

# Graduate Programme

## “Optimization of Energy Networks”

Application form (closing date 6 February 2013)

**3TU**.AMI



**MATHEMATICS** FOR INNOVATION

 **TU**Delft UNIVERSITY OF TWENTE. **TU/e**

# 1 Basic details

## 1.1 Host institution, name and address of the school (Graduate Programme)

- Name school:
- 3TU.AMI Graduate School "Optimization of energy networks"
- Visiting address:
- 3TU Applied Mathematics Institute  
 Prof.dr.ir. C. Vuik, Scientific Director  
 TU Delft, EWI  
 Mekelweg 4  
 2628 CD, Delft
- Website of AMI: <http://ami.3tu.nl>
  - interuniversity school
  - Host university: TUD

## 1.2 Details of contact person

- Prof.dr.ir. C. Vuik, Scientific Director of 3TU.AMI
- Male
- TU Delft
- Room : HB 03.070  
 Building 36  
 Mekelweg 4  
 2628 CD Delft
- Telephone: +31 (0)15 27 85530
- E-mail: [c.vuik@tudelft.nl](mailto:c.vuik@tudelft.nl)

## 1.3 Summary of research programme

The programme is a joint initiative of the three Mathematics departments of 3TU. It is also an international programme because of the collaboration with MATHEON (Berlin), the Mathematics institute of the three Berlin universities and two research institutes.

In the field of energy networks, the classic one-way traffic [producer  $\square$  consumer] becomes a highway with a variety of access roads and exits. Many variables are involved: speed, pressure, temperature, several gas types, geopolitics, soil condition, markets, future demand, etc. Mathematics and ICT are key to the transport of energy and thus the success of optimized complex networks.

### Energy Hub

The Netherlands is a gas hub which combines various strengths: the location, gas fields, logistics hub for (underground) storage and transportation, and concentration of knowledge and experience. New investments are made in gas storage, an LNG terminal and new routes and connections.

In the Netherlands electricity is becoming 'green' by wind and solar energy. In most cases, energy is needed where there is insufficient green energy, so transport of energy is vital and thus the efficiency of smart grids.

### Developments

The current developments in the area of gas and power supply in the Netherlands and Europe require additional expertise and R&D:

- Sustainability is the decisive factor for government policy. Besides wind and sun, gas is a 'clean' form of energy.

- Gas and electricity will be more interconnected and the peaks in power consumption can be leveled off by gas. In the future there will be no separate markets for gas and electricity, but one market for "energy".
- Several gas flows will enter the Dutch network: Russian gas, LNG from Rotterdam etc. Not only the capacity of the network shall be used in an effective way, also the quality of high- and low-caloric flows is at stake.
- Also power from different electricity sources (wind, solar, water) will enter the network.
- In the near future the present partition between storage and networks will end.
- The objective of the EU policy is to create a European energy network with many more interconnectors between the EU countries.

### **Integral network management in the Netherlands**

The current energy networks were designed some decades ago.

At that time the energy market and technologies were completely different from the present situation. Below we indicate a number of these changes:

- The energy networks are no longer national but international. Connections with countries inside and outside Europe are standard practice nowadays.
- Due to the green energy movement, the amount of energy produced by sustainable sources: solar, wind, and biogas has increased considerably. Most of these sources have a stochastic behavior in contrast to the situation some decades ago.
- Consumers became prosumers, which consume energy in a certain period and produce energy in another period.
- The number of different sources has increased. We started with mainly Slochteren gas. Now we have gas from Russia, LNG from various sources, biogas and maybe in the future shale gas.
- Gas and electricity become more and more dependent. If the wind speed decreases, gas fired power plants are the only alternatives to bridge the gap. On the other hand if the wind is strong power-to-gas can be the only available alternative to store electrical energy in an easy way.

As these changes make the design and day to day operation of the energy networks very challenging. In the opinion of many industries and researchers this can only be handled by using in an optimal way the language of modern science: Mathematics !

Various subdisciplines, like scientific computing, probability theory, optimization and control theory, are essential for the design, analysis, optimization and control of energy resources.

### **Focus on transport**

It is distinctive of Energy that the sources are located in areas that are distant from the consumers and users. Solar energy, windmills, hydro-electric power stations, LNG, natural gas, biogas, coal... the energy from all these sources has to be transported to the consumers and users by ship, pipeline, and cable. The energy networks of storage and distribution are the focus of the Graduate Programme.

