Energy Technology Network (EnergyNET)

NorhedII project 2021-2026

Project Report 2025 and Activity Plan 2026

Ole Jorgen Nydal (Project Coordinator)	NTNU,	Norwegian University of Science and Technology
Joseph Kihedu	UDSM,	University of Dar es Salaam, Tanzania
Karidewa Nyeinga	MAK,	Makerere University, Kampala, Uganda
Boaventura Cuamba,	UEM,	University of Eduardo Mondlane, Mozambique
Abdulkadir Aman Hassen	AAU,	Addis Ababa University, Ethiopia
Akatew Haile	MU,	Mekelle University, Ethiopia
Ishmael B.M. Kosamu ,	MUBAS,	Malawi University of Business and Applied Sciences
Konjo Francis Potte Sindani	UoJ,	University of Juba, South Sudan

Foreword

The following gives a report of activities and results of the NorhedII project "Energy Technology Network, EnergyNET". The report is updated every year for the project period 2021-2026. Activities are reported from the previous year and planned activities specified for the following year.

The Result Framework for EnergyNET consists of three files:

- EnergyNET-ResultsFrameworkTable.xls is the template format for the overall result framework.
- EnergyNET-WorkPlan.docx is the planning document, following the structure for Norhed projects.
- EnergyNET-TimePlan.xlsx is the time plan for the activities at each partner university

The structure of this report follows the structure of the Work Plan for ENET.
Each section has a summary for 2025 and plans for 2026.

Contents

Summary 2025

The core of the ENET project is a group of PhDs working on the challenges of small scale energy technology, from development to implementation. A group of PhDs are established and working towards development and implementation of three particular types of small-scale renewable energy technologies:

- Heat storage for cooking, frying and baking
- Refrigeration systems
- Pumps as turbines

A PhD from UEM focus on the social side of energy transition technology. The PhD group is also extended with candidates who have partial ENET support but work under the ENET research objectives and contribute to the group. Master research topics are also defined in support of the ENET objectives.

The project has had good synergies with two other projects.

- Students at NTNU and at UDSM who are defined within the ENET tasks have exchange periods between the universities in a NORPART project. The NORPART project concludes in 2025.
- ENET PhDs benefit from the PhD course developed in the Erasmus+ UNET project and the support for the training equipment can be optimized through both UNET and ENET. UNET also included a mobility program for staff and PhD visits to the partner laboratories. The UNET project concluded in early 2025.

Some highlights from 2025 are:

- Graduation of 4 PhDs: Jimmy Chaciga (MAK), Tusiime Swaleh (MAK, from EnPe period) Ibrahim Mwasubila (UDSM), Emanual Nyirenda (UDSM/MUBAS) and Casiana Lwiwa (NTNU).
- 4 PhDs (AAU and UEM) spent 1-3 months at NTNU, taking part in laboratory work and working on their theses. The candidate for UDSM also did the groundwork for acquisition of research equipment to UDSM.
- Three pilot concepts have been displayed and received strong attention at university innovation events at MAK and UDSM and AAU.
- The cooker pilot at MAK has been copied and taken for field testing at a school for refugees in northern Uganda.
- The annual ENET meeting was hosted by MUBAS in Malawi and included participation of private and governmental stakeholders.
- ENET work from UDSM and AAU was presented at World Renewable Energy Conference in UK, WREC 2025
- NTNU visited almost all partners in 2025, including Mekelle University.

Project participants

The NorhedII project "Energy Technology Network EnergyNET" builds on a long term collaboration with a group of universities on research and education in Renewable Energy Technology. A series of joint projects the last 15 years have resulted in master programs and research capacity in Renewable Energy, with particular focus on small scale systems with off-grid applications.

The participating universities, contact persons are:

Table 1 Project members

University		Name
NTNU	Norwegian University of Science and Technology, Trondheim, Norway	Ole Jorgen Nydal (Project Coordinator) Trygve Eikevik Govert Valkenburg Torbjørn Kristian Nielsen Johannes Jäschke
AAU	Addis Ababa University, Ethiopia	Abdulkadir Aman Hassen (Coordinator) Demiss Alemu Amibe Yilma Tadesse Birhane Kamil Dino Adem
MAK	Makerere University, Kampala, Uganda	Karidewa Nyeinga (Coordinator) Denis Okello
UEM	University of Eudardo Mondlane, Maputo, Mozambique	Boaventura Cuamba (Coordinator) Antonio Leao Rogério Uthui Alberto Tsamba
UDSM	University of Dar es Salaam, Tanzania	Joseph Kihedu (Coordinator) Cuthbert Z. M. Kimambo
MU	Mekelle University, Ethiopia	Mulu Bayray (Coordinator) Asfafaw Haileselassie Mulualem Gebregiorgis Akatew haile <akatew.haile@mu.edu.et>
MUBAS	Malawi University of Business and Applied Sciences, Malawi	Ishmael B.M. Kosamu (Coordinator) Suzgo Kaunda
UoJ	University of Juba, South Sudan	Konjo Francis (Coordinator) Tito Achire

Mekelle University, MU; became active again in 2023, after the period of political conflict in Ethiopia. Akatew Haile is the coordinator from MU from 2024..

Synergies with other projects

EnergyNET is linked with other projects, which gives the following synergies:

- "**UDSM-NTNU Mobility Program on Energy Technology, 2019-2024**"
  Exchange of master students. Students are initiated with research tasks in line with ENET PhD researchers and can travel to UDSM and to NTNU for a period of research during their master thesis work. https://www.ntnu.edu/ept/udsm-ntnu

- **"University Network on PhD Programmes in Energy Technology, UNET" 2021-2024**
  Erasmus+ Capacity Building program. Development of PhD Curriculum and improving Training Facilities. ENET PhD researchers can benefit from PhD courses, improvements in training facilities and some mobility opportunities from the UNET project to take part in courses and make use of training facilities. https://www.ntnu.edu/uneterasmus/

- **NORHEDII project: Capacity building for socially just and sustainable energy transitions**
  A master student will link the two projects with supervisors from both sides.

- ENET staff at UEM are involved in the **Energy Research Centre** (CPE). The Energy Centre will interact more closely with the UEM **Center of Studies in Oil and Gas**, where PhD studies are not limited to the oil and gas area but can be initiated to also be relevant for the ENET work in Renewable Energy Technology.

- The group of master students at UEM is coordinated with another project with Chalmers University, Sweden. This gives a larger number of master students than it would otherwise be possible at UEM. The division of support is indicated in the Appendix in the table of master students.

- **SANORD** is the Southern African - Nordic Centre which promotes university collaboration. Our relation with SANORD has been through the hosting of a master student from University of Namibia in 2024. The student had stipend form SANORD and joined a group of visiting ENET researchers to the laboratories at EPT, NTNU.

The combined ENET/UNET group of universities is then 10 universities:

University Dar es Salaam, **Tanzania** University of Dodoma, **Tanzania**	Makerere University, **Uganda** Busitema University, **Uganda**
Addis Ababa University, **Ethiopia** Mekelle University, **Ethiopia**	Eduardo Mondlane University, **Mozambique** SAVE university, **Mozambique**
Malawi University of Business and Applied Sciences, **Malawi**	JUBA University, **South Sudan**
Norwegian University of Science and Technology, **Norway**	

1 - Programmes and methods

MSC programmes on Renewable Energy.

Background

Master programmes have been established during the sequence of earlier collaboration periods in the NOMA programme (UDSM and MAK), the EnPeI programme (MU) and EnPeII programme (UEM). MUBAS and UoJ will benefit from knowledge transfer on MSc curriculum and research programmes at the other partner universities.

The review of the master programs has been on the agenda of two Workshops in 2021. A Working Group for the review has been established for the further work:

Table 2 Working group for the review of the master programmes.

University	Name
UDSM	Cuthbert Kimambo (Lead)
UEM	Boaventura Cuamba
AAU	Abdulkadir Aman Hassen
MAK	Denis Okello
MUBAS	Chiyembekezo Suzgo Kaunda
UoJ	Achire Tito
MU	

Curriculum reviews are planned in particular for UDSM and UEM. Cross-national harmonization of the programs may be difficult, but synergies can be obtained at the course levels.

Plans for 2026

The plan for 2026 is also to prepare a map on the course level for the similar master programmes among the partners:

- MSc Renewable Energy Engineering at UDSM
- MSc Renewable Energy at MAK
- MSc Renewable Energy at UEM
- MSc Energy Technology at AAU
- MS Energy Technology MU

Tracer study of graduates

NORHED has prepared a template for recording some data of graduates form the project. This is to be completed as part of the final reporting of the projects.
The template can in ENET be used as a basis for also including data from previous NORAD programs, to the extent possible.

MSc. in Renewable Energy at UDSM

Curriculum review

An analysis from UDSM in 2021 indicated some points for considerations, notably on the point of training facilities:

- Fieldwork and internship not integrated in programme values

- Lack of equipment, outdated equipment and outdated instrumentation
- Low motivation for students and lecturers towards lab experiments
- Lack of applications on course contents, too much basics/fundamentals
- Limited number of students due to lack of online/evening delivery modes, scholarships/mobility schemes

	
Workshop November 2022. MSc programme review	Curriculum Review Validation Workshop 2023

There is also a need to review the programmes with respect to the mismatch between the number of courses (28 at UDSM) and specialization offered (5 at UDSM) and the yearly number of students (about 5). UDSM has provided a template for a Course Mapping and a Tracer Study, which is shared with the group.

Mapping of courses at UDSM for MSc Renewable Energy was completed in 2022. Courses a set on compulsory and elective basis, with a total of 18 courses (10 compulsory and 8 elective courses). There are no specializations as opposed to current curriculum. Currently, there are 21 courses (5 specializations, each 4 courses). The UDSM course mapping has been shared with the other partner universities.

Teams of experts related to the courses being offered under the programme embarked in 2023 on the task of reviewing the programme curriculum, including all the courses that would be offered under the programme. Through a series of working many sessions involving experts from other related fields, the team came up with a draft curriculum document that is in line with the TCU Curriculum Development Framework of November 2021. The draft curriculum was submitted to Stakeholders Validation Workshop for Curriculum Review. This Validation Workshop on Curriculum Review for CoET was held on Saturday, 2nd December 2023. It was organized in the same manner as the one for the tracer study.

The curriculum was approved at the department and College level and submitted to university level for further processing and approval by the Senate, before submitting it to TCU for accreditation.

Details of the curriculum review is attached as appendix B to this report.

Activities in 2024

UDSM completed the process of approval and accreditation of the review of the master program, by the University Senate and the Tanzania Commission for Universities (TCU).

To facilitate smooth transition into the new curriculum, relevant course lecturers were engaged to update/prepare teaching materials for the new curriculum. Synergies with the UNET project could also be noted, where the curriculum for a number of PhD courses were prepared. Some of this course material could also be relevant for master courses.

Activities in 2025

The revised curriculum was submitted for accreditation to Tanzania Commission for Universities (TCU) in February 2025.

Plans for 2026

It is expected that curriculum for MSc Renewable Energy Engineering will be approved early 2026 and therefore kick off for delivery of new curriculum will start in November 2026. To facilitate smooth transition into the new curriculum, relevant course lecturers will be engaged to update/prepare teaching materials for the new curriculum.

Tracer Study at UDSM

The project created synergy with the ongoing University-wide tracer study in 2022. One survey tool for all UDSM programmes was developed, with a common section for social data. General information is requested from all UDSM graduates. There are customized sections for each degree programme and MSc Renewable Energy has been set as per ENET objective. Programme review is requested from 2007 to 2022 graduates, which is thought to be useful for justification of curriculum review. Development of tracer study tools (January to October 2022) built on with support from an e-government survey tools. Pilot data collection conducted followed by hybrid data collection. The target is 60% online data collection, which is set as a threshold to be attained before field can be conducted. Field visits will focus on employers plus the remaining 40% of graduates.

Online data collection took place in November and December 2022. The threshold of 60% online data collection has been achieved for all the three targeted postgraduate programmes, namely MSc in Renewable Energy (70%), MSc in Energy Engineering (60%) and MSc in Oil and Gas Technology (107%).

Programme	Number of Completed Responses	Target Sample	Completion Status (%)
MSc in Renewable Energy	14	20	70%
MSc in Energy Engineering	6	10	60%
MSc in Oil and Gas Technology	16	15	107%

Tracer study at UDSM was concluded in June 2023 and the results obtained provided very important to curriculum review exercise.

MSc. in Renewable Energy at AAU

Curriculum review at AAU

A curriculum review activity was not executed in 2023 due to the restructuring of the university as Chartered University. A program review committee was established at university level and they are performing auditing of the existing programs. Accordingly, we were advised not to modify or launch new programs until the audit findings from the existing programs was completed which may include merging of some programs in the university. However, the activities we have in the project including the availability of funding for PhD students, improvement of infrastructure and research activity with partners demonstrated the positive side of the project and is in line with some of the requirements that we should fulfil in the auditing of the program. The contributions of the project were reported in the response for program auditing.

Activities in 2024

The revision of the existing M.Sc. and Ph.D. curricula in Thermal and Energy Systems Engineering has been completed in 2024 as part of the university's overall program revision and restructuring efforts.

Activities in 2025

The accreditation process was delayed, as the restructuring of the Addis Ababa Institute of Technology to College of Technology and Built Environment took significant resources in 2025.

Plans for 2026

In 2026, the primary focus will be on completion of the accreditation process under the new College structure. The ENET project will provide support for activities related to the accreditation process.

