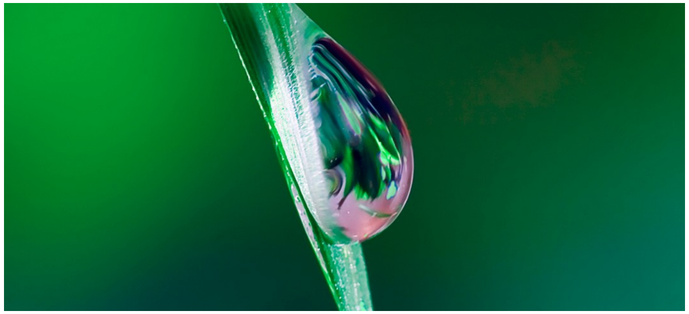


Program: Advanced Energy Solutions

Example major: Energy Conversion Processes

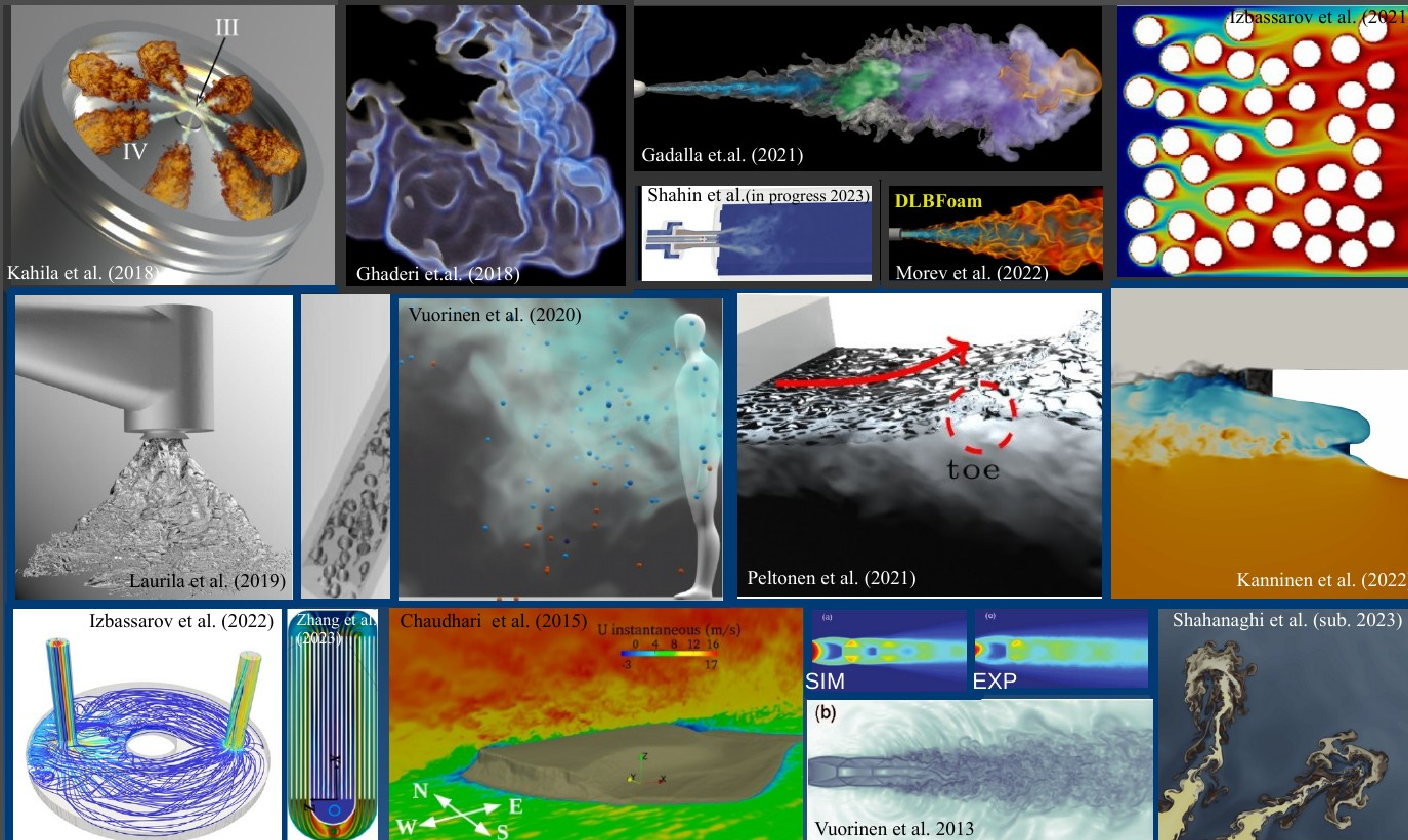
Prof. Ville Vuorinen, Professor in Charge for EC major
Prof. Ossi Kaario
Aalto University, School of Engineering
Aug. 27th 2024
ville.vuorinen@aalto.fi

