Design of Energy Systems

Design of Energy Systems	
Offered by	Department of Mechanical Engineering
Language	English
Primarily interesting for	All students, but most relevant for students with background in ME, AP, CE, SI (Energy) (B, EE, AT only with sufficient additional prior knowledge)
Prerequisites	Required courses: - Recommended courses: 4PB00 Heat and Flow and 4EB00 Thermodynamics
Contact person	Prof.dr.ir. J.A. van Oijen (j.a.v.oijen@tue.nl)
Last year of education/exam given	2026-2027

Content and composition

Provide a description of the content and composition of the elective package.

Course code	Course name	Level classification
4PC00 (2023-2024 and 2024-2025) Q2 (2025-2026 and 2026-2027) Q3	Thermal and fluid engineering	Advanced
3FTX0 (2023-2024 and 2024-2025) Q3 (2025-2026 and 2026-2027) TBA	Turbulence, waves and instability	Advanced
4EC10 (2023-2024 and 2024-2025) Q3 (2025-2026 and 2026-2027) Q2	Dynamics of Energy Systems	Deepening
4BC00 (2023-2024 and 2024-2025) Q4 (2025-2026 and 2026-2027) Q1	Chemically reacting flows	Advanced

Course description

Thermal and fluid engineering (4PC00)
Heat transfer and fluid dynamics of liquids and gasses are an essential part of a lot of industrial processes. Examples include pumps, ventilators, compressors, hydro power turbines, heat exchangers and particle separators. This course focusses on the design of such equipment and their role in energy systems. An important part is the analysis of underlying operating principles from fluid dynamics and heat transfer. For the practical application, these insights are supplemented with (semi-)empirical knowledge and results of numerical calculations. The course fits well in the current focus on energy issues. It covers topics from the large-scale energy production and -conversion, as well as the possibilities for energy savings by optimizing the design and deployment of control strategies. In the practical part of the course, a CFD (computational fluid dynamics) simulation package is introduced, and simple technical design problems are modelled and analyzed.

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Turbelence, waves and instability (3FTX0)
Knowledge of turbulence is essential when designing devices and machines because many flows in industrial energy systems are turbulent in nature. This course offers an introduction to the phenomenological theory of turbulence. Attention is paid to the instability of laminar flows, wave phenomena and statically properties of turbulence. Special attention is paid to the energy management in turbulent flows, as well as the structure of turbulence at fixed walls. Besides, numerical techniques related to modelling turbulence flows will be discussed. The knowledge and insights gained in this course are essential for a better understanding of the operation and performance of industrial flow systems and their design. Those kinds of analysis will be performed in the practical part of the course using the CFD software package.

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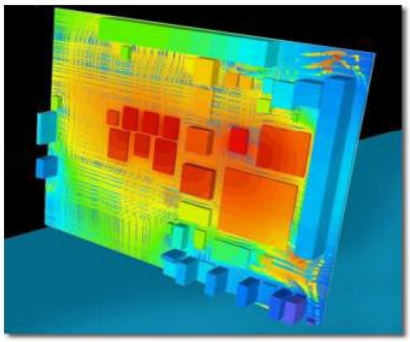
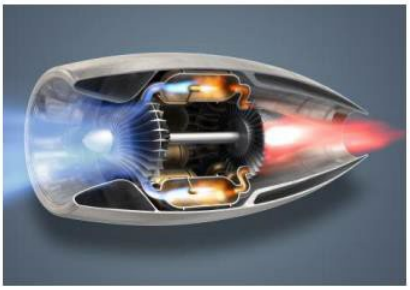
Dynamics of Energy Systems (4EC10)

Many practical thermal systems and processes are essential unsteady and/or nonlinear. Examples with great technological and social importance are sustainable energy systems such as solar power stations and photovoltaic thermal collectors, thermal comfort in people and the built environment, thermal control of microelectronics and transient behaviour of turbomachines and power stations. This course covers the modelling, simulation and dynamic analysis of such systems. The goal is to acquire the necessary skills for the development of models for generic unsteady thermal systems, implementation of numerical schemes and execution of the simulation for such systems and characterization and analysis of their dynamic behaviour. An essential part of the course consists out of numerical practicals (using MATLAB) in which the theory and methods, as presented during the lectures, will be applied in the analysis of some case studies.





Chemically reacting flows (4BC00)

Chemically reacting flows are of great importance in energy systems. Chemical reactions are essential in the conversion of fuels into heat and other forms of energy. Some examples are boilers, biomass gasifiers, combustion engines, gas turbines and furnaces in the steel and glass industry. In order to design this kind of appliances and machines, knowledge of the fundamental physical and chemical processes which occur in chemically reacting flows is necessary. The mathematical models which describe these processes are presented in this course and are then used to analyze simple chemical reactors and combustion systems. The use of numerical tools for the design of practical applications will be exercised in the practical part using the same CFD software package as in the other courses. This knowledge and these skills are essential for designing systems that can convert future sustainable fuels into energy in a clean and efficient manner.