Tracer Study at AAU

A tracer study was conducted at AAU in 2022 by customizing the template shared by UDSM. The collected responses were not sufficient to draw conclusions and the activity will continue by expanding the group of respondents and population size. The responses remain to be analyzed and documented.

MSc. in Renewable Energy at MAK

Curriculum review at MAK

The MSc curriculum in Renewable energy at MAK was recently revised and approved outside this project network. Teaching based on the new curriculum started in October 2022. Similarly, MSc in Physics with renewable energy specialization has also been revised and teaching on the revised version started in 2022. Therefore, it was agreed that it is not appropriate to revise the program again at this stage under EnergyNET. However, the team at MAK will participate in revision of selected courses to enrich the programmes.

Tracer Study at MAK

At MAK, the tracer studies which were originally planned could not be conducted due administrative issues related to financial management at MAK in 2024. Given the challenges in documenting air time, data, it was not possible to carryout tracer studies even in 2024. It is also not possible to estimate the time/hrs required to carry out tracer studies, usually they are expensive. Hence an extensive tracer study at MAK will be reduced to an overview of the current status of former students supported by the EnPe and ENET projects.

Activities in 2025:

Students who graduated under EnergyNET and EnPe (mainly PhDs) has been documented. It has been a challenge to trace some of the MSc graduates under EnPe. This will be continued into 2026

Plans for 2026:

The plan is to continue to trace former students and document in the form of the NORHED template.

MSc. in Renewable Energy at UEM

UEM is implementing two Master Programmes: one on renewable energy science and technology (MCTER), established under EnPe II, and another one, on management of renewable energy systems (MGSER), established under a project supported by the Dutch Government (NICHE – Netherlands Initiative of Cooperation in Higher Education).
ENET project supported both master programmes.
The master programmes are operational. A curriculum review can consider the introduction of new digital teaching methods, research-based content update and better relevance to the private sector.

Curriculum review at UEM

Activities in 2024

The master programs at UEM are quite new, and the activities in the master programs have mainly been to support the momentum of the programs with a good number of scholarships and fee support for students. The experiences from the UNET project has also been useful for the master programs, as some course material can be relevant for master courses.

Activities in 2025

The curriculum review process is ongoing, but relayed and is expected to be finished in 2026, since the cohorts of enrolled students are delayed in the process of presenting their dissertations.
UEM plans a one day workshop for finalizing the Curriculum revision process of the MSc programme on Renewable Energy Science and Technology.

Tracer Study at UEM

Both the master's programmes were long awaited and well received by people working in government departments, public electricity utility, private sector companies and technical schools, so these are *a priori* employed and evaluate the courses positively.
A second group of students are young graduates from universities, who are expected to start their professional life and tracer studies shall be conducted hereof.

Plans for 2026

We expect to conduct the tracer studies during the curriculum evaluation and revision in 2026. Student tracing is also part of the final ENET reporting.

MSc. in Renewable Energy at MU

Curriculum review at UEM

Status of the program

The Thermal and Energy Systems includes a MSc Program in Thermo-Fluid Engineering with funding from the Ministry of Education and one PhD program in Energy sponsored by NORAD and Center of Renewable Energy in Solar and Wind (RE-WISE) project supported by KFW.
The Energy Technology (Mechanical Engineering) master program was launched as part of the EnPE II project in 2010. Since the start the program has been accepting students from university, industry and energy sectors until November 2020. But after the breakout of the war in Tigray (November 2020), the master's program was suspended until November 2022. The program resumed in 2023 and the chair has since then been working to support the students who were interrupted due to the war to complete their studies.

Activities in 2024

The MSc program has since 2023 gradually returned to normal operation, although some challenges remain on the allocation of resources. The chair has succeeded in engaging several partners for support to the educational programs, the MSc in SEE has in particular received support from several partners. UKAiD has sponsored with funds from Carbon Trust through the coordination of University of Cape Town through the project of Transforming Energy Access -Learning Partnership (TEA-LP) focusing on curriculum review and course updating. The partners have now engaging with Program and support the establishment of dedicated website for the program (www.tes.mu.edu.et)

Tracer Study at MU

It would be possible to do a limited tracer study like a list of EnPe graduates and their current employment status. A tracer study could give recommendations for the future of the program and descriptions of the practical benefit they obtained from the program in the perspectives of the real world. The tracer study will become part of the final ENET report, following the NORHED template.

Activities in 2025

The existing Curriculum was planned to be revised (either PhD in Energy or MSc in Thermo-fluid) during 2025, depending on the resources. Due to restrictions imposed by the Ministry of Education on curriculum revisions, we could not implement temporary changes at the time. Now that the restriction has been lifted, the most critical area will be revisited in 2026 either for the PhD or MSc curriculum in Energy.

Plan for 2025

To conduct the curriculum revision of the MSc In sustainable Energy Engineering (SEE) with limited tracing profiles of graduates of the previous EnPe graduates as input for the curriculum revision.

Multidisciplinary PhD program (UEM)

Background

A research-based PhD programme in Energy Science and Technology has been running at UEM since 2011. It is interdisciplinary in its nature, meaning that students can come from whatever the field of competence, i. e. engineering, natural sciences, social sciences, and economics, among others. The PhD study duration is scheduled to four academic years, meaning 240 credit points. This programme has graduated 6 (six) PhD in technological areas, 1 (one) is waiting for the defense of his thesis and 14 (fourteen) are at different stages of their research work leading to their thesis. For the first time a social sciences student has been enrolled in this PhD programme.
This type of PhD program is very convenient in situations where there are candidates from different fields of competence. Nevertheless, where situations justify the other type of PhD studies, combining taught courses and research activities, can be implemented. Such a taught based programme will be established as part of EnergyNET activities.

The activities in 2021 towards a new PhD program were preparational, including work during two EnergyNET workshops. The program will benefit from courses being developed in the Erasmus+ project "University Network on PhD program in Energy Technology, UNET". The UEM PhD programme will be designed making partly use of the course matrix from UNET.

A course catalogue for the technological PhD programme has been developed by the partner universities, as part of the UNET project, and approved in 2022. One student from social/economic/environmental sciences has been enrolled. The PhD program activities at UEM have in 2023 mainly concerned operation of the existing research based program. A local cooperation with the Center of Studies in Oil and Gas at the University, provided scholarship to seven students working on energy related issues.
Curriculum revision of this PhD programme to become a taught based program has been initiated.

Activities in 2024

The UNET project period was extended to include the year 2024. UEM hosted visiting PhD researchers for evaluation of new PhD courses at UEM, and UEM staff and students likewise visited MAK, UDSM and AAU for course evaluations and for assessment of the training facilities for PhD researchers. This UNET activity gave a good base for the improvement and extension of the PhD programs at UEM.

Plans for 2025:

The plans towards revision accreditation of the PhD programs includes

- One day workshop for finalizing the curriculum revision of the ongoing research-based PhD programme
- One day workshop on the development of the new taught PhD programme

The revision of the existing research based multi-disciplinary PhD programme will be ended and submitted to the university authorities and then accredited by the National High Education Regulator at the same period.

UEM UPDATE PLEASE

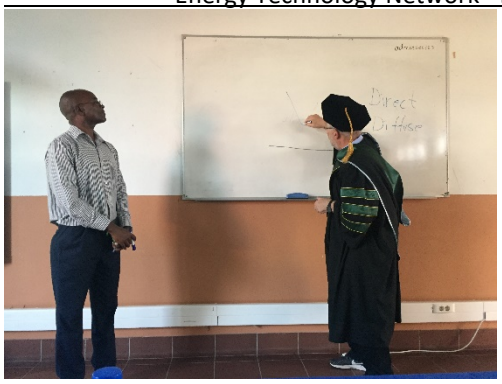


Photo: Amos Veremaci was the first graduate from the PhD programme at UEM (EnPe Capacity5 project). Opponent at the PhD defense was Bjørn Karlson (2019)

Short training courses

Background

The partner universities experience needs for specialized short training courses on a range of thematic areas and target groups. Research students (PhD/MSc) starting on laboratory work need introduction to experimental methods and procedures. Introduction to programming systems can be useful for both theoretical and experimental students. Knowledge of specialized simulation software is typically required in different branches of science and technology. New academic staff needs training for supervision of MSc/PhD students.

Such short-term courses are not part of the regular curriculum, and the intention is that such short courses can be developed and shared in such a way that they are sustained also in the future.

MUBAS and UoJ will benefit from knowledge transfer on short courses for postgraduate students.

Administration systems for PhD programs

PhD studies at universities require administrative systems for the PhD programs, including the regulation frameworks for recruitment, financing, laboratory management, IP rights, supervision, thesis evaluation and defence.

During a Workshop at NTNU in May 2022, the following short courses were given:

- **PhD administration systems and regulations (**Runa Nilssen, 10 May 2022)
  The PhD management systems and regulations at the Faculty of Engineering was introduced to ENET partners. The introduction covered all aspects from initiation to thesis defence, both on the academic and the administrative side. A "PhD Handbook – Quality in PhD Education" includes the relevant information and is available for all partners.
- **Laboratory administration systems** (Morten Grønli, 10 May 2022)
  PhDs often make use of laboratories in experimentally oriented research tasks. The Department of Energy and Process Engineering maintains extensive and advanced laboratory facilities, which are used for both PhD research tasks as well as for external contract research (e.g. SINTEF and others). The laboratory has about 100 projects every year. This requires efficient management systems, including resource management (staff and material), procurement systems and financial management systems. The management systems were presented for the partners. Microsoft TEAMS has recently been introduced as an efficient communication tool between laboratory staff and the users.
- **Purchase Systems** (Marianne Trælnes 10 May 2022)
  Operation of efficient procurement systems is a challenge for many universities. An introduction on how this is made at NTNU was given by the procurement officer at Department of Energy and Process Engineering. Tender procedures are invoked for purchases above NOK 100.000. NTNU has framework agreements with suppliers for a range of products. Purchases are handled centrally at the department, based on forms submitted by the user, where each purchase needs a project number.
- **PhD supervision training courses** (Kristin Skjeldestad, 10 May 2022)
  An introduction to how training for PhD supervisors is made at NTNU was given during a Workshop with all partners in May 2022. NTNU has three levels of support for supervisors: 1) the Uniped pedagogical program has one module on professional guidance, 2) a Central NTNU PhD supervision seminar is given two times each year and 3) seminars/courses are also provided at Faculty levels.
  The NTNU central PhD supervision seminar was presented. It is a 2-3 day event which covers a range of aspects of PhD supervision and includes group work among the participants.

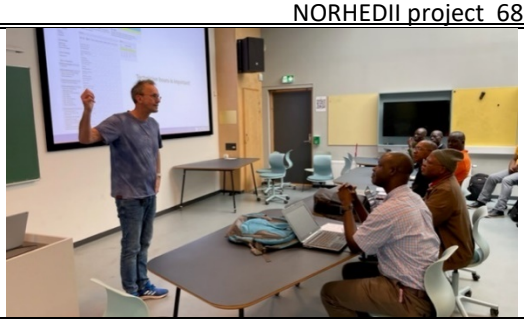
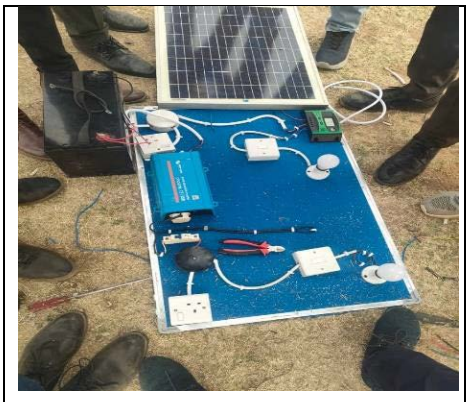
	
PhD supervision training schemes (Kristin Skjeldestad, 2022)	Laboratory management systems (Morten Grønli, 2022)

Photo Voltaics (MAK)

Makerere has established a training program for PV systems, where attendants physically put together a small system to demonstrate PV charging of a battery which provides power for lights and mobile phone chargers. The event has been organized on a yearly basis.

In 2023 the participants have complained that the attendance was primarily for females, so some openings have been made for males as well. MAK developed a PV training manual in 2023 and the manual was uploaded on TEAMS. Other partner institutions can use the manual as a basis for their own training programmes.

A positive side-effect of the training scheme at MAK was that MAK supported a similar event at UoJ (see report in Attachment). This was very successful and due to the initiatives and dedication from the ENET staff at UoJ (Konjo Francis and Tito Achire). The ENET project at UoJ has strong attention from the institution in Juba.

		
PV training event at UoJ, with support from MAK in 2023		

Activities in 2024

Makerere has been offering PV training programme to female students and the industry on annual basis for more than 8 years. The programme has been successful but in 2024, no solar PV training for female students was conducted at MAK. This was mainly due to the need to use external consultants instead of our staff. Contracting external consultants is beyond our budget, and again our team has better expertise in this field.

Activities in 2025

No PV training programme was planned for 2025.

MAK developed a PV training manual in 2023. This manual is now being used as part of course material – for teaching solar energy courses at both bachelor and MSc levels.

Equipment purchased during the project and UNET Project are being used by students and staff for both teaching and solar energy research.

Plans for 2026

In 2026, the PV training manual will continue to form part of the teaching materials for solar energy. In addition, the use of equipment for both research and teaching will continue.

Experimental Methods (MAK/UDSM)

Preparational work was made in 2022 with NTNU and MAK developing a stand-alone data logger based on Arduino. The Arduino can be powered by a small PV panel charging a small battery in the Arduino system. Data is logged to a memory card. The autonomous system can be useful for logging the performance of pilot systems in off-grid field locations.