The EU is committed to a carbon neutral Europe by 2050, while Finland's respective target is already in 2035.

*To reach this goal, energy conversion processes need to be designed, re-designed or improved and understood **based on natural sciences and interaction between different disciplines**.*

Computational fluid dynamics team at Aalto University, Finland

- Prof. V.Vuorinen + Prof. O.Kaario + 20 researchers
- 15 supervised PhD's, 100+ journal papers
- Hydrogen, e-fuels, reactive multiphase flow, heat transfer, gas-/hydrodynamics
- OpenFOAM, StarCCM+, STAR-CD, LES/DNS/RANS/DES, DLBFoam



Example: M.Sc. thesis on energy storage in 5G smartpoles (Business Finland and Nokia), A.Lagerström, Experimental study on a new latent heat storage system, M.Sc. Thesis, Aalto 2021 https://aaltodoc.aalto.fi/items/a9c8bd62-9e20-43f8-b80c-f70a102b6f06

Example: M.Sc. thesis on energy storage in 5G smartpoles (Business Finland and Nokia), A.Lagerström, Experimental study on a new latent heat storage system, M.Sc. Thesis, Aalto 2021 https://aaltodoc.aalto.fi/items/a9c8bd62-9e20-43f8-b80c-f70a102b6f06

Figure 2: Overview of Kera area ecosystem and its components. Smart poles will also be located in this environment. (Visuals made of Aalto University Design Factory team)

Example: M.Sc. thesis on energy storage in 5G smartpoles (Business Finland and Nokia), A.Lagerström, Experimental study on a new latent heat storage system, M.Sc. Thesis, Aalto 2021 https://aaltodoc.aalto.fi/items/a9c8bd62-9e20-43f8-b80c-f70a102b6f06

