Degree programme documentation, Abstract

Master’s degree programme in Resource Efficient and Sustainable Building

Faculty of Civil, Geo and Environmental Engineering
Department of Architecture
Technical University of Munich

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<tr>
<th><strong>Designation:</strong></th>
<th>Resource Efficient and Sustainable Building</th>
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<td><strong>Organisational assignment:</strong></td>
<td>Faculty of Civil, Geo and Environmental Engineering</td>
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<td><strong>Qualification attained:</strong></td>
<td>Master of Science (M.Sc.)</td>
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<tr>
<td><strong>Regular duration of programme (credits, hours per semester week):</strong></td>
<td>4 semesters (120 credits)</td>
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<td><strong>Form of studies:</strong></td>
<td>Full-time, on-campus, interfaculty Master’s degree programme in engineering science</td>
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<td><strong>Admission:</strong></td>
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<td><strong>Starting date:</strong></td>
<td>Winter semester 2018/19</td>
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<td><strong>Language(s):</strong></td>
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<tr>
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Objectives of the programme

The purpose of the M.Sc. in Resource Efficient and Sustainable Building (RNB)

Why does the degree programme exist, and what is the programme to achieve?

Preliminary remarks

Solving global challenges such as climate change, the destruction of the environment, resource rivalries, demographic change and urbanisation, as well as the challenges that these pose for our societies, are among the central questions of our time. A vital role is played here by the construction industry when it comes to reducing CO$_2$ emissions, adapting our towns and cities, neighbourhoods and buildings to climate change, reducing the use of resources (e.g. land, material and water), and adjusting the built-up environment to rapidly-changing economic and societal circumstances.

Over and above this, roughly 66 hectares of land are approved as housing and traffic development zones in Germany every day\(^1\), making them unavailable for other uses such as food production, ecological compensation areas, recreation areas or water storage. These are alarming figures given the current size of the global population’s ecological footprint, and in light of the fact that we are overtaxing our planet by more than 1½ times its biocapacity, which can already be felt today. Against the background of ongoing, rapid global population growth and the consequences which this has for equally rapidly rising CO$_2$ emissions and resource consumption, there is an urgent need to place the management of the construction industry on an exclusively sustainable footing.

Resource Efficient and Sustainable Building

The development, planning and implementation of resource efficient, sustainable solutions pose massive challenges to the construction sector, which given their scope and complexity can only be solved by considering all scale levels (region-town&city-neighbourhood-building-building system-component-material) and all players that are involved in the supply chain (e.g. legislature, standards committees and expert bodies, planning offices, approval authorities, builder-owners and developers, planners, engineers, building contractors, etc.).

There is already an urgent need to seek solutions to comply with the statutory provisions which will be applicable from 2020 onwards in order to ensure that buildings are operated virtually CO$_2$ free.

Given the scale depicted above, but particularly also because of the complexity of the challenges posed by resource efficient, sustainable building, it is imperative to adopt an interdisciplinary approach in order to ensure that the tasks are properly addressed.

This becomes clear for instance in the field of tasks related to upgrading the building stock’s energy performance.

The situation is similar when it comes to issues relating to the economic viability of energy retrofits (cost-benefit assessment), as well as to other aspects for supporting and/or motivating building owners and users to improve the energy performance of the building stock. Resource Efficient and Sustainable Building therefore calls for a fundamental change in the linear planning practice of the past, towards interdisciplinary, holistic planning processes.

This calls for close cooperation between engineers with an analytical and technical mindset, and creative planners and architects, to develop appropriate concepts from day one.

Together with the Department of Architecture, the Faculty of Civil, Geo and Environmental Engineering offers an interdisciplinary, inter-faculty Master’s degree programme on the topic of “Resource Efficiency and Sustainability” in order to achieve the above goals.