A session at the UNET/ENET Workshop organized by AUU in September 2023 introduced the autonomous Arduino based data loggers, as prototyped at NTNU and MAK. Jimmy Chaciga (MAK) presented the temperature data logger which is powered by PV and stores data on a memory card. The system components were described together with the building procedures and the data logging program.

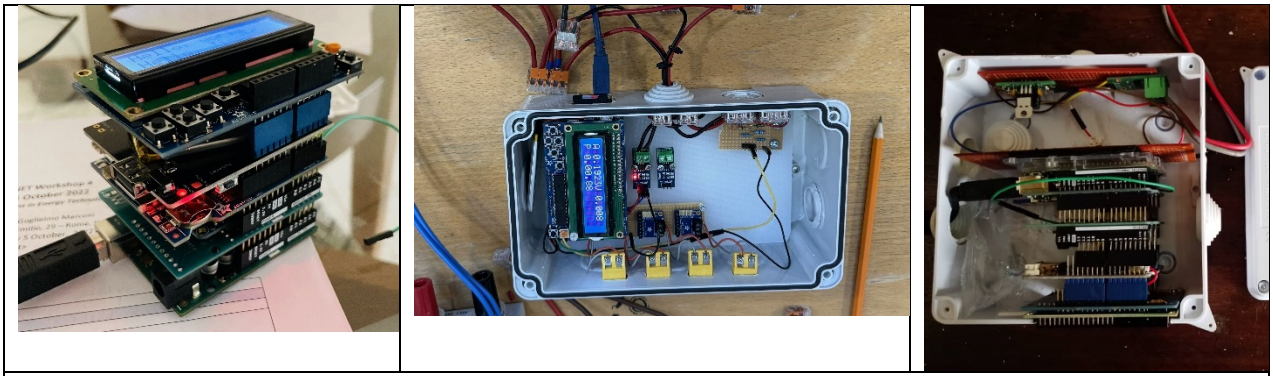
Activities in 2024

The Arduino based activity was extended during the UNET/ENET workshop at NTNU in May 2024. 5 PhDs were present at NTNU during the Workshop, as it coincides with their ENET mobility period to NTNU. Training on the Arduino based data logger was an important part of their laboratory work during the 3 months stay at NTNU. Data loggers were assembled for temperature and power measurements, and the visitors brought the Arduino loggers with them on return to their home universities.

A visiting master student from University of Namibia likewise participated in the assembly of Arduino data logger. The master thesis gives a detailed description of the components, the assembly procedures and the software for the system and can as such be used as a document for training purposes.

The PhD Mobility periods in the UNET project also included practical training on experimental methods at UDSM. A similar Arduino based is used for AC power measurement of a Pump as Hydroturbine.

The Arduino system has also been extended for application to load switching for control of Photovoltaic power directly to a string of heating elements. The system was tested at MAK during a visit of OJ Nydal in late 2024.



Training on Arduino based data loggers 2024

Activities in 2025:

OJ and Jimmy built and an Arduino based load controller for a PV system. It is used to measure and record current, voltage and power, and temperature. A second Arduino based data logger was built to be used in the field during piloting. These Aurdino based loggers are cheaper than the commercial ones. Again they can be used without the need for computers; this very important especially for when deployed in the

field.
In 2025, MSc student John Kivumbi who is working on PTC based iron block hot plate for frying chapatti developed an Arduino based data logger for current, power and temperature measurement. Experiments are ongoing.
Another MSc student, Noah, used an Arduino based data loggers for data measurement and recording for a wind turbine.

Plans for 2026:
At MAK, more effort will be put on the use of Arduino based data loggers as an alternative to expensive commercial data loggers. Training will be conducted for both students and staff who are interested to participate in building Arduino data loggers.

At NTNU, the Arduino based data loggers will be further extended during PhD visits from AAU and UEM to include measurements of power for AC systems. A separate unit for logging of solar radiation is also planned to be made. Autonomous data loggers for solar radiation can in particular be useful during the testing of PV based heat storage solutions.

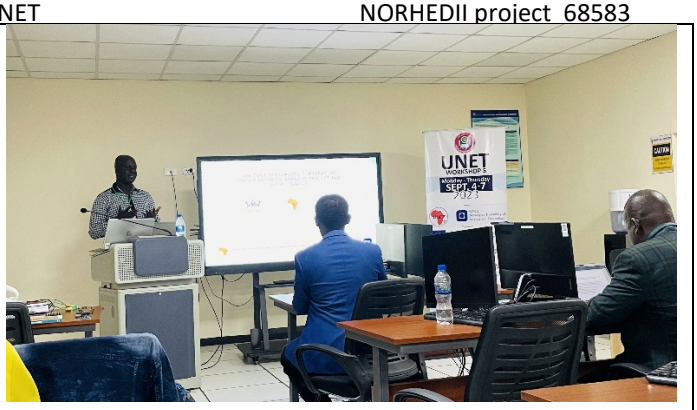
ANSYS short CFD course (AAU) and Computational Methods (MAK/UDSM)

MAK acquired COMSOL licence under UNET Project in 2022 and AAU acquired ANSYS license. ENET PhD and MSc students are already learning and using the software.
The two simulation programs have similarities and overlapping aeras of application. The two training activities are therefore merged and largely based on demonstration cases where ENET PhDs are making use of the simulators. The knowledge and experiences with the software have been shared on practical and relevant cases, including examples of case preparations based on the PhDs work.

In 2023, ANSYS Fluent and COMSOL were presented at AAU as part of a UNET Workshop. The presentations were based on demonstration cases by considering on-going research activities on single tank storage system and energy storage for Injera Frying. The case of a single tank oil/rock bed flow system was presented by Karidewa Nyeinga (MAK) on behalf of Tito Achire (PhD from UoJ at MAK) who is using COMSOL as a tool for the flow analysis of the heat storage. COMSOL is likewise used at AAU for heat conduction analysis of injera fryers under development.

Activities in 2024
The training session during the 2023 Workshop at AAU has led to extended training activities in 2024. Two Phds working with COMSOL had in particular useful interactions in 2024, concerning simulations of heat storage systems (Gashaw at AAU and Tito at MAK). Master students have also been engaged at MAK, on heat storage simulations with training from the PhD at MAK. The PhD student has documented steps on how to use COMSOL.

The synergies with the UNET project is also noteworthy for the training on simulation in 2024. AAU hosted PhDs from ENET, who could benefit from both new workstations at AAU and from access to ANSYS licenses. A training on COMSOL MULTIPHYSICS was offered during the UNET mobility period. The ENET PhD researcher at AAU has particular experience with application of the COMSOL system.

	
Training on PhD mentorship at AAU in 2023, during UNET Workshop: Best practices and sharing of experiences among the partners. Prof. Tesfaye from AAU offering training on PhD Mentorship	Training on Experimental methods at AAU in 2023, during UNET Workshop: Introduction to Arduino based data logging. Jimmy Chaciga presented a case for building a temperature data logger with Arduino.
	
UNET and ENET PhD students during training on Software at AAiT in 2024.	Practical training on Arduino based PV controllers, NTNU 2025

Activities in 2025

The delivery of Energy Modeling software training for TES academic staff as part of strengthening academic capacity building for 10-15 academic staff of the Department of Thermal and Energy Systems departments at MU was not done in 2025, due to computer lab not being ready.

MSc student Justine Mugalaat MAK used Comsol for simulating a single tank heat storage system, powered by solar PV. PhD student Tito Achire is using Comsol software for simulation of thermal energy storage system with multiplle cooking units. Work on Comsol simulation of pot-in-pot system have been part of one paper published in an international journal by the MAK team.

The training events are then completed, and the further use of the software during the ENET period will be made with training support from the PhDs who have gained sufficient experiences and are using the programs. In 2025, two more students at MAK are expected to use the software to simulate and analyse solar thermal energy systems.

-The AAU team participated in a short-term training program on the use of Artificial Intelligence (AI) for scientists and engineers, organized as part of the collaboration between AAU and the University of Michigan, USA. In addition, the team members completed a micro-certificate course on Generative AI for

Education. The knowledge and experience gained from this training will be utilized in the development of educational materials and laboratory manuals, with the aim of enhancing the course offerings for ENET Master's students.

Plans for 2026

Conduct Energy Modelling training for academic and PG students at MU with the support of ENET project

In 2026, MAK will encourage more students to use the software for their research work in addition to experimental work. They will be trained on the use of Comsol by the PhD student – Tito.

In 2026, Addis Ababa University (AAU) will organize additional training for M.Sc. students on Arduino-based data logging systems, including Python programming. Furthermore, AAU will conduct training on Generative AI aimed at supporting educational material and laboratory manual development for staff and ENET students.

Scientific writing (AAU/UDSM)

There is a need for some training in scientific writing in our type of project, where the core of the project is a group of PhD candidates. A PhD degree includes publications and preparation of PhD dissertations, and basic guidelines and introductions to good practices can then be useful.

Activities in 2024

A dedicated training event on scientific writing was not conducted in 2024. However, the case of proposal writing was considered through a practical session during the UNET/ENET Workshop in December 2024. The partners engaged in the preparation of a proposal in response to a call from the Erasmus+ program.

Plans for 2026

Members of the UEM and UP academic staff will participate in a pedagogical and scientific writing training courses. The course are offered by the UEM staff development unit and can be disseminated to the other partners.

PV systems and energy efficiencies (UEM)

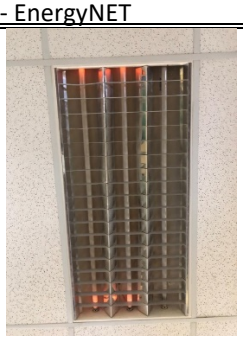
Preparations for several training courses were made in 2022. The plan was that UEM should offer short courses with the following content:

- Photovoltaic systems for productive uses of energy in rural areas (water provision, irrigation, cereal milling, among others).
- Photovoltaic systems for social uses of energy (rural institutions electrification and homes electrification).
- Energy efficiency for lighting and domestic appliances.

The following short training courses were designed and implemented in 2023:

- Energy Efficiency in Laboratories and Lecture rooms; and,
- Energy Efficiency in Buildings,

All of them in the perspective of energy auditing.

		
Short Course on Energy Efficiency in Buildings. Training a group of students at UEM	Energy Audit Implementation at UEM campus	

Activities in 2024

UEM conduced:

- Energy audit activities at the main campus of Eduardo Mondlane University involving MSc students
- Load profile development in the buildings of the main campus with the purpose of installing PV systems
- Training of a student at a MSc level on PV planning in buildings of the UEM main campus
- AAU conducted PV training events at campus.

	
PV training event at AAU, in Collaboration with Green Scene Energy PLC in 2024	
	
An Expert from SNV Ethiopia offered a training on	

avaialble finacing schemes and options for renewable energy, 2024.	

Plans for 2025

.Following activities are planned at UEM:

- A training event on design, installation and management of off-grid renewable energy systems will be offered for public at large, aiming to improve their skills and/or become entrepreneurs.
- Development of energy efficiency measures for the buildings at the UEM main campus. These measures are expected to raise awareness in other public or private institutions throughout the country.
- Design of PV systems to respond to the load profile development undertaken

UEM UPDATE

2 - Systems

Outreach and Technology Transfer

Background

The aim of ENET is to contribute to exploitation of the results from the development work on small scale energy technology. PhD researchers and MSC students have in particular worked towards concepts and solutions for heat storage for cooking and for off-grid refrigeration systems.

The partner universities have offices and structures in place to assist in deployment of research results, to promote innovation and entrepreneurship. However, implementation is a rather challenging task, which is also limited by lack of funding mechanisms. EnergyNET will share experiences in this area, starting with introduction to the experiences from the Technology Transfer Office at NTNU.

This section concerns the system options and support structures at the universities for outreach and technology transfer. The actual cases for implementation are presented in the section on Outreach.

	
MAK researchers visit a kitchen in a refugee camp (2021)	AAU team visiting Bahirdar University Kitchen (2022)
Add more pictures from 2023, 2024	

A TTO seminar with knowledge sharing by relevant officers from the partner institutions was planned for 2021 but deferred to 2022 as the pandemics prohibited group gatherings and travels to NTNU in 2021.

The TTO office at NTNU was presented to the partners, when they met for a Workshop at NTNU in May 2022. Results from the work of academic staff at NTNU needs to be assessed by the TTO office, before external exploitation can be considered. The TTO office can support possible commercialization of results or sign off any commercial interest from NTNU giving the inventor freedom for further use of the results.

A team of AAU researchers visited Bahir Dar university kitchen where about 5000 injera is baked per day with wood fuel. The visit was part of data collection for institutional baking and selection of potential implementation sites for project results.

 TTO Seminar at NTNU, May 2022		Joseph Kihedu presenting a case for implementation from UDSM - adsoption based refrigeration system.

Taking the results from the laboratory to the user

The general question on how to bring the laboratory results to the user has been up for discussion in ENET.

Several external presenters were invited to give their opinions on the case, during a Workshop in 2022 at NTNU. The following options were considered:

Table 3 Presenters on the topic on technology development and implementation. Workshop 2022.

