

Faculty of Science and Engineering

Profile report: Biomimetics of unsteady fluid mechanics applied to energy systems (Biomimetica van in-stationaire stromingsmechanica toegepast op energie-systemen)

- Discipline: Biomimetics of Unsteady Fluid Mechanic Phenomena
- Level: Tenure Track
- Fte: Full time (1,0)

1. Scientific discipline

Many biological model-organisms interacting with their fluid environment use unsteady aero- or hydro-dynamics during only a part or even during the whole duration of these interactions. Unsteady fluid mechanics often results in much higher peak forces and thereby in performance improvements. By analyzing such biological systems, the principles can be derived and potentially applied for improving or (re-)designing energy systems involving fluid mechanics, such as flight systems (MAV'S, Drones), wind- or water turbines, etc., following a biomimetic pathway.

2. Vacancy

This position is opened by the Board of the Faculty (ref. PT/gl/20/00059) in the context of the sector plan for physics and will be embedded in the institute ESRIG (Energy & Sustainability Institute Groningen), basic unit Ocean Ecosystems. The position falls within the framework of 'Career Paths in Science 4' ('Bèta's in Banen 4'). Please see link for [criteria and conditions](#).

3. Selection committee (BAC)

- H.A.J. Meijer (Prof, ESRIG-director), chair
- A.G.J. Buma (Prof, OE-chair)
- E.J. Stamhuis (Assoc. Prof, OE, position supervisor, also Dir of Edu)
- A.Vakis (Prof, ENTEG)
- F. Muijres (Assoc. Prof, WUR Exp. Zoology + Aerodynamics specialist)
- M. Kamperman (Prof, ZIAM, bio-inspired material science)
- Student member (EES-student)

Advisory members:

- A. Van der Woude (HR-member, contact for ESRIG)

4. Research area

The biomimetics of organisms interacting with their fluid environment is a rather new discipline but is very well suitable for designing new energy producing systems or improve existing energy consuming or producing devices. In nature, unsteady aero- and hydrodynamics appears to be present much more often than previously thought. This type of fluid interactions (in e.g. swimming or flying) are often less

straightforward to understand but open many opportunities for new applications or improving existing systems. Since in nature the efficiency of energy use is a key factor in evolution and survival, application of biomimetic principles within the field of Energy & Sustainability may be many.

Biomimetics or bio-inspired design is a developing field in science in general, and at the UG in particular. In many FSE-institutes PI's choose research directions that include inspiration from nature, e.g. on material properties, structural architecture, surface characteristics or micro-fluidics. Within the realm of Energy research, which is one of the key subjects of the UG as a whole, Biomimetics with application to Energy & Sustainability is mainly linked to one group within ESRIG. Here macro- and meso-scale fluid mechanics in nature and technology is the main subject, with application to e.g. wind turbines and the transport sector (road and water). The area of steady fluid mechanics is rather well-known, but in nature often unsteady fluid mechanics appear to be involved in e.g. locomotion systems in air or water. This is internationally a relatively new field of research and may hold many promises for application to improvement of e.g. propulsion systems, artificial flight systems or energy harvesting devices. Because of the relative novelty of this subject, rather fundamental and detailed research has to be performed to analyse the biological system to such a level that application to a technical system, new or existing, can become successful. This involves experimental research using flow tanks as well as wind tunnels and flow analysis systems such as Particle Image Velocimetry, but may also include computational analyses using Computational Fluid Dynamics running on a computer-cluster. The facilities for this kind of work are already present within ESRIG or within the FSE, and further extensions and updates are foreseen within the coming years.

The creation of this TT-position has been stimulated by the sector plans for physics and is meant to strengthen the Energy & Sustainability Biomimetics group within ESRIG. The aim is to find a candidate who will look into meso- and micro-scale aero- and hydro-dynamic phenomena and work on applications to design or improve small-scale flight platforms (for e.g. exploration purposes) or meso-scale energy harvesting devices.