### **The role of Applied Mathematics**

Optimization of energy networks is a mathematical problem. But other fields of research are needed. In Delft, Twente and Eindhoven several disciplines are working together in the field of energy:

- TU Delft: Powerweb is a centre for collaboration between Mathematics, ICT and Policy Research in the field of energy grids.

- University Twente: SETS is an expertise centre for Smart Technologies and Systems for local smart grids. In this Centre researchers are cooperating in the fields of ICT, and Mathematics.
- Eindhoven: focus of the research is on three strategic areas (Health, Energy, and Smart Mobility). Within the area Energy there is a research programme "Power to the people: towards a smarter grid for decentralized power". The focus is on electricity. Research is conducted by the faculties of Electrical Engineering, Mechanical Engineering, and Mathematics & Computer Science.

In the field of Applied Mathematics the Energy projects can be summarized under the following headings:

1. Computational Mechanics
  - Simulation of turbulent flows
  - Power flow computation
  - Decision analysis and risk
  - Gas explosions in pipelines
  - Multi-phase flow in pipelines
  - Maintenance of networks
2. LNG (this is a separate programme)
3. Finance
  - Energy storage in future power systems
  - Reservoir management
  - Economic decision making
  - Future energy resources and markets / prices
  - Commodity (swing) options
4. Grids
  - Domain simulation (TDS) of large power grids
  - Grid advanced simulation at state estimation
  - Safety of smart energy systems
  - Alternative routing in energy networks
  - Energy optimization for distributed embedded systems
  - Control methodology for smart grids
  - Network analysis (e.g. supply chain management)

#### 1.4 Formal organisation

- Participating universities and faculties
  - a. TU Delft: Electrical Engineering, Mathematics and Computer Sciences
  - b. University Of Twente: *Electrical Engineering, Mathematics and Computer Science*
  - c. TU Eindhoven: Mathematics and Computer Science

The preferred partner of 3TU.AMI is MATHEON in Berlin. MATHEON is a research centre that develops mathematics for key technologies and supports partners in industry, economy and science. Founded in 2002, and financed by DFG (until 2015) MATHEON is a joint initiative of the three Berlin universities (FU, HU and TU) and the mathematical research centres (WIAS and ZIB).

On July, 27, 2010, a collaboration agreement was signed by the two Scientific Directors Volker Mehrmann (MATHEON) and Bernard Geurts (3TU.AMI).

- The formal organisational structure of the institute.  
3TU.AMI is part of the 3TU Federation. The Board of 3TU.AMI consists of the three deans of the faculties EWI (TUD), EWI (UT) and W&I (TU/e). The Board is appointed by the Board of the 3TU Federation. The Scientific Director and the Secretary are appointed by the Board of 3TU.AMI. The Management Team (MT) consists of three

professors Applied Mathematics from the three TU's. The MT is appointed by the Board of 3TU.AMI.

3TU.AMI is granted by the 3TU Foundation with a yearly budget.

- How the cooperation between the director of the PhD programme and the director of the related Master programme is organised (if applicable).  
See chapter 2.
  - The school's annual budget.  
The annual budget of AMI consists of 3 distinct parts, i.e. the operational budget, the research budget and the education budget. The operational costs of AMI are funded by the 3TU Federation. The research budget of the school consists in the grants that have been received by the responsible scientists working in AMI (and their respective universities), and is therefore not a direct working budget of AMI itself. The education budget is funded by the 3TU Federation.
- T The budget of AMI amounts for two years (2012-2013):
- Operations: k€ 255
  - 4 SRO's: k€ 100; the Strategic Research Orientations are: Water, Energy, Logistics, and Health. [The objective of SRO's is preparing 3TU cooperation in certain fields of research.]
  - 6 education projects € 1.75 mln.

The research budget (based on the funded research positions) is summarized in the Table below.

Research funding in the Faculties in M€

	1	2	3	Total
2009	17.0	2.6	6.0	25.6
2010	16.2	2.3	6.3	24.8
2011	15.1	2.6	4.9	22.6

\*Source of financing:

1: University /Other

2: NWO, STW

3: Industry, EU-funds, Senter, GTIs, TNO, etc.