The programme’s strategic significance

*What is the programme’s contribution to the Faculty’s teaching strategy?*

- The strategic significance of the M.Sc. RNB in light of the goals of the TUM

The goal of the largest reorganisation programme within any University in Bavaria – innovaTUM2008 – lies in increasing performance and competitiveness, as well as in promoting the academic competition culture. *innovaTUM 2008 therefore focuses not on the existing core skills in terms of structure and content, but on new interdisciplinary strengths. (…), including the future areas “Renewable Raw Materials” and “Energy and the Environment”.*

The two latter points for identifying and expanding “new interdisciplinary strengths” in the future area “Energy and the Environment” constitute the direct point of reference regarding the content emphases and the goals of the M.Sc. in Resource Efficient and Sustainable Building. In addition to the above direct content point of reference, the interdisciplinary orientation and the methodical teaching approach of the M.Sc. RNB are also identical to the goals of the TUM: Given the above goals of the TUM, the M.Sc. RNB programme is to address graduates from Bachelor’s programmes in Architecture, Environmental Engineering, Civil Engineering and Supply Engineering. As a matter of principle, they are taught together as part of an interdisciplinary process. Particular emphasis is to be placed here on the interdisciplinary

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project in the second semester of the programme, in which interdisciplinary teams are taught jointly by instructors from different faculties in the following four skill areas:
- sustainability in architecture, towns and cities and the landscape,
- building services engineering and renewable energies,
- building physics and energy efficiency, and
- constructional engineering and lifecycle engineering.
Skills profile

What knowledge, abilities and skills will the programme graduates have?

The M.Sc. RNB programme graduates are to be able to think holistically and offer their services in resource efficient, sustainable construction as particularly well-qualified engineers, architects and planners. Given their broad-based specialist skills and their interdisciplinary thinking and working, they will help amongst other things to implement the stipulations of national and international law with regard to resource efficient construction. To this end, they will develop constructional design solutions for climate protection, which will continue to be urgently needed, and will help satisfy the increasing need to adjust buildings and neighbourhoods to face the advance of climate change.

To this end, the M.Sc. RNB programme graduates will have the necessary skills in drafting and planning at the scale levels of buildings, neighbourhoods, towns and cities as well as regions. They will also have detailed knowledge of the skill areas of construction physics, building services engineering, structural design and life cycle analysis that are relevant to resource efficient, sustainable construction. They will be familiar with the interactions and synergies of these fields, and will be able to apply the knowledge that they have gained in planning and implementing resource efficient buildings and neighbourhoods.

As “interface specialists”, they have both the necessary abilities to optimise the resource requirements, taking account of aspects that are relevant to sustainability such as ecology, economics and sociocultural factors, as well as being able to communicate both with creative architects and planners and with analytically- and technically-orientated engineers, and to communicate their knowledge in a goal-driven and effective manner. The abilities to optimise building and neighbourhood concepts in a resource-driven, quantifiable manner on the basis of engineering methods and to effectively integrate the knowledge that they have gained into the planning process, taking the entire life cycle into account, constitute special qualifications of graduates from this programme.

The Master’s programme in Resource Efficient and Sustainable Building (RNB) creates an independent activity profile of a sustainability expert in the construction sector who is able to close the gap between classical civil engineers, environmental engineers, architects and building services engineers. Graduates from the Master’s programme in Resource Efficient and Sustainable Building will be able to analyse connections and insights related to all aspects of sustainable design and building in order to develop solutions that implement resource efficient, sustainable buildings at the interdisciplinary interface between man, buildings, infrastructure and the environment.
Target groups

The group of addressees

Who does the programme address?

The target group includes graduates in Architecture, Civil Engineering and Environmental Engineering, as well as Building Systems Engineering and related degree programmes (such as Supply Engineering).

Applicants' prior knowledge

What specific knowledge, abilities and skills are required to start the programme?

Graduates in the above subjects must have mastered the fundamentals in the fields and issues of sustainable, resource efficient design and building, in particular with regard to civil engineering and infrastructure. This knowledge includes:

- the fundamentals of the planning and design process,
- the fundamentals of structural design,
- the fundamentals of energy concepts and building services, and
- the procedures followed in construction processes.

