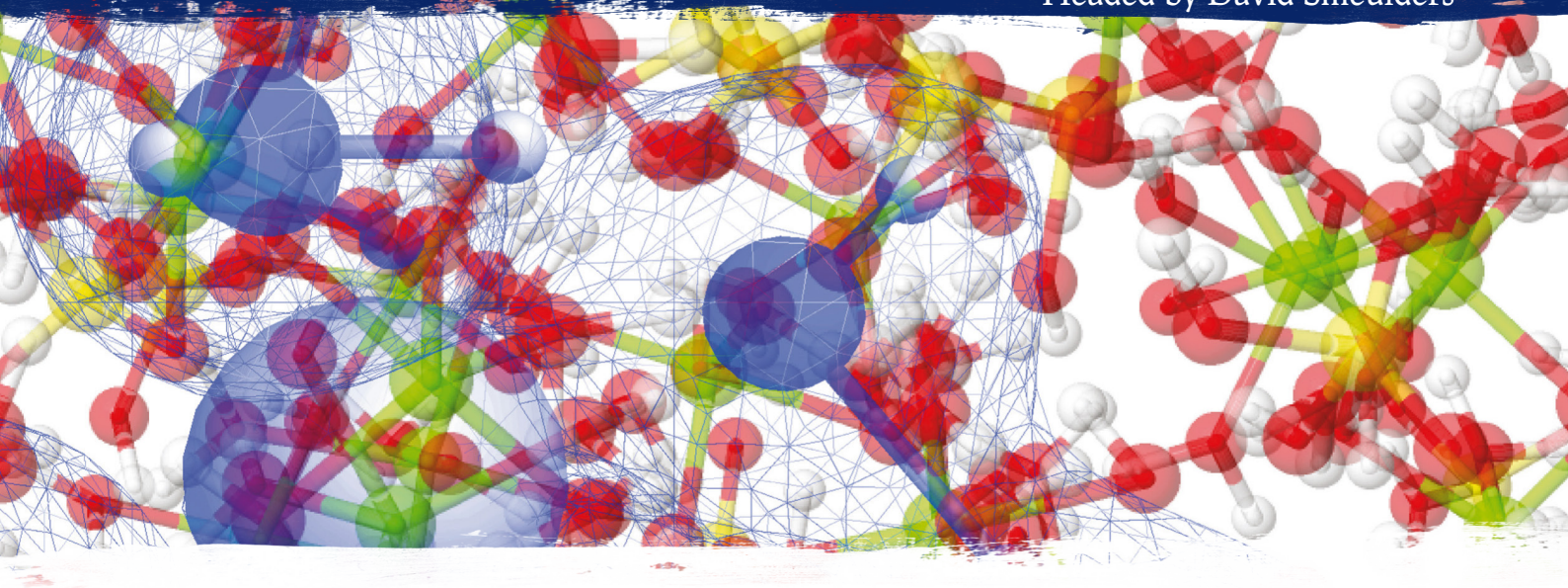
Energy Technology and Fluid Dynamics

Headed by David Smeulders



The mission of ETFD is to advance heat & flow technologies for energy and high-tech applications. This mission encompasses the scientific development of new methods and tools (science); optimizing advanced systems (technology); transferring knowledge to application partners (valorization); and educating and challenging future generations of engineers (education). One of today's most prominent societal challenges is the energy transition. Within the upcoming ten years our society will have to meet stringent CO2 emission targets in order to mitigate climate change. We believe that the solution largely lies in improved storage technologies to cope with diurnal and seasonal renewable energy variations.

Subprograms

1. Thermal Energy Storage (TES)

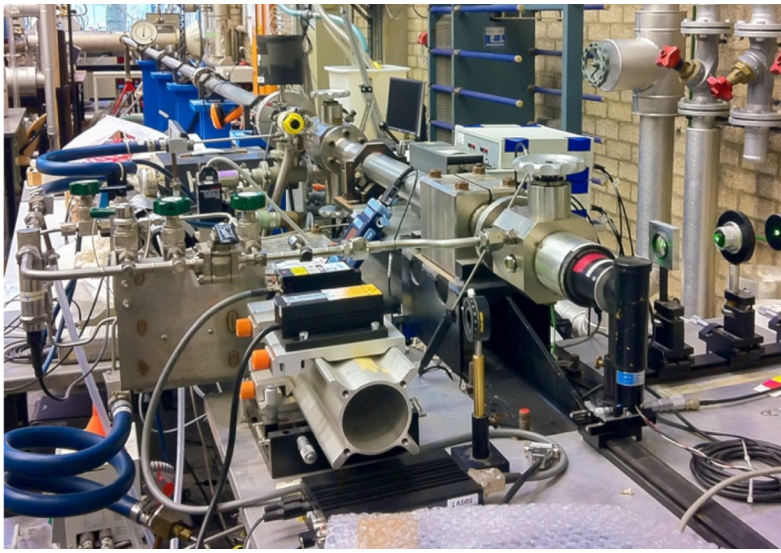
TES aims to develop new materials and systems for heat storage for domestic and industrial applications in line with the RLI (Raad voor de Leefomgeving en Infrastructuur) report on the energy transition. The scientific challenge is to couple fluid flow and heat transfer in complicated geometries.