5. Embedding: institute (and base unit)

The Energy & Sustainability Research Institute Groningen (ESRIG) has two main research areas: 1) Energy Supply and Energy Conversion, and 2) Transition towards Sustainability. ESRIG was founded in 2009 and now consists of 5 groups ('basic units'): Centre for Isotope Research, Center for Energy & Environmental Sciences and Science & Society, the Energy Conversion group, Geo-Energy, and Ocean Ecosystems, and will soon have a sixth group when Thorium-based Nuclear Energy will join the institute. Most of the groups are housed in the Energy Academy building, but the Ocean Ecosystems dept. is housed in the Linnaeusborg with access to biological lab space as well as to aquarium facilities and flow- and laser-labs. The wind tunnel facility is housed in a large lab within the Nuclear Physics building (KVI), where also the new Nuclear Energy group and a new branch of the Energy Conversion group will

be housed. Especially the Aquarium-room and climate-rooms within the Faculty Animal Facilities as well as the Flow and Laser-labs in the Linnaeus-borg will be available for the new TT with regard to animal-related (experimental) research. The ESRIG Wind Tunnel that is housed in the KVI can be used for experimental work with large-scale models (up to 1 m) at low wind speeds as well as smaller scale models at high wind speeds (up to Hurricane F2), but is also capable of doing experimental work with live birds or bats at intermediate wind speeds.

6. Local and (inter)national position

Bio-inspired flow-related work is a developing field internationally where we have cooperation with other universities, such as the University of Ghent and the University of Antwerp (on fish maneuverability as a model for AUV control systems), the Technical UAS in Bremen (on bird unsteady aerodynamics, on modelling undulatory fish swimming and on designing an undulatory propulsion system for AUV's), with the Alfred Wegener Institute in Bremerhaven (on morphing wind turbine blades), with the University of Auckland, NZ (on dielectric deforming structures for morphing blades), with the UAS-Rhein-Waal (on bio-inspired small-scale urban wind turbines), with Nanjing University for Aeronautics & Astronautics in PRC (on bird unsteady aerodynamics with application to flying robots) and with Jilin University in Changchun PRC (on bio-inspired turbine blade design and on bio-inspired drag-reducing surface coatings with anti-fouling characteristics). On a national scale we cooperate with the Wageningen University of Research (WUR) on flight- and biomechanics-related subjects, with the Maritime Research Institute in Wageningen (MARIN) on bio-inspired propulsion systems, but also with a number of industrial partners, such as EmpowerMi (Groningen) and RG-projects (Leiden) on bio-inspired wind turbine development, and with SME-companies from the Netherlands as well as from Germany on a smaller project basis. At the faculty scale, cooperation with other FSE-groups exists and is expanding on a regular basis. Area's and groups with existing cooperation are e.g. ENTEG in the Ocean Grazer project as well as in a project on testing fish lateral line inspired sensors. Fish lateral line based sensor development and testing is also done in cooperation with the Bernoulli Institute. Recently a new platform on Bio-inspired Research within FSE (ESRIG, ENTEG, BMI, ZIAM) was started (ESRIG-initiative) aiming for more cooperative bio-inspired projects within FSE but also with our partner-university in the Jilin province of the PRC, that has a large and strong Bionic Engineering department. In the PRC also cooperation exists with the Nanjing University of Aeronautics and Astronautics (Bio-inspired Technology Dept.). Many of these cooperation opportunities may prove to be useful for stepping in or making connections with respect to the TT-position at hand.

7. Expected contributions to research

The candidate is expected to set up his/her own research group in the field of biomimetic fluid mechanics with an emphasis on unsteady fluid mechanics focusing on medium and small scale phenomena and applications. This research line will be highly interdisciplinary because organisms will serve as models and will need to be

studied experimentally from a biological as well as a physics perspective, whereas when it comes to applications a more technical and engineering approach needs to be taken. In practice the candidate is supposed to contribute to the development and improvement of small to medium scale flight systems (e.g. flapping flight drones for exploration, or morphing or aero-elastic systems for wings or turbine blades) and/or energy harvesting devices (e.g. water turbines with improved performance). Obtaining substantial external funding for PhD projects is crucial. Supervision of PhD students is an important part of the research activities.

8. Expected contributions to teaching

The candidate is expected to teach on his/her field of expertise within the MSc-programs Energy & Environmental Sciences and Mechanical Engineering. Foreseeable are participation in courses on wind energy, on flight systems or on propulsion systems. Depending on the background of the candidate, contributions to one of the disciplinary bachelor programs is also feasible. The candidate will be involved in supervising research projects of BSc and MSc students.

9. Expected contributions to the organization

The candidate is expected to have an active interest and to provide a positive contribution to the management and organizational tasks of the institute. At the level of the FSE, the candidate will contribute to the organization of the faculty, for example by participating in working groups and committees, in the fields of teaching, research and management. The candidate will participate in relevant national and international organizations.