The ability to work scientifically and/or in a method-orientated and research-based manner is a must, as is a general understanding of engineering. Transfer students will naturally also be admitted, providing they have the right qualifications. The starting qualifications and preconditions for admittance to the Master’s programme are regulated by the aptitude procedure and the subject-specific examination and study regulations.
Analysis of needs

What demand is there for our graduates on the jobs market?

The demand for graduates on the jobs market

The modernisation of the building stock, as well as the planning and implementation of resource efficient, sustainable new constructions necessitated by increasingly complex political, ecological and economic frameworks, calls for specialists who have a broad-based understanding of ecological, economic and social contexts. According to forecasts, the market for specialist planners in energy efficient, sustainable construction is set to grow rapidly in the years and decades to come. In order to achieve the political goals of reducing energy demand in the construction sector, it will need to be ensured that the topic of “resource efficiency” has its place in the real estate sector in the future. This also applies to the new challenges posed by the European Construction Products Directive, the Energy Performance of Buildings Directive (EPBD) 2016, and those posed by demographic change. Given these European stipulations, CO₂ emissions in the construction sector need to be drastically reduced by the end of 2020. “All new buildings must be nearly zero-energy buildings.”

At the same time, the need increases to develop new solutions and technologies (circular economy/material sector/increasing resource consumption worldwide caused by climate change and population growth). Design concepts and technical equipment are still being implemented in buildings which leave considerable room for improvement. The above factors in particular frequently call for innovative solutions and new approaches in an interdisciplinary environment.

New demands made of buildings will result in the development of a new profession of “sustainability engineer/consultant”. Given the broad-based training and the complex requirements of the subject, graduates from the RNB Master’s programme will find a multiplicity of job opportunities open to them. This applies not only in architects’ and planning offices, but there will also be openings for instance with property developers, in construction firms, in the industrial sector and in facility management. Particularly in this complex field, specialists with additional skills are needed. New professional fields are currently coming into being in this area, which is of importance to society as a whole. In addition to the purely subject-related skills, the ability to develop interdisciplinary action and thinking is highly important.

The task to be performed by these specialists includes creating technically-sound, innovative solutions. A major focus today consists of energy-conscious, environmentally-friendly, sustainable planning, building, green retrofitting and management of of neighbourhoods, buildings and structures, as well as the infrastructure this involves, such as energy and water supply and building transport links. The future tasks for the graduates can be summed up as follows:

• role of advisor and planner in engineering or planning offices,

• life cycle-orientated evaluation of construction processes and construction work, taking account of ecological and economic aspects,

• coordination of projects and specialist planners/specialists in sustainability processes and integral planning in urban development and infrastructure,

• creating spatial and structural solutions in civil engineering, taking account of architectural, climate- and energy-related aspects,

• drawing up new technical and structural solutions for energy-efficient, sustainable housing and other buildings, whilst taking into account the infrastructural facilities which are necessary for this, such as energy supply, water supply and waste water disposal, as well as transport links,

• application of planning tools to calculate and evaluate the energy footprint, the ecological footprint, the life cycle costs and the quality of the sustainability of neighbourhoods and buildings,

• planning services for new construction projects and energy retrofits of neighbourhoods and buildings, based on concepts with optimised energy, ecological and economical performance, whilst accommodating social aspects,

• planning services for the conservation and renewal of buildings, focussing on the topics of the environment and energy, material and resource management (e.g. recycling and disposal of construction materials), as well as revitalisation and urban renewal, and

• consultancy services to optimise the processes of sustainable real estate development and sustainable real estate management.

The following career choices are open to graduates:

• architects', engineers' or other planning offices,
• public authorities (e.g. building and planning offices, approval authorities),
• experts, consultants,
• construction companies,
• industrial production,
• trade and commerce,
• research and teaching, and
• further training and development.
**Competition analysis**

**Internal competition analysis**

*Does the TUM offer any degree programmes with similar topics? If so, how can this programme be differentiated?*

- The unique feature of the M.Sc. in RNB

The topics of the M.Sc. RNB can, to a certain degree, be found both in research and teaching in the M.Sc. programmes in civil engineering (BI), environmental engineering (UI) and architecture (AR). There is however a pronounced difference with regard to the breadth and intensity of the analysis and the integrated, interdisciplinary approach between the M.Sc. in RNB and the Master’s programmes in BI, UI und AR.