## 1.5 Main field of research

### 1.5.1 Sub fields of research

TU/e	11.20.00	Algebra, group theory
3TU	11.30.00	Functions, differential equations
3TU	11.40.00	Fourier analysis, functional analysis
3TU	11.60.00	Probability theory, statistics
TU/e + UT	11.70.00	Operations research
3TU	11.80.00	Numerical analysis
UT	11.90.00	Mathematics, other = system analysis

The three Faculties have two comparable fields of research and each faculty has one specialisation:

Delft	Eindhoven	Twente
<ul style="list-style-type: none"> <li>- Computational Science and Engineering</li> <li>- Probability, Risk and Statistics</li> </ul>	<ul style="list-style-type: none"> <li>- Applied Analysis and Scientific Computing</li> <li>- Stochastics</li> </ul>	<ul style="list-style-type: none"> <li>- Applied Analysis and Computational Science</li> <li>- Stochastics and Operations Research</li> </ul>
<ul style="list-style-type: none"> <li>- Analysis</li> </ul>	<ul style="list-style-type: none"> <li>- Discrete Mathematics</li> </ul>	<ul style="list-style-type: none"> <li>- Deterministic and Stochastic Systems Theory</li> </ul>

## 2 Criteria

### 2.1 Quality of education

#### 2.1.1 Basic information

*Please list:*

- The total number of Master students and the number of international Master students who begin their study at the school per year (2004-2011).
- The total number of PhD students (including the ones for whom the NWO grant is requested) and the number of international PhD students who begin their PhD research at the school per year<sup>1</sup> (please use table)
- Thesis completion and withdrawal rates (please use table)
- The average time taken for thesis completion (please use table)
- If PhD students are given a 'personal' budget for visiting congresses, education, and so forth then please state the amount.

	A*	B	C	D	E
Year	# PhD students who start in year x (cohort x)	Of cohort x: # stopped (per 01-01-13); number and %	Of cohort x: # finished ** (per 01-01-13); number and %	Of cohort x: Average duration of completed PhD's (per 01-01-13)	Of cohort x: # ongoing (per 01-01-13); number and %
2005					
2006					
2007					
2008					
2009					
2010					
2011					
2012					

\*For each year the sum of the values in B, C, E should equal the total cohort A

\*\*If the percentage of finished PhD's drops below 75%, please explain. You can also provide any other information that is important for interpreting this table

**The total number of graduated students** is higher than might be expected on base of the regular intake of PhD students in the graduate programme; in addition to regular (fulltime) PhD students in the graduate programme, there are several external PhD-candidates (working in the surrounding industry) who finish their PhD study at the three departments. There are also PhD students who enter the programmes from other insitutions ("zij-instroom" or lateral entry).

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<sup>1</sup> The NWO grant allows the funded PhD students to carry out their research. They should, however, do this together with a group of PhD students who follow the same route and work within the same school and research field.

	A*	B	C	D	E
Year	# PhD students who start in year x (cohort x)	Of cohort x: # stopped (per 01-01-13); number and %	Of cohort x: # finished ** (per 01-01-13); number and %	Of cohort x: Average duration of completed PhD's (per 01-01-13)	Of cohort x: # ongoing (per 01-01-13); number and %
2005	31	2 (6%)	29 (94%)	4.5	0
2006	20	1 (5%)	19 (95%)	4.25	0
2007	29	2 (7%)	27 (93%)	4.17	0
2008	29	2 (7%)	24 (83%)	4.10	3 (10%)
2009	15	1 (6%)	4 (27%)	4.06	10 (67%)
2010	18				
2011	23				
2012	34				

### 2.1.2 Implementation of specific conditions for the organisation structure of the school

*Please describe:*

- How selection of students that apply for the Master phase of the school is carried out.
- How often students may enrol in the Master phase of the school.
- How rotations are organised during the Master phase (goal, form, quantity, duration, etc.).
- How Master students are given freedom of choice regarding the research subject of their PhD research.
- How writing of the research proposal by the Master students is facilitated.
- How the Master students with the highest potential are selected for enrolment in the PhD phase.
- How excellent Master students from outside the school can obtain a PhD position within the school.

#### **Extra courses after/ during MSc**

The three Master programmes each have different specialisations:

TUD

- Computational Science and Engineering
- Probability, Risk and Statistics

TU/e

- Computational Science and Engineering
- Discrete Mathematics and Applications
- Statistics, Probability and Operations Research

UT

- Mathematical Physics and Computational Mechanics
- Industrial Engineering and Operations Research

Unfortunately, for "Financial Engineering" no more new Master students are allowed.