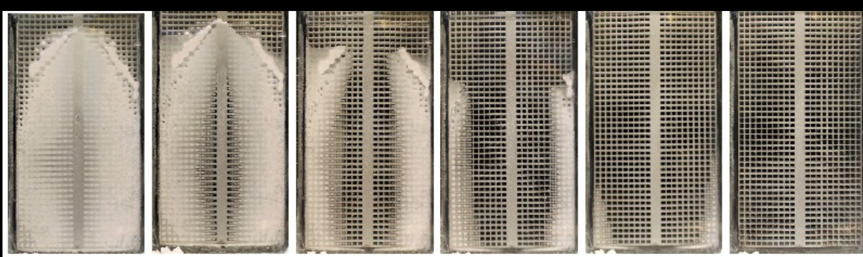


Figure 21: Melting of PCA28 documented with a 4 minute interval

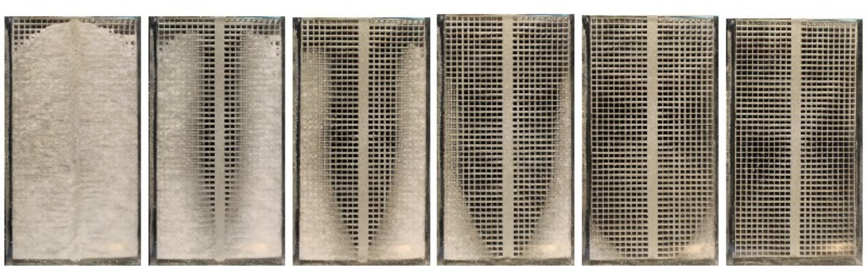
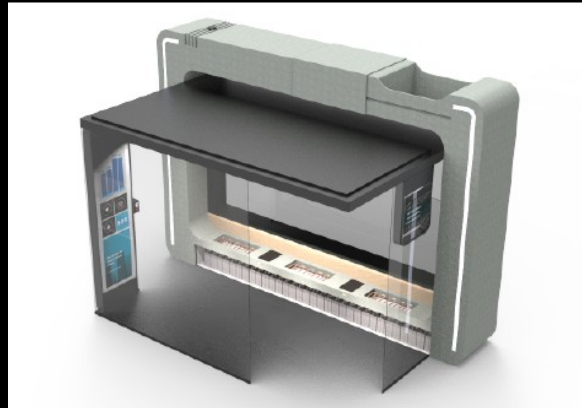
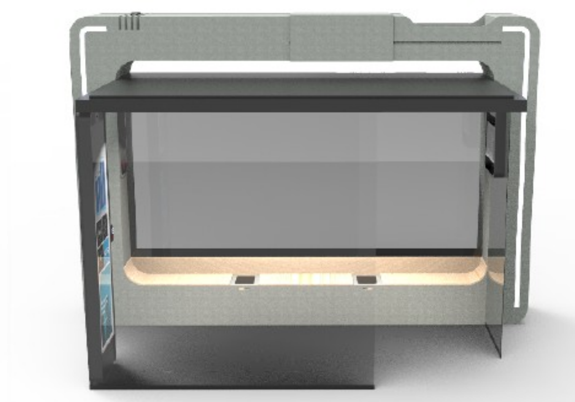


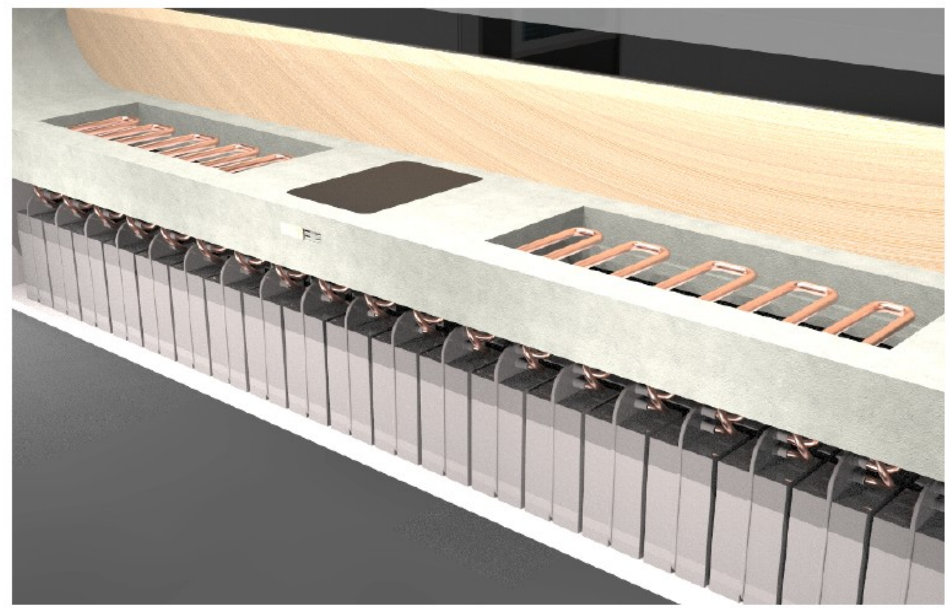
Figure 22: Melting of decanoic acid documented with a 4 minute interval