Topic	Institution	Name
Introduction	NTNU, EPT	Ole Jorgen Nydal
Design driven	NTNU, Design	Manisha Rayaprolu
Research driven: Social Science	NTNU, Multicultural	Govert Valkenburg
Research driven: Natural Science (on-line)	NWU, South Africa	Ashmore Mawire
Individual driven (on-line)	Simply-Solar, Germany (Scheffler)	Heike Hoedt
University driven: NTNU	NTNU, Innovation	Per Arne Wilson
Industry driven (Monday 8 May)	NABA and NTNU	Karl Klingsheim, Kjersti Blauenfeldt, Mathilde Emilie Thue
Public funding driven (on-line)	Innovation Norway	Therese Marie Uppstrom Pankratov
Development collaboration driven (on-line)	NORAD	Anette Løken
Public funding driven (on-line)	NTNU, EU	Patrick Reurink
Humanitarian Engineering driven	EWB	Heidi Hovland Bergfald
Civil Society driven (on-line)	CARE	Morten F. Thomsen
Environment and conservation driven	NTNU, Conservation	Eivin Røskaft

The participants in the Workshop could also give their opinion through a mini-survey during the Workshop, see the Workshop report for 2022 in the Appendix.

Some mid-term reflections on the topic on technology implementation were shared during the ENET annual meeting for 2023, hosted by UEM in early 2024. The general view was that implementation will depend on the commercial viability of the products. The question is then on whether commercially based implementation is to be pursued within the universities or outside, or in a combination. Some views could be noted:

- UDSM
  UDSM has had successful experiences with a line of action form the university side. Collaboration with Technology Development and Transfer Centre (TDTC) on development and implementation and securing IPR with the UDSM Intellectual Property Management Office (IPMO).
  A similar scheme can be applied for ENET results.
- AAU
  There is a strong governmental push for universities on implementation of results, on engagement with the society and on income generating activities for the universities. AAU also has a demonstration site outside Addis Ababa (Butajira).

Banks in Ethiopia are forced to engage in Corporate Social Responsibility schemes which also includes results-based financing of commercialization initiatives. For the ENET case, tested pilots are first needed and these can be tested in dedicated pilot sites.
The AAU team discussed the options of technology transfer and outreach activities with the chair members and a preliminary plan is agreed to involve the technology transfer office in the deployment of research outputs from the chair members within the thematic areas of renewable energy technology.

- UEM
  A possible scheme suggested by UEM is to engage with the Industrial institute of Maputo on the production of pilot units. The implementation could be made with the assistance of an NGO to lead the project, and a company to do the work. NGOs can attract funding and the actual work can be made by professionals on a commercial basis. The universities are not well designed to engage in such activities.
- MAK
  Makerere university is prioritizing research and innovation, and the heat storage technology at the Physcis Department has also caught the attention of the TTO office. As the concept and systems have already been available in the public domain, patenting is not viable, and the current question is rather how the system can forwarded out of from the university. Teaming up with NGOs and companies (existing or startups) can be considered. Ideally, after the field implementation; MAK share results with key stakeholders and this is expected to lead to the development concrete plans for either commercialization of securing funds for mass production and deployment of the system.
- NTNU
  Results which may have commercial potentials from academic staff at NTNU is required to be screened by the TTO office at NTNU. TTO can then choose to take the case further or decline any commercial rights to the results. The prerequisite is often that the results have not been published in any form. Results which have been published cannot be patented. Most of the heat storage concepts from the NTNU laboratory have been cleared and further use is not limited by TTO at NTNU.

The cases for implementation of ENET results are further considered in the section on Outreach below.

The further involvement of the TTO offices (or corresponding offices) at the partner universities will be for each partner to initiate, depending on the status of technology implementation at each site.

- AAU
  The AAU team will identify a possible technology demonstration site in consultation with TTO of AAU. The aim is to focus on one target group (society/village) to study and investigate the impact of renewable technologies which are the outputs of the research activity in the chair, and to closely monitor the results with objective of obtaining measurable KPI's.
  The university has a dedicated technology park planned for 2025. With the support of the Technology Transfer Office the plan is to display some of the research results at the technology park.
- UDSM
  The UDSM Team continues to work hand in hand with the TDTC and IPMO on various aspects of the EnergyNET research works.
- MAK
  As the prototypes have been published, patent based further engagement with TTO at MAK will not be pursued.
- UEM
  UEM has the option of collaboration with the UEM incubator center for startup initiatives and

technology transfer

Shared Network Resources

Background

EnergyNET and UNET (University Network on PhD program in Energy Technology, Erasmus+ project) is based on a core group of universities which have collaborated through a series of joint projects for very many years. The collaboration has covered both development of educational programs as well as coordinated PhD based research activities. Educational programs were initially master programs in Renewable Energy and later PhD programs as well.

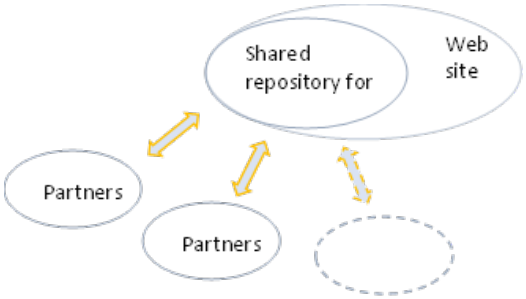
The partners see the need to share results in an efficient way, also for the post-project period.

Common data storage for results

The UNET Erasmus+ project was finalized in early 2025 and an MoU was signed by the partners on the future access to the results. The main results for sharing in the UNET project were the jointly developed PhD courses; course descriptions and material. The MoU also stated the intentions to provide laboratory access for researchers also in the future.

Microsoft TEAMS was used for communication in UNET, as in ENET, and the UNET results will continue to be available through the shared folders in the TEAMS channels.

A similar solution can be useful for ENET, where the results from one partner can be of interest to copy at another partner. Data logging solutions is a particular example of common interests. The current ENET web site describes the project and provides some details on the technology development. This can draw the attention of researchers in other African universities who are active on development and testing of small scale renewable energy technology.



Further activities

An MoU between the partners can be considered for ENET similarly as for UNET, and include the intention to store results in shared repositories also for the future. The partners will return to this issue towards the end of the ENET project period.

3 - People

Background

The core work force in EnergyNET is a group of PhD candidates and associated master students. The intention is also that EnergyNET shall provide opportunities for mobility and exchange between the participants.

		
Hailay Kiros Kelele 2024, NTNU	Jimmy Chaciga and Tusiime Swaleh, 2025, MAK	Ibrahim Mwasubila and Emanual Nyirenda (With Prof. Kimambo) UDSM
		
Casiana Lwiwa, 2025, NTNU		

PhD researchers

Table 4 Overview of PhD/PostDoc/Researchers

Partner	**Title**	**Name**	**Supervisors**	**Time**	**ENET Funding**
UDSM	*Optimisation of Adsorption Refrigeration System Utilizing Various Heat Sources*	Joseph Ibrahim	Cuthbert Kimambo, and Joseph Kihedu (UDSM), Trygve Eikevik and Ole Jorgen Nydal (NTNU)	February 2022 **Completed 2025**	Scholarship Laboratory support (Tuition fee waived by UDSM)
UDSM	*Performance Optimisation of Oil-Based Sensible Thermal Storage System for Cooking Application*	Anna Kisioki Sharishoy	Cuthbert Kimambo, Joseph Kihedu (UDSM) and Ole Jorgen Nydal (NTNU)	November 2022 Ongoing	Laboratory support Mobility (NORPART and UNET)
MAK	*Development and field testing of a solar cooker with a heat storage system*	Jimmy Chaciga	Karidewa Nyeinga and Denis Okello (MAK) and Ole Jorgen Nydal (NTNU)	April 2021 **Completed 2025**	Scholarship Tuition fee Laboratory support
MU	*Heat storage for baking (post doc)*	Mulu Bayray	Ole Jorgen Nydal (NTNU)	2023	Scholarship Laboratory support

MU	*Heating systems for solar heat storages*	Tsige Gebregergs Tesfay	Mulu Bayray (NTNU), Ole J. Nydal (NTNU)	Ongoing	Scholarship Tuition fee Laboratory support
AAU	*Design, Manufacture and Performance Test of Small Scale Milk Refrigeration and Pasteurization Unit*	Fikadu Geremu Bodena	Demiss Alemu (AAiT,AAU), Trygve Eikevik and Ole Jorgen Nydal (NTNU)	September 2021 Ongoing	Scholarship Tuition fee Laboratory support
AAU	*Design, Development and Experimental Investigation of an Institutional Solar Fryer*	Gashaw Getnet Birhanu	Abdulkadir Aman (AAiT,AAU), Demis Alemu and Ole Jorgen Nydal (NTNU)	September 2021 Ongoing	Scholarship Tuition fee Laboratory support
UEM	*Reconstructing life and energy after disaster*	Cândida Bila	Govert Valkenburg (NTNU), Inês Raimundo (UEM)	November 2022 Ongoing	Scholarship Tuition fee Laboratory support
UEM	*Experimental investigation of an oil based solar collector for cooking applications*	Tomas Nhabetse	Boaventura Cuamba, António Leão and Amós Veremachi (UEM), OJ Nydal (NTNU)	From EnPe Ongoing	Scholarship Tuition fee Laboratory support
UEM	*Development an Applications of Thermal Energy Storage from electric systems*	Paulino Rodrigues Muebe	Boaventura Cuamba, Amós Veremachi (UEM), OJ Nydal (NTNU)	September 2024 Ongoing	Scholarship Tuition fee Laboratory support
UoJ / MAK	*Modeling and simulation of heat storage systems for cooking with multiple cookers*	Tito Achire	Denis Okello and Karidewa Nyeinga, (MAK), Ole Jorgen Nydal (NTNU)	October 2022 Ongoing	Scholarship Tuition fee Laboratory support
MUBAS / UDSM	*PerformanceOptimization of PAT-SEIG Operating in an Off-grid Energy Generation Setup*	Emmanuel Jack Nyirenda	Cuthbert Kimambo and Joseph Kihedu (UDSM), Torbjorn Nielsen (NTNU)	Dec 2021 **Completed 2025**	Scholarship Tuition fee Laboratory support
NTNU	*CPC for solar cooking*	Casiana Lwiwa	Ole Jorgen Nydal (NTNU), Cuthbert Kimambo (UDSM)	2019 **Completed 2025**	Laboratory support
MU/NTNU	*Direct and indirect solar fryers*	Mesele Hayelum	Ole Jorgen Nydal (NTNU) Mulu Bayray (NTNU)	From EnPe Ongoing	Support for completion
MU/NTNU	*Aerodynamic and Structural Analysis of Wind Turbine Blade: Mitigation Extreme Wind Loads and Applying Single-Blade Design Concept for Structural Integrity Enhanced Performance and Cost Efficiency*	Hailay Kiros Kelele	Torbjørn Nielsen (NTNU) Mulu Bayray (NTNU)	From EnPe **Completed Dec 2024**	Support for completion
NTNU	*PCM and heat pipe for frying on heat storage*	Abraham Parra	Ole Jorgen Nydal (NTNU)	From NTNU Ongoing	Laboratory support

Recruitment of PhD candidates started early after project kick-off, and some candidates were already registered. The status of the group is given in Table 4 and summaries of each PhD are given in the Appendix. The degree of ENET funding is also noted.

The PhDs work typically in the domains of heat generation and heat storage (MAK, UEM, AAU, MU, UoJ), refrigeration technology (AAU, UDSM), Hydro power (UDSM, MUBAS) and the Social Side (UEM). There is therefore common ground among several PhDs and on-line progress meetings with in-depth presentations are then useful for the group as a whole.

The PhD group includes PhDs at NTNU who have other financing (Abraham Parra is self-financed and Casiana Lwiwa is supported through NTNU Energy) but are managed as part of the ENET group. Two candidates from MU have been transferred from the EnPe "Capacity 5" project, for completion during the ENET period. UDSM also initiated a new PhD on solar thermal in 2023, where ENET supports the research costs.

Three PhDs completed their work in the EnPE program, but graduated during the ENET project period:

- Pamella Kajumba (F) at MAK, 2022. PhD title: *Development and assessment of a cooking unit integrated with a solar thermal energy storage system*.
  Pamella was funded by the EnPe Project, she continued in ENET with graduation. She is a lecturer at Kabala University.
- Michael John (M) at UDSM, May 2022. PhD title: *Development of Adsorption Refrigeration System for Off Grid Application.*
  Michael works as a lecture at UDSM, Department of Mechanical and Industrial Engineering.
- TUSIME Swaleh (M) at MAK, a former EnPe PhD student; completed in 2025. He is a lecturer at Makerere university. PhD title: *Developing experimental control methods and simulation models for solar cookers with heat storage*.

The PhD group progresses well, and several have participated with presentations at conferences since 2022. On-line technical meetings on TEAMS are useful and we have had synergies with the UNET and NORPART project, where we could meet physically more frequent than in ENET alone.
The initial list of PhDs included two candidates at MU. As MU became isolated during the period of armed conflict in Ethiopia, this was modified to become one PostDoc (partial) and one PhD. The PhD (Tsige) had already registered early on in the Norhed II period. Mulu Bayray had the opportunity to stay at NTNU under ENET support, and could perform work tasks with relevance for the ENET scope of work at MU while at NTNU. MU started to become operational again in 2023.

At UEM, a new PhD candidate was enrolled in March 2024 as the selected follow up student of Tomas Nhabetse's project. However, the candidate discontinued later in 2024, giving room for a new recruitment at UEM. ENET was granted a no-cost extension, with also some extended funding, giving sufficient time for a new PhD to complete within the ENET project period.

Coordinated visits of groups of PhDs to NTNU have been fruitful, in particular when timed to coincide with UNET/ENET workshops (2022, 2024).

Several PhDs have graduated by 2025, and many are planned for completion in 2026.