2. Fluid-solid interactions (FSI)

This research theme is at the forefront of scientific developments and is synergetic to various application areas, e.g. hydraulic fracturing for geothermal applications, elasto-capillarity for inkjet printing processes and contamination control in photo-lithography machines. The scientific challenge is to couple fluid flow and structural behaviour.

3. Cooling and Separation (CSEP)

This research line focuses on industrial and domestic cooling systems. An example is the production of LNG by innovative gas pre-treatment steps where cooling and separation of contaminants are combined. A new research line on simulation methods for transport in rarefied gas flows was recently initiated. The scientific challenge is in the combination of (rarefied) gas flow and phase transitions.



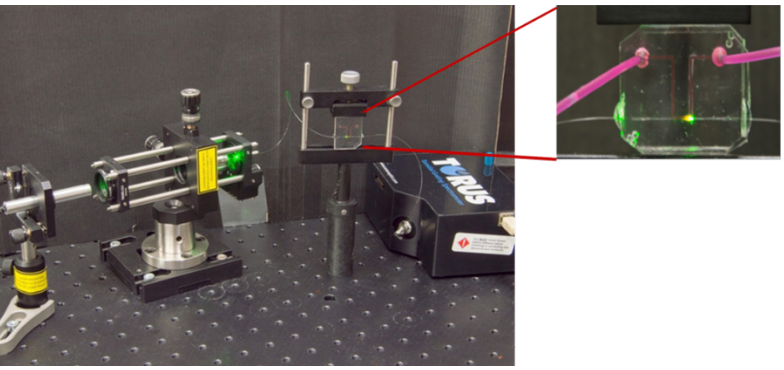
Energy neutral built environment

Low temperature space heating and domestic water heating consume most of the energy in the built environment. In the Netherlands, this energy is almost exclusively supplied by conventional gas-fired boilers. Replacing these by

ETFD and the industry

In our research group we work together with several high-tech industrial companies as ASML, Shell, Philips, TNO, see www.2f2s.org; www.projectcco.org, www.darcycenter.org

all-electric heat pumps can only be part of the solution due to limited capacity of the electricity grid which already has to adapt to the large-scale introduction of intermittant renawables (solar and wind). Moreover, traditional air-water heat pumps are noisy which makes them a less intuitive choice for densily populated district areas. So why not use the heat of the sun directly? Solar energy on a diurnal and seasonal basis is a potential gamechanger indeed. To mitigate the intermittent nature of solar energy availability, thermal storage is of paramount importantance. Our research group participates in the Dutch Compact Conversion and Storage Program (www.projectcco.org) to address the technological breakthroughs to heat and cool our houses and offices with sustainable energy. Essentialy, it comes down to the design of a revolutionary new concept: the heat battery. This design will also facilitate waste heat transportation from industrial sites to local district heating systems, so that in future we will generate, store, transport and consume our energy in a much more decentralized and sustainable way, to limit our CO2 emissions.



Lab-on-a-chip for Kidney Dialysis

The kidneys are responsible for the maintenance of salt, water, acid-base balance and the removal of toxic nitrogenous waste products. The alternatives for a person suffering from chronic renal failure are dialysis treatment and ultimately renal transplant or death. The evolution of haemodialysis (HD) has prolonged the lives of millions by making the kidney failure a treatable disease. HD is usually performed intermittently for around 4hours during 3 days/week.

How does dialysis work?

The physical principles are convection and diffusion across a semi-permeable membrane between blood and dialysate. Through convection, water and sodium are removed by a hydraulic pressure differences across the membrane. Dialysate is the fluid what is used in dialysis. It removes the waste material from blood and transports useful substances, such as bicarbonate, into the blood.