(a) Open bench to view the inside structure



(b) Normal view, hidden structure



(c) Close up view, bench surface and storage tank walls missing

Figure 37: LHTES bench heating concept for a smart bus stop. Visualizations made by Aalto Univeristy Design Factory team

Wind power in Finland

Frontpage > Wind power in Finland > Wind power in Finland > **About wind power in Finland**

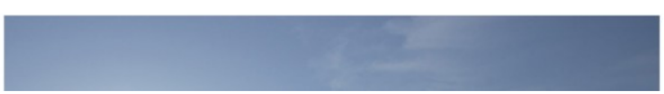
About wind power in Finland

In Finland, wind power construction began later than in many other European countries. However, from 2012 to 2013, wind power construction has gained momentum and national construction and production statistics have been broken year after year.

At the end of 2019, there were 754 installed wind turbine generators, with a combined capacity of 2284 MW. They generated 7 % of Finland's electricity consumption in 2019.

2284 MW

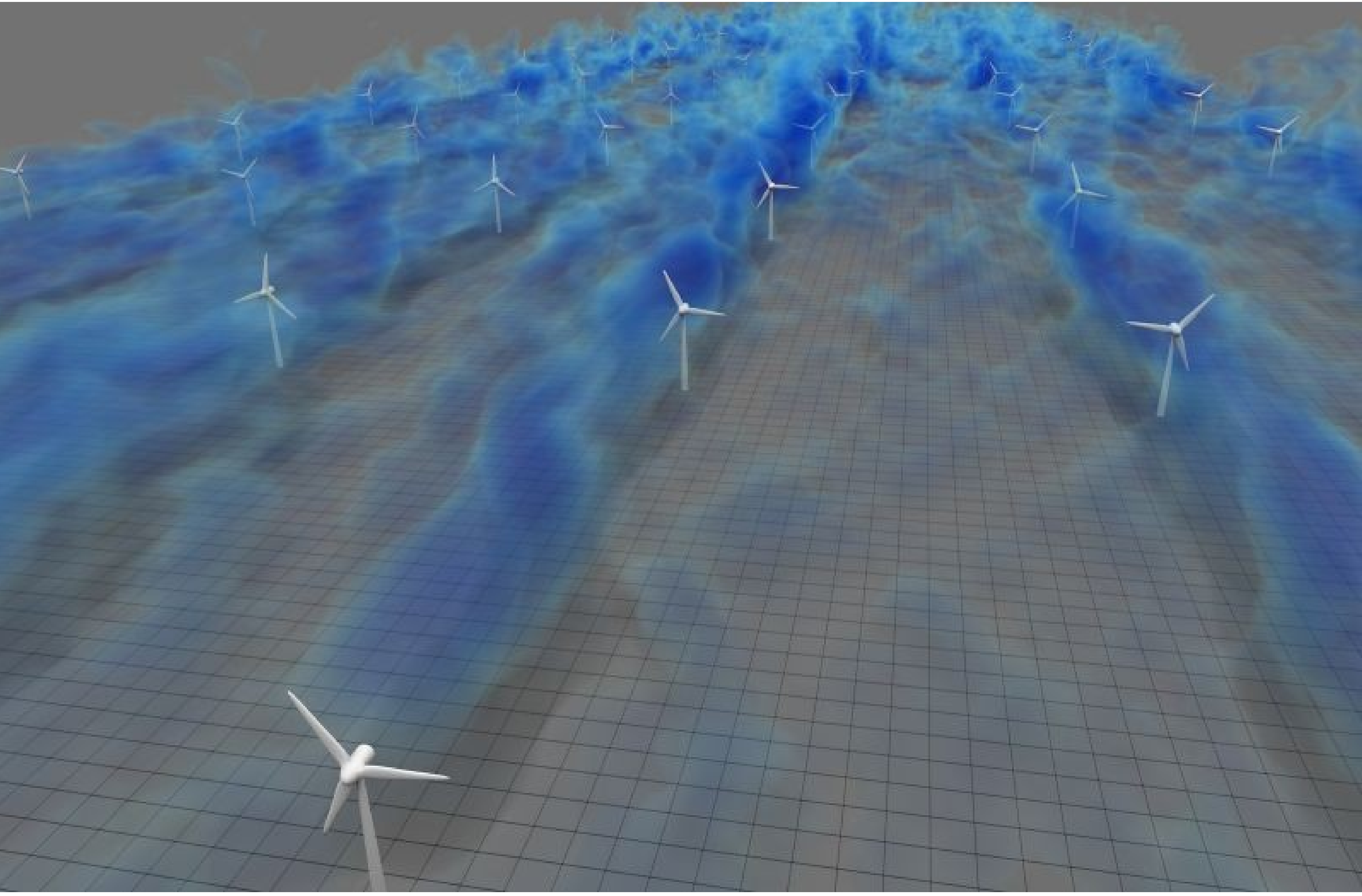
In 2019, there were 754 installed wind turbine generators, with a compined capacity of 2284 MW.