Graduations in 2025
Jimmy Chaciga completed at MAK and he will continue further on supporting the implementation tests on an institutional solar cooker.
At UDSM two candidates submitted PhD thesis for examination, passed the examination and successfully defended their thesis. Ibrahim Mwasubila is a staff member at UDSM and Emanual Nyirenda is a staff member at MUBAS, both graduated in December 2025.

Plans for 2026
Most of the remaining PhDs are planned for graduation in 2026. 2 visits from MU to NTNU are planned for 2026, both will work on the completion of the dissertations.
PhDs at both UDSM and MAK who have graduated will continue to be active in ENET in 2026 to be drivers

for implementation tests of their PhD results: institutional solar cookers and refrigeration technologies. The two PhD candidates from AAU, Gashaw and Fikadu, are expected to complete their studies by mid-2026.

Master students

Master students are initiated to support the research areas of the PhDs, and they are reported here as part of the group when their research costs and/or their tuition /scholarship costs are supported by EnergyNET. Table 6 indicates the type of support from EnergyNET, the Appendix gives more details on the research topics of the master students.

MAK

Makerere has involved 9 master students during the project period, with varying degree of support. The students focus on aspects of PV and wind based clean cooking solutions, which is the main research line for MAK in ENET. Some of the students show slow progress and the focus at MAK is now on completion of the existing student. 2 of the students in 2025 are self financed, ENET provides experimental support. students

UDSM

UDSM has initiated three master students of which two graduated in 2025. The female one (Neema Muhogolo) worked on ice storage for adsorption refrigeration system in coordination with the PhD student. Neema also had a period of stay at NTNU through the NORPART project. The second (male), Juma Msuya worked with PhD student to develop the cooker.The tuition fees and stipend are covered by UDSM Merit Scholarship programme while ENET supports research costs.

AAU

The Approach at AAU is to try to accommodate many applicants mainly female, by covering only the tuition fee for those who fulfil the requirements. Thus, we can enrol 11 students in the program. It also gives us opportunity to work on several research topics as part of their M.Sc. thesis work. Recruitment has been through notices publicized on different platforms including university notice board, social media and emails. A poster for call of application was prepared and shared on different platforms. Accordingly, 37 applications were received in the first round of applications. The list was reduced to 15 for further screening through interview and entrance examination. However, the university requirement to sit for Graduate Admission Test was the main limiting factor as many of the applicants were not able to come and attend the test. The instabilities in different parts of the country were restricting many applicants to come and attend the test and only six of them managed to sit in the first round.

Six M.Sc. students (5 male and 1 female) were enrolled in mid-2025, and their education and research are supported by ENET. The previously enrolled three M.Sc. students are currently working on their theses and are expected to complete their studies by mid-2026. At present, AAU has a total of 12 M.Sc. students, consisting of Nine males and Three females.

UEM

The implementation of both MSc programmes at UEM has continued. The taught component of the studies was successfully finished by all the cohort of students. About 40 students are in the process of finalizing their dissertations. Twenty of them are sponsored by ENET program and their situation is illustrated in the Appendix. The 20 students come from both MSc programmes (MCTER and MGSER). They started their studies in 2022, finished the taught component and submitted their research projects for their dissertations in 2023.

Call for applications for MSc support program at AAU

NTNU

NTNU participates with more than 20 master students, where ENET covers the laboratory expenses. The research tasks are defined to be in line with the ENET PhDs; heat storage, wind controllers and testing of refrigeration concepts.

The NORPART project also has provided welcoming opportunities for periods of exchange with UDSM.

A visiting master student from University of Namibia, under the SANORD program, was also interaacting with ENET and provided a good link to solar cooking researchers at UNAM.

2 students participated at NTNU in 2025, in coordination with PhD at UDSM on refrigeration. A a final student will be included in 2026.

Further plans

The partners will focus on supporting the already enrolled students to complete their master degrees.

Table: Master students with ENET support

Year Start	University	Male	Female	Tuition	Scholarship	Lab costs	Completion by 2025
2021	NTNU	3	1			4	4
2022	NTNU	1	2			3	3
	AAU	2	3		5	5	4
	UDSM		1	1			1
	MAK	5	3	5	4	5	4
	MAK/UoJ	4	3	6	5	7	1
	UEM	8	12	20	12		
2023	NTNU	5	1			6	6
	UDSM	1				1	1
	AAU	3		3		3	
2024	NTNU	3	4			6	6
	MAK	2				2	
	UoJ/MAK	1					
	UDSM	1		1	1	1	
	AAU	2	1	2	1	3	
2025	NTNU		2			2	2
	AAU	7	2	6	6	6	3
All	**83**	48	35	44	34	54	35

Mobility

Mobility between partner universities gives efficient resource sharing, enhances the collaboration by personal contacts, increases the awareness of the differences and the similarities between the cultures and the socioeconomic conditions in the partner countries, and promotes further joint initiatives. These are benefits for both staff and students.

Travels to partner universities or workshops/meetings is also optimized together with the following projects:

- Erasmus+ project: University Network on PhD Program in Energy Technology 2021-2024.
- NORPART project: UDSM-NTNU Mobility Program in Energy Technology 2019-2024.

Activities in 2021

Travels and exchanges were very limited in 2021 due to the pandemic regulations. Workshops were rescheduled and moved. Two workshops were nevertheless organized and hosted by UDSM in Tanzania. Even if not all project members can join, the physical meetings are very useful.

Activities in 2022

In 2022, Mulu Bayera from MU happened to be in Europe during the challenging political situation in Ethiopia. It was therefore possible for him to come for a stay at NTNU with partial support from the MU part of the ENET budget (Post Doc). Mulu engaged in activities at NTNU which were planned for MU.

Jimmy Chaciga from MAK spent one and half month at NTNU in 2022, working in the laboratory together with NTNU master students on the solar storage technology. Going back to MAK, Jimmy could copy the system from the NTNU laboratory and proceed with it at MAK. MAK also hosted 2 master students from

Upsala university, Sweden; they carried research within the project thematic areas. Thesis was supervised by Makerere and Uppsala.

OJ Nydal visited UDSM, MAK, AAU and UEM during his sabbatical period the last part of 2022.

Activities in 2023

UDSM Team continued to cooperate with members of partner Universities of various areas outside the EnergyNET project, under the auspices of the existing MOUs between the institutions. There have been three visits to UDSM by researchers and leaders from UEM in 2023, all hosted by EnergyNET Team.

The NORPART mobility project facilitated exchange of MSc students between UDSM and NTNU also in 2023. This is very inspirational for the students. In 2023. Two ENET PhDs from UDSM (Ibrahim Joseph and Anna Kisioki) also joined the NORPART project group from UDSM. Ibrahim returned in late 2023 and continued with experimental work on adsorption refrigeration, under the ENET mobility funding.

Hailay Kiros (MU) is registered as a NTNU PhD candidate (from EnPe project) and came to NTNU for a half year period to work on the finalization of his dissertation. Mulu Bayray could also continue at NTNU, and later transferred to a Post Doc position at Electrical Department at NTNU.

The second part of the sabbatical period of OJ Nydal took place during the last part of 2023, where he again could visit the partners in Ethiopia, Tanzania, Uganda and Mozambique.

Activities in 2024

A mobility period in the UNET project also came to the support of ENET PhDs. UEM, UDSM, AAU and MAK hosted a group of visitors in turn, where the objectives were to 1) provide evaluations of selected courses from the new Joint PhD Course Catalogue in UNET and 2) get experiences from the specialized training facilities at the host universities. The students attended lectures and participated in laboratory exercises as well.

A group of PhDs came for a period of stay (about 3 months) at NTNU in 2024 during the period April-June 2024.

- UDSM: Emmanuel Nyirenda (Hydropower) worked on his thesis on pumps as turbines.
- MAK: Jimmy Chaciga (Solar thermal) tested solutions for mini-cookers in the EPT laboratories.
- AAU: Fikadu Geremu (Solar heating and cooling) tested the use of waxes for heat storage in the laboratories at EPT. Gashaw Getenet (Solar frying) tested the use of PTC heating elements for frying. Several small PTC elements were attached to an aluminium frying pan.
- UEM: Candida Bila (Social science) participated in courses and worked on her thesis.
- MU: Tsige Gebregergs Tesfay (Hybrid Wind and Solar systems) tested the use of PTC elements for Solar Thermal applications. An Arduino based data logger for power.

Most of the visitors took part in developing Arduino based data loggers. This is very useful knowledge, as data loggers can be assembled based on low cost components, instead of relying on more costly commercial data logging systems. The group returned with data loggers and associated equipment to their home universities.

A master student from University of Namibia (UNAM) was also participating in the group, under a SANORD stipend. Cecilia Naule worked on Arduino logger for temperature and power, which she could bring back home to UNAM for her experiments on a solar heat storage unit.

PhD visitors to NTNU laboratories, 2024

PhD students from partner institutions attending practical exercises on solar PV system and heat storage at MAK

IV Curve tracing, 2024.

PhD visits to UEM, solar oil heating, 2024

PhD visits to UDSM, turbine test rig, 2024

PhD visits to AAU, PV to heating and cooling, 2024

Lecture session with visitors AAU, 2024

Activities in 2025

Most of PhD ENET mobility for laboratory experiments at NTNU took place in 2024. 4 students visited NTNU in 2025:

- UDSM One PhD candidate from UDSM (Ibrahim) visited for one month May. Ibrahim organized the transfer of equipment for refrigeration research from NTNU to UDSM.
- UEM: One PhD candidate (Paulino Muebe) visited for three months. Paulino was introduced to solar controllers and data loggers for PV to heat. Equipment was brought back to Mozambique for continued work at UEM.
- AAU: Two PhDs (Fikadu and Gashaw) from AAU visited for 3 months. Gashaw worked on heating elements and controllers for injera frying. Fikadu prepared worked on the dissertation and publications. Both plan for completion by June 2026.
- OJ visited all partners in 2025 as part of support for the PhD candidates and for project meetings.

Table 7: Overview of mobilities.

	Mobility	Months	Persons	Comments
2022	MAK-to-NTNU	1	1	
	MU-to-NTNU		1	Partial ENET support
	NTNU-to-all	Short visits	1	Facilitated by sabbatical period for OJ Nydal
2023	UDSM-to-NTNU	3	2	NORPART support
	UDSM-to-NTNU	3	1	Fully supported by ENET
	MU-to-NTNU	5-8	2	
	NTNU-to-all	Short visits	1	Facilitated by sabbatical period for OJ Nydal
2024	UDSM-to-NTNU	3	1	Part of group visit
	MU-to-NTNU	3	1	Part of group visit
	UEM-to-NTNU	3	1	Part of group visit
	AAU-to-NTNU	3	2	Part of group visit
	MAK-to-NTNU	3	1	Part of group visit
	AAU-to-UEM	2	1	UNET mobility, ENET research
	MAK-to-UEM	2	1	UNET mobility, ENET research
	MU-to-UEM	2	1	UNET mobility, ENET research
	UDSM-to-MAK	2	4	UNET mobility, ENET research
	AAU-to-MAK	2	1	UNET mobility, ENET research
	MU-to-MAK	2	1	UNET mobility, ENET research
	UEM-to-AAU	2	3	UNET mobility, ENET research
	AAU -to-UDSM	2	4	UNET mobility, ENET research
	MU -to-UDSM	2	1	UNET mobility, ENET research
2025	UDSM-to-NTNU	1	1	Refrigeration research
	AAU-to-NTNU	3	2	Part of group visit
	UEM-to-NTNU	3	1	Part of group visit
	NTNU-to-all	-	1	Research visits

4 - Gender and Equity

Background

Inclusion of women will in particular be valuable for the research tasks in EnergyNET, as the implementation of the energy technology solution for reducing the use of fire wood will foremost benefit women. Female researchers taking part in the development and dissemination are therefore also expected to increase the impact of the results, in terms of awareness and acceptability among the users.

It is a challenge to recruit females to PhD positions among staff members, simply because the recruitment base is often very small. The female recruitment base for MSc studies is larger, as the applications are nationwide.

11 types of awareness and recruitment actions are planned, targeting females in particular. Some of these will be recurring events.

Activities 2021

As the general academic activities have been reduced across most universities in 2021, the actions targeting females have also been limited in 2021.

At Makerere, Solar PV training sessions were conducted for female students at the bachelor level. Due to Covid restrictions, trainings were carried out in a staggered manner: separate trainings held for each class, i.e. year 1, year 2, and year 3 students. The training covered: design and installation of solar PV system mainly for standalone system; and system maintenance. After the theory and demonstration in the class; the students were moved into practical sessions outside where the small groups were guided by technical staffs.

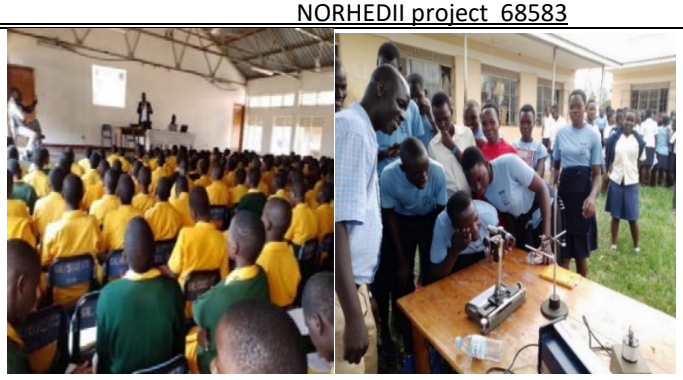
PV training event at MAK 2023 (participants and Karidewa Nyienga)
2022)

Makerere: Students attending PV practical sessions; and students during classroom sessions on PV system.