Individualized dialysis

Dialysate is prepared with a fixed concentration but the individual differences are not taken into account. Though most patients bear the procedure well, some tolerate it poorly due to intra-dialytic low blood pressure. Individualization of dialysate prescription is difficult because there is no in-line ion-selective electrolyte monitoring available. In-line monitoring of ionic mass balance and blood concentrations of vital electrolytes during dialysis can enable such an individualized and tailored dialysis prescription, thereby preventing or at least mitigating complications. We work on a lab-on-a-chip technology that can measure these concentrations in-situ.

Highlights in the ETFD-group

In the future we will heat our homes with a solar collector on the roof and a big container of cat grit in the basement. Want to know more? Then watch David Smeulders' lecture. http://tiny.cc/smeulders

Master's student Joep Berghs

'I consciously chose to gain experience in business already during my Master's Sustainable Energy Technology, because I had missed that practical experience in my Bachelor's. I did my graduation project with energy company ENGIE. That was such a success for both parties that I was hired as an energy consultant immediately after I graduated.

What always attracted me to the Energy Technology and Fluid Dynamics research group was the versatility of the subjects: from heat transfer to fluid dynamics and everything in between. You get very broad training as an engineer with great expertise in energy technology. And that now is very useful to me in my job.

During my graduation project I investigated using software whether it might be interesting to combine an air heat pump with a storage tank with Phase Change Materials (PCMs). Heat pumps as they are used today to heat homes and buildings have the disadvantage that they don't perform as well at low temperatures. In my research I demonstrated that a combination of a heat pump with PCMs can indeed deliver considerable savings, both in energy and to a lesser extent also cost.

As an energy consultant, I work with various kinds of energy supplies on a daily basis. I examine for customers whether energy savings are possible. I also advise companies that want to do renovations or develop a whole new area. If you get involved at the start of a project with smart solutions for energy generation, you can solve any problems right away. It's really great that I can now use all the theory I have learned at the TU/e to help ENGIE customers. So all the hard work has not been for nothing.'

PhD student Ernst Remeij

'What I like so much about this research group is that you can work on highly relevant social issues. It is fascinating to contribute to developments in society. Inventions from our research group

can truly make a difference in tomorrow's world.
The Energy Technology and Fluid Dynamics research group collaborates with businesses extensively, both in the region and far beyond. There is a lot of interest from the market for the types of research that are being done in our group. In many cases, we actually do joint projects.
Over the past few years I have been involved in fracking: a technology used to extract oil and gas by breaking up rock deep in the earth. With the discussion about gas extraction in Groningen in mind, this is a pretty interesting, but also controversial subject. That makes it even more important to learn more about this technology, because not that much is known at present about the possible consequences of fracking. After all, you cannot see what is going on three kilometers down. By devising new calculation models I try to gain more insight in the possible consequences.

My research is part of a much bigger project in which not only the TU/e is involved, but also Utrecht and Delft University as well as several companies. This multidisciplinary team is looking at fracking from many angles, from potential consequences within a radius of dozens of kilometers to effects on the earth's crust itself. It is very inspiring to work together, both with the research groups from other universities and different companies. I feel I should mention that our research is always leading; we are not under pressure from the market.

I got my PhD in February, and I'm now working on a post-doc. Academia is the place for me!'

Associate professor Clemens Verhoosel

'Over the next few decades we will have to take giant leaps forward in the field of energy technology and high tech systems, especially in the development of clean technology for energy conversion and storage as an alternative to fossil fuels. To realize these developments new expertise has to be developed in the area of heat and flow technology.

The Energy Technology and Fluid Dynamics research group's objective is to give its students a solid grounding in these areas so that as the engineers and scientists of the future they will be well equipped to deal with technological and scientific challenges. The group's focus is on transferring and applying fundamental knowledge in the field of energy technology and high tech systems. That means that the degree program focuses on core skills like applied mathematics, physical modeling of flows and heat transfer, and skills in the area of simulating and experimentation in the context of energy technology and high tech systems. But the program also leaves room for learning to apply these core skills in practice, e.g. in lab sessions and internships. In our group students are free to choose whether they want the degree program to lean towards fundamental skills or rather more towards application-oriented components.

Our students are equipped with a broad basis of scientific and technological skills in the area of of energy technology and high tech systems. Alumni possess universal skills in the areas of experimentation, modeling and simulation - valuable qualities that can be used also outside the domain of energy technology. For example, alumni can apply their knowledge and skills in multidisciplinary teams.
The scientific and technological challenges in the areas of energy technology and high tech systems are huge. So there is strong demand for young, talented engineers and scientists with a background in these areas. In order to deal with the challenges, both fundamental and application-oriented developments are necessary. If there is one single discipline where as an engineer or scientists you can make a difference for the future, it is in the field of energy technology and high tech systems.