In the area of teaching, the “Interdisciplinary Project” makes this particularly clear. Within an interdisciplinary module, B.A. and B.Sc. graduates from the fields of architecture, civil, environmental and supply engineering, work closely together to deploy analysis and synthesis methods (design) in an integrated manner in order to develop holistic, optimised solutions at neighbourhood level, both in energy retrofits of existing buildings and construction of new ones.
The structure of the programme

The first semester of the degree programme serves above all to provide fundamental knowledge in the four skill areas above. The obligatory and elective modules offered here ensure that all of the programme’s graduates have the core skills forming the basis for resource efficient, sustainable construction. In preparation for the interdisciplinary project, graduates of the Bachelor’s programme in Architecture attend the module entitled “Physical principles of energy-efficient construction”, and graduates with a Bachelor’s degree in engineering attend the module entitled “Aspects of sustainable urbanism”.

The above core skills are expanded upon in further obligatory modules in the second semester of the degree programme. The central element of this programme is the “Interdisciplinary Project”, in which the skills obtained so far are implemented and expanded in teams with an interdisciplinary composition (e.g. B.A. AR, B.Sc. BI and B.Sc. UI) in a design-orientated project. The focus here is placed on the interaction between the analysis, for instance of the life cycle-based resource consumption of alternative solutions, and on the synthesis in the context of the design-orientated development of energy concepts in the energy retrofitting of existing buildings and construction of new ones. In this context, the obligatory module entitled “Application of a life cycle analysis” is also part of the second semester of the degree programme, which is directly connected with the application-orientated development work carried out in the “Interdisciplinary project” (IDP). The work carried out in the IDP is highly practical in its orientation. In addition to expanding specialist skills, imparting social skills (e.g. teamwork and team leadership, visual, verbal and non-verbal communication, etc.) in preparation for the IDP is a major element of the first semester of the degree programme and, along with the project, also forms a component of the second semester.

Because of the long list of options available, the third semester of the degree programme offers students the opportunity to expand their specialist knowledge in a targeted manner. Moreover, the third semester offers an opportunity to both obtain and contribute specialist knowledge while spending time at other Universities abroad.

The fourth semester of the degree programme focuses on the Master’s thesis and the Master’s colloquium.

Required modules are used in the first two semesters to achieve harmonisation of the different academic backgrounds. These modules are mostly subjects already offered in the Bachelor’s programmes and are designated requirements for this degree programme.
Organisational links and responsibilities

Who is responsible for the content and organisational implementation of the degree programme?

The Faculty of Civil, Geo and Environmental Engineering is responsible for the organisation of the Master’s degree programme.

The Chair of ENPB is responsible for implementing the programme, and is in charge of

- study programme supervision and advice; mentoring within its academic field,
- applications and admittance,
- organisation of the aptitude procedure,
- the overall coordination of the Master’s programme,
- the examination committee and providing support for the examination administration,
- public relations work and information activities,
- examining the quality of the studies,
- student management (together with the Office of the Dean of Studies of Civil, Geo and Environmental Engineering [BGU]),
- examination management (together with the Office of the Dean of Studies of Civil, Geo and Environmental Engineering [BGU]), and
- representing the programme in the Study Commission.

Other Chairs and Institutes are also involved in the teaching and mentoring of students in the seminars and projects

- the Institute of Building Physics,
- the Chair of Building Technology and Climate Responsive Design, and
- the Chair of Timber Structures and Building Construction.

In content terms, the Master’s programme is also supported by other chairs within the Departments of Architecture and Civil Engineering, also involving amongst others the Department of Electrical and Computer Engineering, the Department of Mechanical Engineering, as well as the Institute for Energy Systems.