Activities 2022

- **PV training for female students (MAK)**
  Makerere carried out a five day PV training programme on 16-20 May 2022. The training programmes are designed to equip participants with competence and skills needed in the sizing, installation and maintenance of solar Photovoltaic systems and biogas plants. Technicians from the Industry participated as well. EnergyNET sponsored female students at both MSc and bachelor level to participate in the training. The training was reported on the College of Natural Sciences, Makerere, website on: https://cns.mak.ac.ug/blog/8th-workshop-solar-photovoltaic-installation-biogas-production-underway-conas. The training was also reported on social media platforms of the college: https://twitter.com/MakCoNAS .
- **Recruiting female students for EnergyNET supported studies (All)**
  The current fraction of female master students in EnergyNET is 57%. The fraction for female PhD students in EnergyNET is less, 25%, due to smaller recruitment base among the university staff.
- **Awareness seminars in selected rural schools (MAK)**
  The education sector in Uganda is still constrained by many challenges despite the increase of the number of children enrolled in schools. It is still a major challenge to transfer teachers to disadvantaged areas commonly referred to as “hard to reach areas”. Northern Uganda is a region which has been involved in war for more than twenty years; forcing the majority people into internal displaced people’s (IDP) camp. The number of girls attending secondary school education in most rural parts of northern Uganda is still low. During the period 11-15 July 2022, a team of staff from the Department of Physics, Makerere University visited 8 schools in Northern Uganda to promote/motivate girls to pursue science education beyond the secondary school level. The students were also given access to equipment; these are equipment taught in class but have never used them practically. The mobile lab has excited both students and teachers in the rural schools.
- **NORHED Gender Workshop (Entebbe)**
  Jimmy, Karidewa , and Ole Jorgen participated in Gender Workshop at Entebbe, Uganda, 30 August – 1st September 2022, organized by NTNU (Charlotte). Karidewa made a presentation on gender related activities in the EnergyNET project.
- **Motivation to girls' secondary school (UDSM)**
  Students from girls' secondary school in Morogoro region were invited to attend the Annual University Research Week event at UDSM, where renewable energy teaching and research activities were exhibited. The activity targeted to motivate girls to choose energy subjects, when they join university. It should be noted that the said secondary school in Morogoro admits girls who are school drop-outs due to failure to pay tuition fee or childhood pregnancy. The UDSM EnergyNET project Team organized a visit of staff and students to the same school in 2021 to provide inspirational talks. The activity was finance by the project.

Twitter on PV training at MAK



Mobile lab demonstration and career guidance in rural schools (MAK)

NORHED Gender Workshop at Entebbe, Uganda, 30 August – 1st September 2022

Secondary School Girls from Morogoro Region visited UDSM in April 2022

Activities 2023

- **PV training for female students (MAK).**
  The history of the PV training for female students continued also in 2023.
- **Awareness creation for refugee communities (AAU)**
  The training planned for refugee communities have been on hold, due to the security conditions in the country hindering safe implementation of project activities. An indirect awareness creation has been initiated for injera bakeries and cookstove users with a local company which has experience in offering similar trainings on cook stove users (DANAS Electrical Engineering). The Ethiopian Energy Authority proposed to engage stakeholders from regions, but this is on hold due to the ongoing conflicts in different region.We plan to offer the trainings in 2024.

- **Awareness creation for female students (AAU)**
  The awareness creation for female students on PV technologies has been initiated in 2023. A call for registration brochure is prepared and disseminated to reach out to as many female students as possible from the undergraduate program from remote areas. A local company named 'Green Scene Energy' with ample experience in the area expressed willingness to support in the offering of the training. The training content and venue for theoretical and practical trainings were identified and preparation are underway.
- **Support to Association of Women** (**UEM**) in matters of solar irrigation. This took place in a rural community of the district of Chókwè, Province of Gaza.

Activiities in 2024

MAK

At MAK, no PV training programme was conducted in 2024; auditors advised that MAK should hire external consultants to facilitate the training programme. This is not possible since the budget cannot support the hiring of external consultants. Again the MAK team has better expertise in this field.

Mobile laboratory and visit to rural school:
At MAK, our team visited schools in rural areas in northern Uganda; the schools visited were: Adjumani secondary school, Alere secondary school, and Pagirinya secondary school.
Main activities included:

- Provide career guidance
- To motivate the students to concentrate and pursue education despite the students being in rural and hard to reach areas
- Demonstration with equipment: mobile laboratory. The schools do not have lab facilities and such visits give them an opportunity to see and use such equipment for the first time.
- To strengthen the teachers to work hard and carryout their duties with pride despite the challenges of being rural areas.

At Alere Secondary school in Uganda: a) addressing the students inside a hall, b) Mobile lab demonstrations. 2024

UEM

The gender specific training activities did not take place in 2024, due to political unrest following the general elections at the country. We will reprogram these activities for the second semester of 2025, to

be accomplished with the involvement of students.

UDSM

UDSM continues with motivation visits to Secondary School in Morogoro Region.

MU

In support of the ENET Project, We have conducted Gender Mainstreaming in Energy Sector Training for participants from Axum University, Mekelle University, Adigrat University, Mekelle Gender Office and EiT-M finance departments on the following Four modules.

1. Module 1: Gender Mainstreaming in Energy Planning.
   Integrating gender perspectives into energy strategies.
2. Module 2: Gender Dynamics and Sector-Specific Energy Applications in Post-Conflict Ethiopia:A Tigray Perspective. Exploring localized challenges and opportunities in a recovery context.
3. Module 3: Gender Mainstreaming in the Energy Sector. Strategies, Tools, and Monitoring Approaches to equips participants with practical frameworks for implementation and evaluation.
4. Module 4: Gender–Energy Nexus: Global to Ethiopia Context. Bridging international best practices with national realities, fostering sustainable, inclusive energy development

The training was officially launched by Mekelle University's Academic Vice President, Dr. Abdelkadir Kedir. He highlighted this event as a key milestone in the 20-year collaboration with the Norwegian Government via the NORAD project. The NORHED II initiative further strengthens this partnership, with gender mainstreaming as one of the university's core focus areas. Support for these efforts will continue into the future. Following the opening speech by AVP Dr. Goitom Desta, Deputy Director for Postgraduates and Research at the Ethiopia Institute of Technology (EiT-M), he elaborated on the collaboration and extended thanks to the ENET project for its invaluable contributions—particularly in gender mainstreaming and PhD student support during challenging times.

<table>
<tr><td> 
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<tr><td>GM banner</td><td>Certificate ceremony at MU</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Female Participant of the GM trainees</td><td>Participants with Trainers and facilitators</td></tr>
</table>

AAU

An awareness creation trainings on PV technologies for female students was conducted and a registration brochure is prepared and disseminated to reach out as many female students as possible from the undergraduate program from remote areas. The gender office of the institute was also contacted to select female students. Due to limited number of female participants, male students were also invited to attend the training. The training involve both classroom and onsite demonstrations.

AAU: Female Students attending Practical training on Solar PV Systems at AAiT in 2024

Activities in 2025

MAK

PV training

MAK developed a PV training manual in 2023. This manual is now being used as part of course material – for teaching solar energy courses at both bachelor and MSc levels.

In 2026, the PV training manual will continue to form part of the teaching materials for solar energy.

Mobile laboratory

The team at MAK visited rural schools in northern Uganda. Basic lab equipment were taken to the schools and demonstrations on the use of such equipment was carried out. The students were fully involved in the use of the equipment. These type of equipment are part of the school curriculum but the schools cannot afford to purchase them.

During mobile lab activities; career guidance was also provided to the students in addition to motivating them to work hard.

Dr. Bosco and Jimmy making presentation to the students in Ofua SS.

Mobile lab – demonstrations. Students gathered in small groups and participating in experiments guided by tutors from Makerere.

Demonstration/ mobile experiments using equipment brought from the Department of Physics at Pagirinya SS. The students were divided into groups and operated the various equipment.

Introduction to new solar cooking technology for females

The pilot unit on institutional cooker is often demonstrated for the public and guests to MAK, as well as for dedicated female groups.

	
Group visit for introduction to the solar cooker at MAK, 2025.	Jimmy explaining the system

AAU

AAU has been supporting female Master's students in the ENET program. In addition, female undergraduate students are also supported as part of capacity development and awareness creation in the field of energy. Furthermore, two undergraduate thesis projects undertaken by female students have been supported through the ENET project.

Plans for 2026:

Due to the high demand by schools for the mobile lab; MAK will continue to visit more schools in 2026.

MU

The solar cooking demonstration was strategically integrated with the gender mainstreaming training, rather than conducted separately. This contextual adaptation ensured safety and efficiency. Over a focused one-day session, participants explored an evolution of solar technologies—from the pioneering Enpe Project to recent innovations supported by UNET and ENET projects. Hands-on learning emphasized practical applications, including live demonstrations of roasting coffee and popcorn, highlighting the gender-energy nexus and post-conflict resilience in sustainable cooking solutions.

Solar Cooker demonstration for trainees at MU, 2025

Plans for 2026

The demonstration activities will be continued and extended to increase the awareness and visibility of the activities.

The Gender Mainstreaming training will be conducted again with wide scope and stakeholders. In collaboration with Postgraduate and Research office and Center of Energy Office, the GM training will be linked

UDSM

UDSM continued to support female PhD candidate research work on sensible heat solar cooker. This research is expected to bring positive impact on gender equality as exhibited during 2026 open research Week.

Plans for 2026

UDSM will continue with motivation of girls at secondary level to science fields. Such activity will target schools in Morogoro and Southern regions.

AAU

AAU will continue supporting female students in the program and within the college. Female-focused capacity development initiatives are also planned.

5 - Infrastructure

Background

One aim of the university collaboration is to share access to research resources. As scientific equipment can be rather expensive, this shared approach will be cost-effective, and promote future interactions. It will also give higher quality of the facilities, as the investments can be specialized.
The pandemic has also revealed the importance of efficient internet communication systems, as on-line events tends to become more common.
EnergyNET plans on improving three types of facilities.

- Upgrades of technical laboratories (dedicated rooms, equipment, tools and instrumentation)
- Computer laboratory (high capacity computers and software licenses)
- ICT rooms to also support EnergyNET collaboration on research and education

Most of the EnergyNET partners also participate in the Erasmus+ UNET project, which has some budget allocations for training facilities as well.

Activities 2021

The planning of the equipment and infrastructure activities in ENET is made alongside the UNET planning. The UNET project time span is shorter than the EnergyNET time span. The time scheduling for the acquisition of research equipment in EnergyNET has therefore been proposed to come after the UNET UNET equipment has been processed first. This gives time for optimizing the further acquisition of EnergyNET equipment.

The facilities for upgrading are:

- UDSM: Upgrading Renewable Energy Laboratory and Computer laboratory for digital training
- MAK: Improved institutional small scale infrastructure and equipment for education and research
- MU: Hybrid solar/wind /hydro laboratory and Computer laboratory
- AAU: Thermal energy laboratory and ICT-room for e-learning
- UEM: PV/Thermal laboratory upgrade, with focus on thermal storage
- MUBAS: Hydropower
- UoJ: Solar energy

Activities 2022

- **MAK: Improved Solar Seminar Room**
  The solar seminar room which is being used by visitors (both students and professors from abroad) and for meeting graduate students was improved; the floor was tiled; curtains and basic furniture acquired; windows and outside repaired. The roof top was also worked upon to avoid water leakages. The front was improved to stop rain water from flowing in. Electrical work and internet network done.
- **MAK: Equipment for solar thermal research**
  Solar PV modules and accessories were purchased for research in solar thermal heating. Insulating materials, charge controllers, heating elements and components for Arduino based data logger were received from NTNU. K-type thermocouples were purchased for temperature measurement.

Activities 2023

- **UDSM: Upgrading of MSc Renewable Energy lecture room**
  Upgrading of dedicated room in form of replacement of room air conditioners for MSc in Renewable Energy was initiated in August 2023. Due to major changes in financial and procurement systems, the tender for procurement of the air conditioners was delayed until March 2024. Supply and installation of the air conditioners conclude, payment is pending on UDSM internal procedures.
- **AAU: Seminar room upgrading**
  Equipments to upgrade the seminar room were identified but the purchase was put on hold mainly due to the possibility of acquiring the resources from other sources of funding. In 2023 the plan was to purchase furniture and some electronic equipment for the room. However, as the furniture could be obtained from other funding sources the plan is to use the ENET budget in the procurement of other ICT facilities for the room.

Activiities in 2024
The purchase of equipment and refurbishing of seminar rooms has been largely deferred until the procurements in the UNET project were completed. At MAK, no equipment were purchased since activities were slowed down in 2024, only one laptop was purchased for PhD student Tito Achire from Juba.

Activities in 2025:

- **MAK: Equipment for solar cooker testing**
  At MAK, one laptop was purchased for a PhD student.
  Solar PV systems, battery, controllers, cables, and accessories were procured. The equipment will also be important for the field testing of the solar cooker in a refugee school.
- **MU: Equipment for hybrid wind-solar systems**
  Dumpload to a high temperature heat storage in a PV battery system has been demonstrated. The objective is to collect excess power into a heat storage for cooking.
  It has been a challenge to acquire a suitable wind turbine for the hybrid solar-wind test system. A wind turbine with accessories arrived in MU but require high wind speed for convincing performance. The use of Arduino based instrumentation and data loggers is successful.
- **AAU.** The Mechanical Engineering PhD conference room was partially renovated, and a secure door access system was installed. In addition, an inverter and other research equipment were purchased to support PhD students. Laboratory resources, including phase change materials, iron bars, and steel structures, were also procured for research purposes.