In the future there will be a joint 3TU MSc track "Energy networks". But in the meantime a supplementary programme is sufficient. This programme consists of three topics after (or during) the Master programme:

- Two compulsory courses: "Organisation of Energy markets in the Netherlands and Europe", and "Grids as socio-technical systems" (together 4 EC's). These courses will be given by the department of technology policy of TU Delft. Location: Utrecht.
- A visit to one of the groups in the Graduate Programme. The students can choose between: Computational Science, Grid, Finance (see 1.3). A report is required; it will be discussed. This item is 2 EC.
- A visit to a Winter or Summer School, including a report (2 EC). The report will be discussed. See 2.1.4 Joint activities of 3TU.AMI and MATHEON.

It is possible for interested students to complete this programme during their final Master year.

### **Selection procedure**

For internal students:

Every Master student Mathematics of 3TU or MATHEON (Berlin) can apply to the school. In practice, professors who are active in the Graduate Programme will invite students who have shown interest in the subject of Energy.

- a. In any case an interview will take place with the Director of the school. The student must have a serious potential and motivation to become a PhD student.
- b. A separate Admission Committee will screen all the applicants for the Preparation Activities (the 3 EC courses and visits).

For external students (from other Dutch or foreign universities):

- c. The standard procedure for selection of external students is applied.
- d. An extra requirement is a demonstration by the candidate of his or her interest in the field of Energy. This may be shown by the subject of MSc thesis, a track, internship, or a subsidiary subject.
- e. The same Preparation Activities (3 EC) are applied to external students.

After completion of the Preparation Activities the Director of the School and the Admission Committee will select a maximum of 7 high potential students for the first year. All eligible candidates (internal and external) have to write a research proposal, which will be evaluated by the Admission Committee. The 4 best proposals will be selected for direct funding by NWO, whereas the other proposals will be funded externally or by other NWO programmes (e.g. funds from the Top sector Energy).

In the third year the same procedure will be followed: 4 proposals selected for direct funding by NWO and 3 proposals funded externally or by other NWO programmes.

### **PhD project budget for conferences and education**

Since the majority of all PhD projects is externally funded, an adequate contribution is granted for the travel budget, needed to participate at conferences and courses. This amounts typically to k€ 10-20, depending on the funding source. For the students funded in this Graduate Programme, the host groups chosen by the PhD students will guarantee an equal project budget compared to other PhD students working in the research schools. Since collaboration between 3TU.AMI and MATHEON (Berlin) will be very intense, extra funds will be needed. 3TU.AMI will apply for a subsidy from NWO International.

### **2.1.3 Training and education programme**

*Please describe how training and education of the students is organised and refer to issues mentioned below (if applicable). Other relevant subjects may be included.*

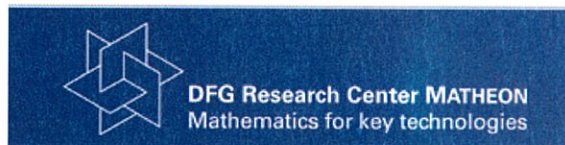
- The training and education programme of the Master phase (include courses, research activities and other relevant activities)
- The training and education programme of the PhD phase.
- The relation between the training and education programme of the Master and PhD phases.
- The relation between the training and education programme and the core research activities of the school.
- How international activities of Master and PhD students are facilitated.

- How lecturers are selected and how (new) lecturers are trained.
- How knowledge utilization is addressed in the education programme

### **PhD phase**

The Graduate School will connect to PhD-programmes of the three departments of Applied Mathematics. Purpose of these programmes is the development of PhD students into independent researchers in the field Applied Mathematics. To reach this goal a thorough and fundamental knowledge of modeling fluid/solid mechanics phenomena and their mathematical and numerical modeling is required, as well as the ability to further develop this knowledge and to apply it to solve scientific and technical problems. An important part of the PhD-programme consists of the execution of a scientific research project under the supervision of an expert at the university. The three departments organize the education in the PhD phase through a course curriculum of minimum 20 ECTS credits.

### **Joint activities of 3TU.AMI and MATHEON**



MATHEON is a research centre that develops mathematics for key technologies and supports partners in industry, economy and science. Founded in 2002, and financed by DFG (until 2015) MATHEON is a joint initiative of the three Berlin universities (FU, HU and TU) and the mathematical research centres (WIAS and ZIB).