30 TWh by 2030

Fluid dynamics: CFD simulation of a wind park

Reference: https://pof.tnw.utwente.nl/research/turbulencebubbles/windles



Green hydrogen via electrolysis

https://p2x.fi/en/

P2X News Project Team Contact Us Suomi

P2X solutions

We change the world to become cleaner – together

Producer of green hydrogen and forerunner of Power-to-X technology in Finland

As a developer of emission-free welfare society we are a forerunner of energy future – our vision is to produce green hydrogen and refine it further into synthetic fuels in a cost-effective manner

R&D and role of natural sciences: Fluid dynamics, heat transfer, chemical reactions and thermodynamics crucial to many industries e.g. practical utilization of carbon free fuels in engines, combustors, fuel cells etc (e.g. hydrogen & ammonia).

Example: EU level, high-profile interest in hydrogen flames (e.g. clean aviation)

CLEAN AVIATION

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Launch of Clean Aviation's Working Group on Validation of Hydrogen Flame Numerical Simulations

Thursday 11/05/2023

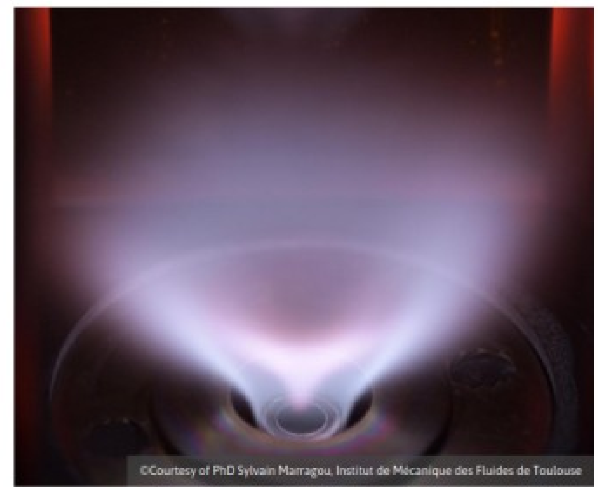
Validating hydrogen combustion simulations

Turbulent combustion sits at the intersection of two highly non-linear phenomena: chemistry and turbulence. Despite its importance and wide application, there is still no comprehensive scientific theory about **turbulent combustion. Reliable computational models** are needed **to help develop new, clean jet engines**, essential for ensuring the transition to a decarbonised world.

The challenge to overcome

The specific features of combustion in jet engines (complex geometries, swirled flows, compact chambers, complicated cooling devices, high-pressure flames, limited NOx emissions) make these simulations a daunting challenge. The lack of theory and adapted codes becomes all the more obvious with the switch to hydrogen. One would have thought that for hydrogen, being the smallest fuel molecule, hydrogen combustion would be easier. However, nothing could be further from the truth. Recent research has indeed shown that it is more difficult to burn hydrogen cleanly and safely, and that **modelling hydrogen** using advanced 3D computational fluid dynamics (CFD) solvers remains **very challenging**.