Plans for 2026
The need for equipment in 2026 will include general laboratory support but increasingly more for the case of supporting field tests.

MAK: Equipment for the solar thermal laboratory and for extended prototype testing.
UDSM: PV and wind equipment for Renewable Energy laboratory
AAU: Equipment for thermal laboratory, including support for field testing. Improving computational resources
MU: Equipment and instrumentation for hybrid solar / wind laboratory. Renovation and rebuilding after the degradation during the shut down period.
MUBAS: Use of extended funding for capacity building on Renewable Energy Laboratory for Clean Cooking, RELACO. The establishment of the laboratory at MUABS has been approved jointly by two colleges.
UoJ Use of extended funding for research infrastructure at UoJ. Solar PV installations as well as ICT

equipment.

6 - Outreach

Implementation of results

Background

An important objective of EnergyNET is to proceed towards implementation of research results. This involves more complex and multidisciplinary types of challenges than the pure technical ones. The aim is that university researchers shall be involved in these challenges though PhD studies and that master students can be trained in this area through relevant course work and through participation in research and field work.

The energy solutions for implementation have been selected based on the experiences and results from the previous collaboration and targets essentially off-grid solutions for food preparation (cooking and frying) and conservation (refrigeration).
The systems will be first established and kept operational as test systems at the universities, before ported to field tests.

Activities on implementation

The PhDs will be instrumental in the implementation activities. 2021 has been a year of startup for the PhDs, the status on each is given in the appendix. Implementation activities will follow, after a test and qualification period at the universities, which has proceeded in 2022.

The technology units for testing have the following plans:

UDSM: Solar refrigeration

An adsorption refrigeration process has been explored in a PhD study at UDSM in an EnPeII project (Capacity5). This is a static system, which have no moving parts and rely only on a heat source which can be direct or indirect solar energy or heat generated by burning biomass materials such as agricultural waste.

The main objective of the UDSM Energy Technology Transfer from University to Industry project is to fully develop and commercialize on prototype renewable energy technology. Specifically, the project aims finalize the development of the solar refrigeration prototype in collaboration with Technology Development and Transfer Centre (TDTC) conduct field tests of the systems and conclude arrangements for commercialization of the technology in collaboration with the UDSM Intellectual Property Management Office (IPMO).

Activities 2022

Prototype for adsorption refrigerator for household application has been manufactured at UDSM. The refrigerator has been made in standing box shape similar to common domestic vapour compression refrigerators. Performance testing has not been concluded; however, it is expected that temperature variation in the cold chamber (evaporator) is expected to prevail.

		Prototype for adsorption refrigerator built at UDSM

Activities 2023

UDSM Team continued to work hand in hand with the TTO agencies, namely the Technology Development and Transfer Centre (TDTC) and Intellectual Property Management Office (IPMO) on various aspects of the EnergyNET research works.

Activities in 2024

UDSM continued to work on the solar refrigeration technology focusing on technical issues, moving from methanol to ammonia system. Particular issues have been:

- Stabilize evaporator temperature oscillatory behaviours through cold storage
- Confirm suitability of solar energy as source of heat for adsorption refrigeration
- Testing of box type adsorption refrigeration
  An Arduino based autonomous data logger has been designed and produced, and will be installed on the test sites for the prototypes.

Activities in 2025

The case for field testing from UDSM is the adsorption refrigeration system. The PhD on the testing of the methanol case completed in 2025, and will be available for further work towards field testing in 2026. The conclusion regarding implementation is that Ammonia system is to be preferred and that the direct solar heating solution is feasible. An ammonia system was tested at NTNU and released for shipment to Tanzania for further work at UDSM.

Another case for field testing is the solar cooker, similar to the concept at Makerere. The system has been laboratory tested, and presented on an Innovation Exhibition.

Plans for 2026

The experiences from the electrically heated system (the cabinet prototype) and from the direct solar heating experiments will be the basis for construction of a pilot for field testing. The plan is to engage the two completed PhDs on further development solar adsorption prototype, Dr Ibrahim Mwasubila and Dr Michael John as post-doctoral candidates.

The further involvement of the TTO at UDSM can be made through the Intellectual Property Management Office (IPMO) and the Technology Development and Transfer Centre (TDTC). Activities to be performed are to explore and utilised any potential for intellectual property right and prototype manufacture and field testing respectively.

PhD candidate (Anna Kissioki) will continue with restaurant shows for the solar cooker in 2026. This will also give valuable experiences regarding the social acceptance of the system.

MAK: Solar cooker for a school

The main goal of the outreach programme at Makerere is to deploy and test a solar cooker with thermal energy storage system at school in a refugee camp. This is line with the strategic plan of the university requiring researchers to conduct community outreach programmes. The proposed outreach is expected to establish and strengthen collaboration between academia, government, industry and humanitarian organizations.

Solar cooker –concepts/ system components have been developed and tested at NTNU and Makerere over the past years. No field tests of the solar cooker technology have been carried out in the previous projects. A solar cooker with heat storage will be deployed at a school in a refugee camp, in Adjumani district. The district hosts about 200,000 refugees from South Sudan.

Activities 2022

- **Pilot systems**
  The work at Makerere on thermal energy storage system integrated with cooking units has been in the laboratory in 2022. Several pilot units have been established at MAK
  1) single tank heat storage system – small size;
  2) single tank heat storage system –larger size;
  3) dual tank – based on mild steel;
  4) dual tank based on Aluminium.
  Cooking units were fabricated out of Aluminium; and cooking units purchased from the local market.
- **Data logger**
  An Arduino based autonomous data logger has been designed and produced, and will be installed on the test sites for the prototypes.
- **Field visit to refugee camps**
  The Makerere team visited two refugee camps in northern Uganda, namely 1)Pagirinya in Adjumani district, and 2) Bidibidi in Yumbe district. The team held meetings with officials from UNHCR, Office of the Prime Minister – Refugee desk; school managers; local Community Based Organizations; and district local government officials. The research on solar cookers with heat storage thoroughly discussed; and the plan to pilot the system in a selected school in a refugee camp attracted a lot of interest from the stakeholders.
- **Field visit to solar measurement stations**
  The department of Physics has established four solar measurement stations in the country. Our technical staffs visited the stations in Mbarara, and Tororo to download the data; and carryout maintenance work.

Activities 2023

More laboratory tests were made at MAK on the system to be implemented. This concerned in particular the performance of the PV controllers and on the circulation system for the power regulation. The system seems to perform convincingly. The final needs before implementation will be a temperature safety control method, to avoid overheating of the oil.

The same principles with self-circulation in an oil based heat storage was also tested for a mini-version of the system. The aim is down-scaling to household levels.

	
The MAK team at Bidibid refugee camp (2022)	Pagirinya refugee camp – March 2022.

Activiities in 2024

It was not possible to implement the field testing of the solar cooker in 2024. However, our team continued to engage key stakeholders.

In 2024, our team visited Kigumba technical college; the aim of the visit was to check their workshop facilities and discuss with the management the possibility of using the facilities to fabricate solar thermal storage tanks and components. Kigumba is training students in various technical fields including welding. We discovered that they have all the facilities and tools necessary to produce quality heat storage tanks with components. They are equally willing to collaborate and work with our research team in fabricating components.

The team from MAK with the Deputy Principal of Kigumba Technical College. The college has good workshop facilities supported by Government of Uganda and South Korea.

Activities in 2025

In 2025, a solar cooker with heat storage was constructed in Kampala and installed in a refugee school called Pagirinya secondary school, in Adjumani district. The school has about 1800 students both south Sudanese refugees and Ugandan students. The installed cooker is used to prepare food for about 150 students. The system is undergoing cooking tests for the next 6 months. Upon successful tests, the system will be up-scaled to cook food for more students.

Plans for 2026

The team will continue to carryout cooking tests using the solar cooker installed in a refugee school. Jimmy completed his PhD in 2025 and will lead the team in a postdoc position. Jimmy will work closely

with the cooks at the school and MSc students from MAK. Main activities for 2026 include:

- Training of the cooks on how to use the solar cooker
- Technical studies on the performance of the solar cooker
- Evaluate the economic and social aspects of the system.
- A very comprehensive documentation on the performance of the solar cooker to be produced.
- Upscale the system to cook food for about 1000 students.
- Seek funding to support production and installation of more solar cookers in 10 other schools in Uganda.
- Develop comprehensive plans for mass production and commercialization of the system.

The process involves hiring local welders to weld the frames and install solar panels

Installation of the electrical components

The installed system in the kitchen at Pagirinya SS.

Testing cooking of rice; and an excited cook serving food from the e-cooker.

AAU: Milk cooling and pasteurization

A theoretical study of a refrigeration system for off grid food preservation and pasteurization has been made. The developed computer model can size milk chiller or a refrigeration system with PV power supply and pasteurization system with solar water heater based.

The target system is for cooling and pasteurization of 50 liter milk per day at Semera, Afar Region, Ethiopia. The objective of the project is to manufacture and performance test a prototype small scale refrigeration and pasteurization system that uses solar energy (solar water heater and PV) with ice thermal storage for night cooling. First the system will be tested in the university compound followed by deployment of a mirror system in the village of the dairy farmers. The implementation of the technology is expected to pave the way for better cooperation with farmer cooperatives and improve the livelihood of the people.

Activities 2022

The PhDs have completed their course work. Detailed discussion on the proposal of the PhDs were conducted on dedicated sessions for PhDs both online and physical meetings. The PhD work was refined, and modeling and simulations of the proposed system was conducted to identify the best operating conditions and size of components. Based on the simulation results and sizing, the refrigeration system equipment procurement was started.

Activities in 2023

The implementation of results is the main issue nowadays in AAU. Our PhD researchers are at experimental phase of their PhD work. However, until the prototypes are tested and ready for deployment, the chair members are proposing to try the implementation of other research outputs in the chair by deploying in selected pilot demonstration site. Accordingly three technology types were identified for implementation purposes.

- Forced draft gasifier stove and dissemination with PV for cooking, lighting and charging to rural community
- Refrigeration PV technologies including Drying (solar bubble dryer)
- Institutional cook stoves (solar thermal storage)

It is also proposed to implement technologies which were already tested by EnergyNET partners in the project.

	
AAU EnergyNET PhD students while installing PV in AAiT compound (2023)	AAU building a latent heat fryer (2023)

Activities in 2024
The work in 2024 was mainly on the development of the system. Wax based heat storage options were evaluated as a phase change material during a visit to NTNU. A combined heating and cooling concept were evaluated, where the excess heat form a cooling cycle is used for heating the milk for the pasteurization. A compressor was purchased for delivery to AAU.

Activities in 2025
A hybrid test system was in 2025 established for pasteurization and refrigeration of milk at AAU. A DC compressor powers the refrigeration cycle, where the heat from the condenser heats the milk. The hybrid heating and cooling setup gives high efficiencies.

Plans for 2026
The PhD is planned for completion by mid 2026. Efforts on field testing of a system will then follow, in coordination with similar field test activities on the Injera fryer system.

AAU: Injera fryer
AAU has been working on injera baking technologies for household use and encouraging results were obtained in terms of improving the thickness of the baking pan and the possibility of baking using heat transfer oils.
The objective is to manufacture and deploy a solar thermal based institutional baking system to be used in the university compound. Part of the existing biomass based injera baking system will be replaced by the proposed solar based system.

Activities 2022
Gashaw conducted a series of experiments to check the possibility of baking on metal surfaces and encouraging results were obtained which will pave the way to consider baking on metal surfaces as an option to use in the system which is going to be developed in this project.

Activities 2023
2023 was a year of experimental work at AAU, building a prototype fryer.

Activities in 2024
Progress was made on the technical side after testing of several small PTC heating elements (Progressive

Temperature Coefficients) attached to an aluminium frying pan during a research visit to NTNU. The work was taken further at AAU and baking of injera was successfully demonstrated on the plate. An efficient method to use PV panels for the power needs to be established, as well as the attachment of the plate to the heat storage.

Activities in 2025

A load switching unit was tested and further extended during a visit to NTNU. This unit regulates the load by switching between an array of small heating elements, to obtain the optimal power from the PV panels. An alternative using AC elements and grid power was also successfully tested with frying of pancakes during the NTNU visit, and the relevant components were brought back to AAU.

Plans for 2026

The PhD research on institutional injera baking is delayed to mid 2026, with implementation to follow shortly after including the participation of a research assistant.
The implementation can include both the cases with direct solar frying and with heat storage attached. The field tests and the dissemination of the results will be organized with support from the Technology Transfer Office. AAU has links with the Sebeta Agricultural Research Institute's demonstration site. The institutional injera baking and milk pasteurization systems are the key technologies expected to be tested in a community setup.

	
Concept testing of hybrid heating and cooling of milk, 2025	Heating an injera frying plate from PV power, 2025

UEM: PV/Thermal system test and socio-economic study

UEM has been working on combined PV and thermal systems, where water heaters are converted to oil heatersand the PV power provides the additional rise in temperature, which is needed for cooking. Extension of the concept is also the topic of a PhD study, which will include field testing. The socio-economic aspects of adaption to new energy technology is not well documented, and the awareness status is not well mapped.
The objective is to finalize and optimize the hybrid concept at the university first and then introduce the concept in a field test. The developed cookers will be tested in a rural context. The field assessments will include a socio-economic study.