On July, 27, 2010, a collaboration agreement was signed by the two Scientific Directors Volker Mehrmann (MATHEON) and Bernard Geurts (3TU.AMI).

It was agreed that both institutions will apply for funds to start a Graduate School and a "Graduiertenkolleg" respectively, in the field of optimization of energy networks. 3TU.AMI and MATHEON are already negotiating with gas companies [Gasunie and Open Grid Europe/OGE (former E.ON)] to start a joint research programme. Also, both institutions are looking for opportunities to initiate a consortium for a EU research programme (in NL, Germany, Norway, Belgium, and Czechia).

MATHEON has applied for a fund from DFG for a Graduiertenkolleg. The new Director of the "Graduiertenkolleg" is Prof. Dr. Nicole Marheineke. As agreed, both Graduate Schools will organize joint Summer and Winter Schools. The first Winter and Summer School will be local with guest lecturers from the preferred partner school, but after one year the meetings will be fully international, that is that all PhD students can choose to visit at least one School at the foreign partner. The programmes of the Schools will be interdisciplinary:

"Neben den standorteigenen, disziplinspezifischen Modulen im Rahmen der Masterstudiengänge wird der disziplinübergreifende Charakter des Graduiertenkollegs durch 2-wöchige Sommer- und Winterschulen gefördert, die für alle Stipendiaten zyklisch an den drei Standorten jeweils am Ende eines Semesters stattfinden. Bei diesen Veranstaltungen stehen die Verknüpfungen der Modelle und Methoden der verschiedenen Disziplinen im Mittelpunkt. Zu diesen Schulen werden auch (internationale) Gastredner / -dozenten eingeladen."

The focus of MATHEON in optimisation of energy networks is on:

- Numerical pde's
- Numerical analysis of dae's
- Numerical linear algebra
- Optimisation with pde's
- Nonlinear optimisation
- Control theory
- Network flows and design

Exchange of staff and PhD students will be encouraged. In some cases, depending on the subject of the research project, visits to the partner institution will be required:

- PhD students can visit MATHEON for a period of ½ to 1 year. In these cases, agreements will be made to guarantee the supervision by an expert or co-promotor.
- Staff can visit MATHEON for short stays (1 to 4 weeks).

#### 2.1.4 Supervision

*Please describe how supervision of the PhD students is organised and refer to issues mentioned below (if applicable). Other relevant subjects may be included.*

- What does the training and supervision plan consist of?
- How is the supervision team for the individual PhD student formed and how is the performance of the supervision team monitored adequately?
- How is progress of the PhD student monitored and what measures are taken (e.g. go/no go moment) if progress is regarded as insufficient?
- Are end terms for acquiring the PhD title clearly discussed with the PhD student?
- Are "codes of good practice" (handleidingen) available for supervisors and PhD students?
- How are supervisors selected and how are (new) supervisors trained?
- What is the number of PhD students who are supervised by one supervisor?

#### **General**

Students that apply for the PhD phase of the school can carry out the Preparation Activities at two periods: Summer or Winter.

- Enrolments is two times a year. The total number of selected students is 7.
- The Master students are given total freedom of choice regarding the research subject of their PhD research. However, the 4 PhD proposals that will be funded directly through the NWO Graduate Programme, must have a high risk character. That is, the proposal has to concern long term research and/or the subject may be of interest but the project may fail. Still, the impact on society may be great.

#### **Training and supervision plan**

All PhD students have 1, 2 or even more supervisors depending on the embedding in their research

group and the multidisciplinary nature of the PhD project. The full training programme of a PhD student consists of several parts:

- Presentation trainings: As a regular part of the training plan, all PhD students present on a regular basis the progress in their work in internal group meetings, departmental meetings, project progress meetings, and conferences.
- PhD educational programme: The educational programme is the prime responsibility of the three departments. All course activities of all PhD students are logged, through which the progress of all students is monitored.
- Knowledge dissemination: all PhD students are actively trained to disseminate knowledge by participating in national and international meetings and conferences, and by writing scientific papers on the original contributions in their PhD work.
- Personal development plan: The training programme is complemented by optional courses or trainings, which are needed to improve on a particular skill. Typical examples are the PhD student's proficiency in English, technical writing skills, etc.
- Career development guidance: In the last year, most PhD students are offered assistance in their further career development, often facilitated by the local HRM support.

The supervision plan is made by the responsible professor, including the daily supervision (assured by faculty members in the group) and regular progress meetings. For many projects

that are externally funded, additional project meetings take place to fine tune the activities and the progress with other partners or work packages.