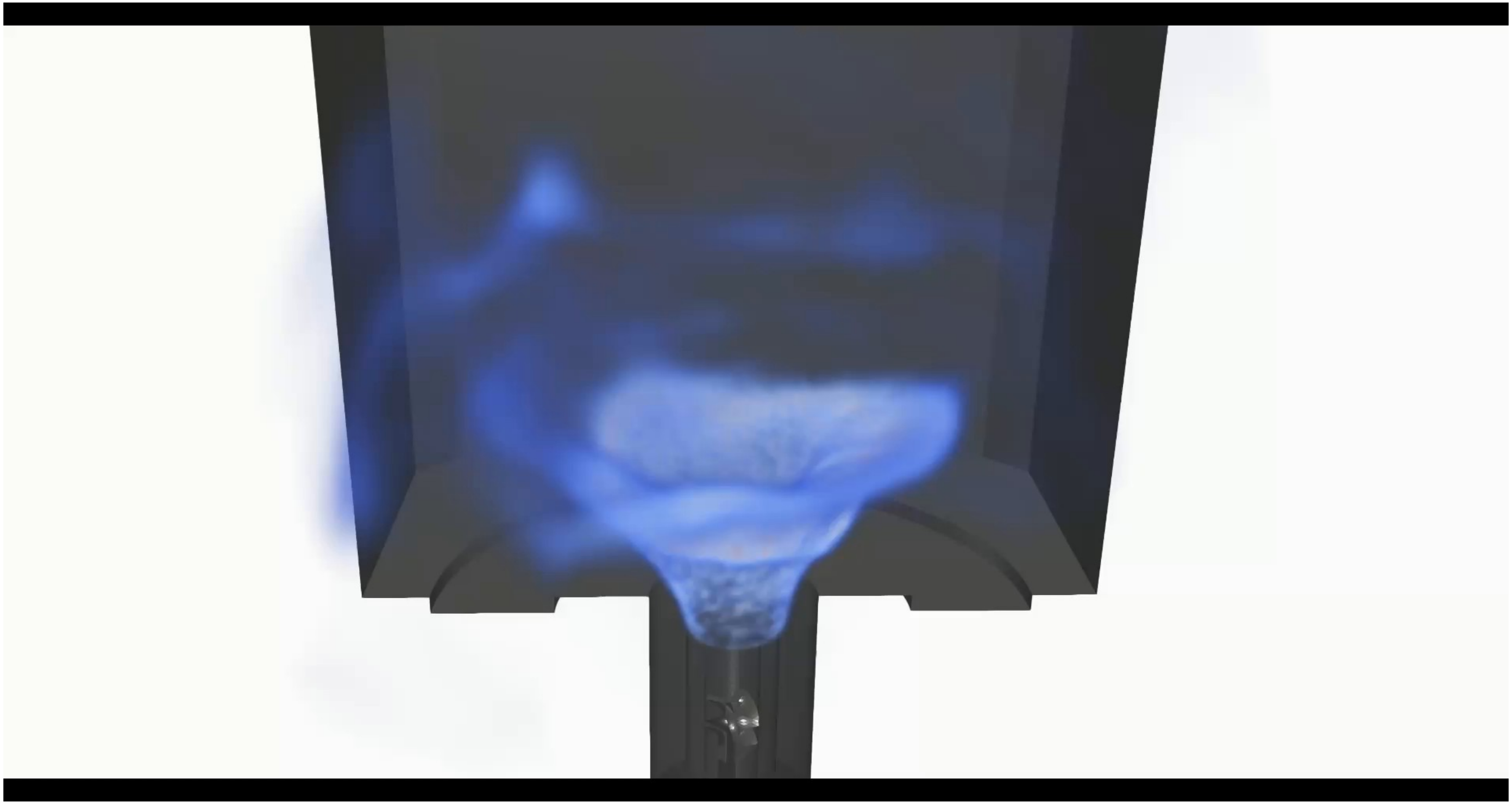
How Clean Aviation can help



©Courtesy of PhD Sylvain Marragou, Institut de Mécanique des Fluides de Toulouse

Example: M.Sc. Thesis on CFD simulation of hydrogen combustion in a co-annular double swirl burner

