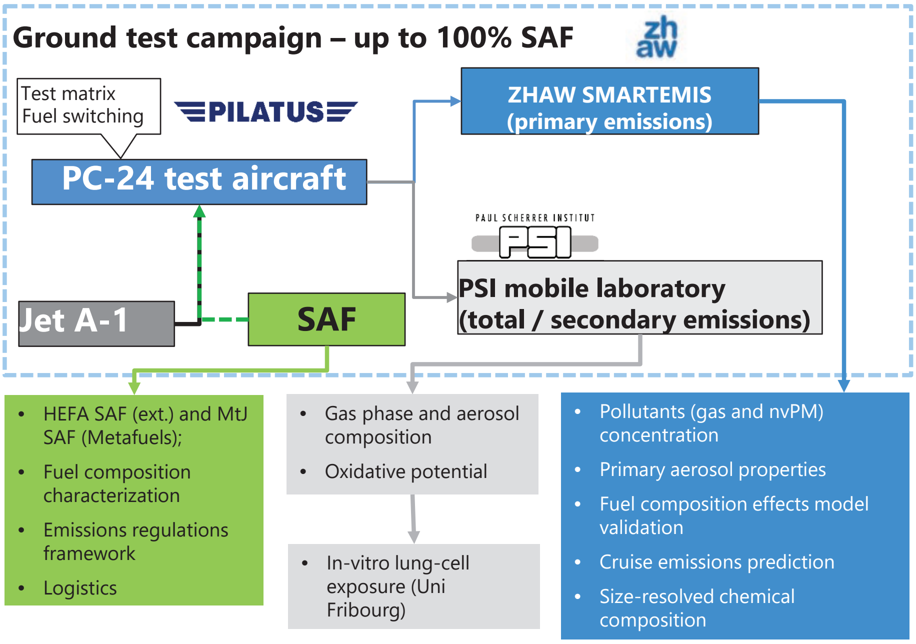
Promising sustainable fuel

Not yet ASTM-certified

Non-CO_2 emissions

Large climate effect (2/3 of aviation impact)

Still large uncertainties, especially for small engines



Impact

- Demonstrate low plant-to-tank emission along logistics chain
- Determine influence of SAF (in particular MtJ) on:
  - Reduction of non-CO2 climate impact
  - Reduction of local pollution (landing/take-off emissions)
- Improve understanding of health effects of emissions with MtJ fuel

Timeline and Milestones

Timeline: M22 – M69 (Q4 2024 – Q3 2028); SFLV application: Q4 2024

	Year 2	Year 3				Year 4				Year 5				Year 6		
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task	M22-M24	M25-M27	M28-M30	M31-M33	M34-M36	M37-M39	M40-M42	M43-M45	M46-M48	M49-M51	M52-M54	M55-M57	M58-M60	M61-M63	M64-M66	M67-M69
T0 Coordination	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
T1 Campaign planning				■	■	■	■	■	■	■						
T2 Measurement campaign								■	■	■						
T3 Analysis of test results								■	■	■	■	■	■			
T4 Modeling										■	■	■	■	■		
T5 Publication								■	■	■	■	■	■	■	■	■

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