### ***PhD supervision and monitoring of supervision***

The supervision of the PhD students is carried out via the professors of the three departments. They are responsible for the execution of the training and supervision plan for the student. Supervision is carried out on a daily basis, and regular meetings in which the progress of the work and the next steps to be taken are discussed. All projects have a project plan, with a clear planning of activities, which is adapted where needed as a result of the new insights gained from completed research tasks. The supervision is monitored at the level of the research schools by verifying the throughput of PhD students in each group and by assessing the reasons for an early withdrawal of a PhD student. At the level of the research groups, regular contacts exist between the scientific directors of the research schools and the group leaders, whereby supervision issues are discussed if needed.

### ***Progress monitoring and measures***

The progress is monitored at different levels and different frequencies:

- At the level of the daily supervisor: the progress is here monitored on a daily to weekly basis, through the frequent interactions between the PhD student and his/her supervisor(s).
- At the level of the promoter: the progress is here monitored at least on a monthly basis, in close interaction with the daily supervisor(s).
- A yearly assessment (performance interview) is made by the responsible professor and discusses the progress and the performance of the PhD student, as well as the expectations and planning for the coming year. At this point, it is monitored if sufficient progress has been made to successfully finish the project within the PhD term. If the assessment is convincingly negative, the student's participation in the programme is discontinued (which is the main part of the earlier reported withdrawal rates), and the student is guided towards alternative career opportunities.

## **2.1.5 Quality management**

*Please describe how quality management is assured and refer to issues mentioned below (if applicable). Other relevant subjects may be included.*

- How is feedback of (ex-) PhD students acquired and how is this information used to improve education and supervision?
- How do (external and/or international) advisory boards play a role in the improvement of education and supervision?
- How has a database containing essential information about PhD students and their progress been given form?

*Please note for all of section 2.1:*

*The quality of the research programme may have been assessed prior to this application (SEP/QANU/ECOS-KNAW). Please include conclusions or summaries of these assessments that are relevant to any of the subsections.*

*If the school consists of various units with different research programmes then the lecturers and supervisors of the unit in which the PhD students funded by NWO and their fellow PhD students will carry out their research need to be listed.*

Every department of Applied Mathematics at the three TU's has its own quality management system. Every system has been accredited.

## 2.2 Scientific Quality

*A maximum of 5 pages is permitted for Section 2.2.1.*

*Please describe:*

- The school's mission and long-term strategy
- The school's core research programme
- The school's international status
- The contribution and distribution of the work between the various research groups (if applicable)

*Also, please fill out the table below:*

	# Veni grants	# Vidi grants	# Vici grants	# Spinoza grants	# ERC Starting Grants	# ERC Advanced Grants
For your school:						

*Please note*

*The quality of the research programme may have been assessed prior to this application (SEP/QANU/ECOS-KNAW). Please include relevant conclusions or summaries of these assessments and give the scores for the most recent evaluation using the table below.*

SEP/QANU scores for (the groups in) your school:	Quality	Productivity	Relevance	Viability/Vitality

### 2.2.1 Quality of research programme

The number of grants is shown in the Table:

	# Veni grants	# Vidi grants	# Vici grants	# Spinoza grants	# ERC Starting Grants	# ERC Advanced Grants
3TU.AMI	0	3	3	0	1	0

The three departments of Applied Mathematics are responsible for the quality of the research. In September 2009 (report of 2010), the average results of the QANU research review were:

Average 3TU Mathematics (2010)

Quality	4,2
Productivity	4,2
Relevance	4,9
Viability	4,7

***Mission and strategy***

**3TU.AMI**

**Applied Mathematics Institute**

Of the 3 Technical Universities  
In the Netherlands

**Applied Mathematics Institute (AMI)** see also <http://ami.3tu.nl>

3TU.AMI is part of the 3TU Federation. The Board consist of the 3 Deans of the three departments Applied Mathematics in Delft, Eindhoven, and Twente. Chairman is Prof.dr. Arjeh Cohen (TU/e). Scientific Director is Prof.dr.ir. Kees Vuik (TUD). The Management consists of three professors of the three departments: Arnold Heemink (TUD), Anton Stoorvogel (UT), and Onno Boxma (TU/e). Secretary is Ton Langendorff (head of research policy, TU/e).