(Z.Shahin, M.Sc. Thesis (2023): https://aaltodoc.aalto.fi/items/691b86a9-0080-4a14-9d6d-cde9c74710dd)



https://www.aalto.fi/en/programmes/masters-programme-in-advanced-energy-solutions/curriculum-2024-2

120 ECTS = 60+30+30 = major + elective + M.Sc. thesis

Energy Conversion Processes

Code: ENG3069
Teacher in charge: Ville Vuorinen

Intended learning outcomes of the major

–

- Identify the fundamental natural phenomena of modern energy conversion technologies and apply different methods to design and develop them
- Be able to take a holistic view to understand dependencies across large energy systems
- Analyze and evaluate existing and future challenges in the field of energy, and the role of energytechnologies and processes in addressing these challenges
- Design sustainable energy conversion and storage solutions based on a scientific approach

Major 60 ECTS

The programme compulsory courses are compulsory for all the students in the Advanced Energy Solutions Master's programme. It is highly recommended to complete all the programme compulsory courses during the first year of studies. Please note that the compulsory studies courses are often prerequisites for the advanced studies courses.

Code	Course name	ECTS credits	Period
AAE-E1000	Introduction to Advanced Energy Solutions	5	I-II
AAE-E3090	Renewable Energy Engineering	5	III-V
AAE-E3006	Energy Markets	5	I

Major Compulsory Courses (20 cr)

The major compulsory courses are for all the students taking the Energy Conversion Processes major. It is highly recommended to complete all the major compulsory courses during the first year of studies. Please note that the major compulsory courses are often prerequisites for the advanced studies courses.

Code	Course name	ECTS credits	Period	Recommended study year
MEC-E1020	Fluid Dynamics	5	II	1. year
AAE-E2005	Thermochemical Energy Conversion D	5	III-IV	1. year
AAE-E1040	Measurement and Control of Energy Systems D	5	I-II	1. year
AAE-E3110	Hydrogen technology D	5	V	1. year

Optional studies (Select 25 ECTS)

Select 25 credits from the courses below. Please note the course specific pre-requisites. The following list is divided by thematic topic: conversion and storage, methods, and systems and technologies. Please see the study paths under Recommended timetable section for suggestions.

Code	Course name	ECTS credits	Period	Recommended study year
CHEM-E4255	Electrochemical Energy Conversion D	5	II	1. or 2. year
AAE-E3100	Energy Carriers D	5	I	2. year
AAE-E3070	Electrical Energy Storage Systems D	5	III	1. year
AAE-E3080	Thermal Energy Storage Systems D	5	IV-V	1. or 2. year
AAE-E3120	Circular Economy for Energy Storage D	5	II	2. year
AAE-E3005	Exercises in Energy Technology V D	5	I-V	1. or 2. year
AAE-E3002	Power Process Simulation D	5	IV-V	1. year
AAE-E2001	Computational Fluid Dynamics D	5	III-IV	1. year
AAE-E3030	Numerical Modelling of Multiphase Flows D	5	IV-V	1. year
MEC-E2010	Computational Fluid Modelling D	5	I-II	2. year
AAE-E2004	Mass Transfer D	5	III-IV	1. year
PHYS-E6570	Solar Energy Engineering D	5	III-IV*	1. or 2. year (organizes every other year)*
AAE-E3095	Wind Power Engineering and Development	5	I-II	1. or 2. year
PHYS-E0460	Introduction to Reactor Physics	5	I-II	1. or 2. year
AAE-E3004	District heating and cooling	5	III	1. or 2. year
CS-C3240	Machine learning D	5	I	1. or 2. year
MS-E1651	Numerical matrix computations D	5	I	2. year

* Lectured every other year:

PHYS-E6570 lectured in the spring 2026

E.g. EKO-C1017
(former “Heat Transfer” EEN-E1020)

Master's thesis 30 ECTS +

Elective studies 30 ECTS +

Aalto University