The activities of 3TU.AMI are on top of the three departments. The main task is to encourage cooperation:

- 4 Strategic Research Orientations (SRO's), to stimulate research cooperation in the fields of Energy, Water, Logistics, and Health
- 6 Education projects (with 3TU funds of € 2.2 mln.), e.g. digital education, international guest lecturers, new PDEng programmes (health logistics) etc.
- Each year two conferences: Spring Festival (enjoyable lectures on the beauty of Mathematics) and Autumn Show (duo lectures with academia and business enterprises)
- Outreach (Mathekalender, in cooperation with MATHEON)
- Funding / sponsoring workshops, conferences of 3TU, and Study Week Mathematics & Industry
- International cooperation in research (MATHEON)
- Cooperation with SME's (software, applied mathematics, risk management) for implementing innovations in client enterprises. In most cases enterprises need expertise to implement innovations in order to apply the results of AMI research. But it is not the task of university professors to do such consulting, training, and writing of software. In these cases the partner SME's can take over.

### Quality of research programmes

SEP/QANU scores for (the groups in) your school:	Quality	Productivity	Relevance	Viability/Vitality
TUD a/ Computational Science and Engineering	3	5	5	5
b/ Probability, Risk and Statistics	4	4	5	4
TU/e a/ Applied Analysis and Scientific Computing	5	4	5	5
b/ Statistics, Probability and Operations Research	5	5	5	5
UT a/ Applied Analysis and Computational Science	4	5	5	5
b/ Stochastics and Operations Research	3	4	3	5

#### 2.2.2 Participating scientists

*A maximum of 10 pages is permitted for Section 2.2.2.*

Convincing evidence of the excellence of the participating researchers should be provided.

*Issues mentioned below (if applicable) or other relevant subjects may be addressed.*

- The participating (core) researchers of the school including a very brief CV (maximum ½ page).
- Five key publications from each participating researcher relevant to the school's research scope.
- Prizes, awards or grants / significant contributions to congresses / memberships of scientific societies / international activities.

For those researchers who carry out tasks related to education and supervision please include information about:

- Activities related to education (e.g. responsibility for which courses, courses in the MSc and/or PhD phase, workload per lecturer).
- Activities related to supervision (e.g. track record regarding the number of PhD students who have completed their PhD).

*Please note*

*Include relevant conclusions or summaries of (SEP/QANU/ECOS-KNAW) assessments.*

**Professors of 3TU.AMI who will contribute to the Graduate School**

The programmes (TUD a/ and b/, etc.) correspond with the titles of the programmes mentioned above.

TU Delft

## a/ Computational Science and Engineering

A. Heemink	Mathematical Physics
C.W. Oosterlee	Numerical Analysis
C. Vuik	Numerical Analysis

## b/ Probability, Risk and Statistics

F. Redig	Applied Probability
G. Jongbloed	Mathematical Statistics

University of Twente

## a/ Applied Analysis and Computational Science

B. Geurts	Numerical Analysis and Computational Mechanics + TU/e (Applied Physics): Fluid Dynamics
J.G.M. Kuerten	Computational Multiscale Methods + TU/e (Mechanical Engineering): Two-Phase Flows

## b/ Stochastics and Operations Research

R. Boucherie	Stochastic Operations Research
N. van Dijk	Operations Research and Management
J. Hurink	Discrete Mathematics and Mathematical Programming
M. Uetz	Discrete Mathematics and Mathematical Programming
H. Zwart	Stochastics System and Signal Theory + TU/e (Mechanical Engineering) Dynamics and Control of Distributed Parameter Systems

Tu Eindhoven

## a/ Applied Analysis and Scientific Computing

M. Peletier	Variational Systems
B. Koren	Scientific Computing
W. Schilders	Scientific Computing

## b/ Statistics, Probability and Operations Research

O. Boxma	Stochastics
G. Woeginger	Combinatoric Optimization

### 3 Signature

**By submitting this application through the electronic system 'Iris', I declare that I have completed this form truthfully.**

Please state your NAME:

Prof.dr.ir. C. Vuik



Delft, February 2013

5 Februari

– The application must be submitted, in PDF format, no later than 6 February 2013 (23:59) by using Iris ([www.iris.nwo.nl](http://www.iris.nwo.nl)).

Appendices:

1. List of the participating professors and their cv's etc.
2. Compilation of 3TU.AMI Research Projects relevant to the Energy sector, 2011/2012