Activities 2022

The performance of water heaters converted to oil heaters, to provide heat for cooking, has been explored for flat plate collectors and for evacuated tube collectors, as part of the PhD work of Tomas Nhabetse. Work in 2022 has included documentation of the results in the form of conference presentations and the preparation of the dissertation has started.

Activities 2023

The work on water heaters converted to oil heaters, to provide heat for cooking, has been completed, and Tomas Nhabetse has mainly worked on the completion of his PhD dissertation.

Activities in 2024

UEM is working with an agrarian association in a rural area of the province of Gaza, southern Mozambique, on solar irrigation, training in marketing issues to the communities.
Regarding energy efficiency, UEM continued its collaboration with the National Railways Company. UEM implemented an energy efficiency study at the Main University campus. This project is being implemented in collaboration with the Polytechnic of Milan, Italy (Polimi).

Activities in 2025

The PhD completed on converting solar water heater to oil heaters completed his dissertation in 2025, and the defence will be in 2026. An experimental setup for heating water in a tank using evacuated tubes has been tested with a master student at NTNU and the system was packed and released for shipping to Mozambique for further use at UEM.
Meanwhile, the new PhD at UEM (Paulino Muebe) visited NTNU and worked on PC heating solutions using an array of small PTC heating elements. The oil heater system will most likely require top heating from PV panels. A direct application of the tests made during the NTNU visit could be cooking on an iron cylinder which has been heated with PV power using the array of heating elements.
A second result from the visit to NTNU was the construction and testing of an autonomous solar radiation data logger, based on a small PV panel attached to a box with an Arduino based data logger. The box includes a battery with a charger powered by the small PV panel.

Plans for 2026

The PhD will conclude on the case of using a metal cylinder as a heat storage for cooking, powered by PV panels and an array of small heating elements. If successful, this can be extended for field tests as well.
The load radiation data logger system will be calibrated using solar instrumentation at UEM.
Further use of the components for direct solar heating form NTNU will be evaluated after arrival of the system in Maputo.

MU: PV/Wind system with thermal and electrical energy storage

Activities in 2024

MU has returned as an active partner in ENET, after a period of absence. The PhD candidate at MU has in 2024 been working on hybrid solar-wind system with both electrical and thermal energy storage units. Testing of Arduino based electronic components were also made during a visiting period at NTNU.

Activities in 2025

Work continued on the hybrid solar-wind system in 2025. A good test setup is established, but a limitation has been the identification and procurement of suitable wind turbines.
The case of attaching a heat storage to a PV battery system has been explored. The idea is to harvest excess energy from a PV system into high temperature heat storage for cooking.

Plans for 2026

Mu is planning to make this wind-solar Hybrid laboratory to serve as a demonstration center for training for the community, students, and stakeholders for the future until the technology has matured to reach field testing somewhere for the community school or rural community.

MU: Direct and indirect solar injera frying

Activities in 2025

A PhD candidate at MU started in the previous EnPe NORAD program. The work was interrupted during the period of political unrest in Ethiopia and candidate has resumed work for completion in ENET.
Frying of Injera has been demonstrated with solar concentrators. A pan can be placed in the focal area of the fryer for direct frying in the sunshine. A pumped oil loop gives indirect frying, where the pan can be positioned inside a building.

Plans for 2026
The PhD work is completed and the candidate is finishing the write-up for graduation in 2026. After graduation, there can be openings for field tests of the system. This can build on the experiences at MU on a similar outreach earlier, where a direct cooker was presented for the general public.

NTNU: Support partners on pilot implementation
NTNU has participated with prototype development and testing in the NTNU laboratories in the past projects and in ENET. This has been for supporting visiting researchers from partner universities and MSc students at NTNU have participated as well.
The objective is to provide support to EnergyNET partners on PhD supervision and on the technical and socio-economic aspects of development and implementation of specific small scale energy systems and components.

Activities 2021
The scope of work of the PhDs have been discussed in a number of dedicated meetings with the candidates and the supervisors. Such meetings are in particular important at the point of startup of the PhDs.
Master students at NTNU have participated with laboratory testing of solar cookers and fryers.
One NTNU-supported PhD candidate at NTNU (Casiana Lwiwa) has worked on Compound Parabolic Concentrators for solar cookers. Some results were presented at the SASEC 2022 conference.

Activities 2022
NTNU continued to support the ENET objectives with activities defined as part of master theses (heat storage for cooking and frying, wind-to-heat, refrigeration).
OJ Nydal had half year sabbatical leave and visited the partners (MAK, UDSM, AAU, UEM) during the last part of 2022. The sabbatical period was used to support the construction of pilot units of a heat storage for cooking and to explore possible test sites. A unit was made at MAK and another was initiated at Arusha Technical College (ATC). An Arduino based data logger for temperatures was also made during a visit to MAK.
Visits to University of Namibia (UNAM), Namibia University of Science and Technology (NUST) and to the Namibia Energy Institute (ENI) were also made, based on previous communication and interest from people at the Namibian institutions.
Particular test sites which have been identified and visited in 2022 are:

- Canteen at ATC and CoET canteen at UDSM
- Kikuletwa Renewable Energy Centre
- Haydom Lutheran Hospital, Mbulu, Tanzania

Off-grid tourist camp sites and lodges in the national parks are also relevant sites, and one tented camp with a PV system was visited.

PhD Casiana Lwiwa tested a box CPC funnel design with an iron cylinder as heat storage. The cylinder was also tested separately regarding the potential for being a dedicated bean cooker.

Activities in 2023
NTNU continued to support the ENET objectives with activities defined as part of master theses (heat

storage for cooking and frying, wind-to-heat, refrigeration, instrumentation).
During the second part of the sabbatical period of OJ Nydal (last part of 2023) a small scale version of the oil based cooker was tested at MAK. Construction of two systems in Arusha were initiated. However, the experience is that progress is slow unless a contact person is present at the location.

Plans for 2024
The oil/rock bed system is ready for pilot implementations and NTNU will be supportive of such actions. MAK has plans for test introductions to a refugee camp and the piloting work started in Tanzania will be pursued further. The same system may very well be tested in Ethiopia and Mozambique as well, after some experiences in Uganda.
The work on the refrigeration concept will be supported with two master students at NTNU, in communication with UDSM.
Wind-to-heat still requires testing of load controllers.

Activiities in 2024
The technical support from NTNU in 2024 has been with the engagement of 6 master students, participation in the laboratory work during the visit of the PhD group and with support during visits to partners. The type of work has been

- PV power for heat storage: PTC elements have been tested both with PV power and with laboratory power supplies. Heating of small and large frying pans with an array of small heating elements can be a feasible solution.
- Wind to heat: Load switching with a number of heating elements can also be an option for wind power directly to heat
- Refrigeration concepts. The laboratory work concerned both vapor and adsorption cycles
- OJ Nydal had useful visits to partners in 2025, in particular to Tanzania and Uganda regarding the heat storage systems.

Activities in 2025
Direct contributions on technical solutions at NTNU in 2025 included

- Testing of an ammonia based refrigeration cycle with 2 master students working in coordination with the PhD at UDSM.
- Working towards next version of the oil based solar cooker with 1 master student.
- Working towards a heat storage solution for baking by hosting a researcher with background from MU (Mulu Bayray). Mulu also gives supervison support to students and visiting researchers.
- Development of data loggers and PV controllers to support field tests for partners. This includes a test version for an autonomous data logger for solar radiation.
- Support on the system for field testing at MAK

Plans for 2026
The testing of a baking solution will be completed in 2026, and the potentials for shipping to Ehtiopia for field tests evaluated thereafter.

Particular support will be on test units for power control in PV systems and for data logging for field conditions:

- PV Injera frying concept at AAU
- Institutional cooking system at MAK
- Cooking unit at UDSM
- Small scale cooking at UEM and MAK

Dissemination and stakeholders involvement

Dissemination activities are planned at project level and partner level in the form of web pages, exhibitions, stakeholder workshops, field demonstrations and scientific publications. A list of publications is given in the Appendix.

Dissemination activities and events

Activities 2021

- A project web page is hosted at NTNU, using the standard templates for projects at NTNU (https://www.ntnu.edu/ept/energynet)
- MAK prepared a project web site (https://cns.mak.ac.ug/energynet/) which includes a summary of results from previous projects supported by NORAD.
- AAU conducted an official kick-off meeting in July 2021, with participation of Institute management, TTO officer and private company working in the relevant area.
- At UEM, information about the project has been established at the official page of UEM, a facebook about dissemination activities of UEM has been established.

Official launch of UNET and EnergyNET projects in AAiT-AAU (2021)

Meeting VC and DVC at MAK during annual meeting 2022 (January 2023)

Activities 2022

- MAK is active in using social media on publishing ENET event, as also demonstrated during the annual meeting for 2022 (9-11 January 2023).
- ENET posters have been made at NTNU and at MAK.
- UNHCR is a stakeholder for the work at MAK on solar cooking. A representative from UNHCR travelled to Kampala and participated in the annual meeting with a presentation on the energy needs at refugee camps in Uganda.
- ENET Acknowledgements are noted in publications and conference presentations.
- Workshop 3 at NTNU in May 2022 included an Open Day, with 12 external presenters on the topic of drivers for technology development and implementation.
- ENET has been presented for the VC offices at universities during visits and events.
    - VC and DVC at MAK (during annual meeting for 2022).
    - DVC at UniSAVE during visit.
    - DVC at NTNU during Workshop 3.
    - Rector at ATC during visit.
- Presentation by MAK students at departmental seminars. A number of MSc students who have been doing research in the thematic areas within the project made presentations of their work at the weekly departmental seminars.

OJ gave a seminar at UNAM, Namibia (September 2022) on ENET and the research challenges on heat storage for cooking.

- NORHED II week
  EnergyNET participated in NORHED II week (25-29 April 2022) at Makekere; all Norhed II funded projects at Makerere attended this one-week event. Participants visited three selected laboratories; and the solar thermal lab was one of them.
- UDSM NORPART stakeholder meeting, ENET project summary presented
- Visit by Muni University. Muni staff visited Makerere and had a meeting with EnergyNET researchers on 30 May 2022. Muni being a young university, is interested in future collaboration and support for capacity building of their staffs in the field of energy.

Activities 2023

- NORHED II week at UDSM. UDSM held NORHED II week at Dar es Salam between 9th and 13th October. ENET Project was represented by participants from UDSM and NTNU. Among other activities, presentation on ENET project was done covering project partner institutions, project set-up and planned objectives, PhD and research focus as well as synergy with other projects.
- UDSM-NTNU NORPART Stakeholders Meeting
  Annual stakeholders meeting was held on 27th February 2023 in Arusha and attended by stakeholders including ENET/NORPART project coordinators, ENET PhD student, NTNU Exchange students, representative from TotalEnergies and representatives from Tanzania renewable Energy Association (TAREA)
- The latent heat mini-cooker we tested some years back in Tanzania has now come on display at a new section on energy at the Technical Museum in Oslo!.
- During the SWC2023 in India, we met by chance with the Minister of Energy in Uganda, and discussed the heat storage for cooking technology. He commented that a commercialization will be necessary for the technology to be disseminated.
- MAK hosted the project annual workshop for 2022 in early 2023.
- Project leaders had courtesy call at the office of the Vice Chancellor and his deputy at MAK. They expressed support for the project and were specifically interested in the project results on the cooking technology.
- EnergyNET participated in the MAK-Expo in October 2023 where the cooking technology was demonstrated for cooking. The Expo attracted several people from the country.
-

Activiities in 2024

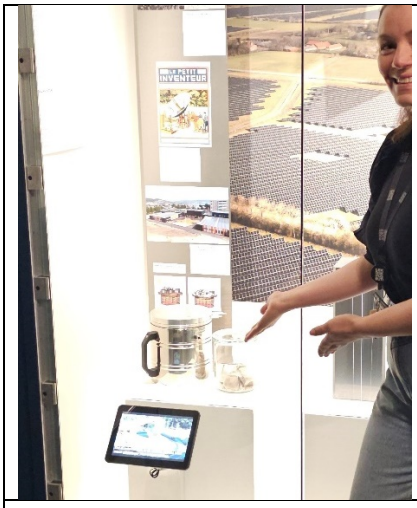
- All NORHED projects with Malawi gathered during the NOREHD week in October 2024 at MUBAS in Blantyre. The ENET project was presented by Kaunda.
- The ENET report for 2023 has been posted on the ENET web site
- UDSM organized MIE 2024 conference in Arusha, Tanzania and ENET was well represented with several presentations from UDSM, AAU and MAK and with an ENET poster on display.
- ENET roll-ups are on permanent display in the NTNU laboratory and in the seminar room at MAK.
- The Ambassador at the Norwegian Embassy in Dar es Salaam visited NTNU in August 2024 and was introduced to the ENET activities in our laboratory
- A UNET video from 2024 has also some relevance for ENET, UNET,
  https://ntnu.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=8152e3cf-8f7a-4d84-b3fc-b29900d45131
- Nancy Bazilchuk from the NTNU communication division prepared a pod cast:
  https://shows.acast.com/63-degrees-north/episodes/old-flames-die-hard
- A training program was arranged at AAU together with a private company (Green Scene Energy) on 'Solar PV Systems on Off-grid Use.

- A training event on financing options for dissemination of renewable energy technologies was executed together with the awareness training. An Expert from SNV Ethiopia offered a training on avaialble finacing schemes.

Plans for 2025

- An updated ENET report will be linked on the web pages.
- Web site: An ENET video will be made with external support.
- Conference: The aim for 2025 is that the ENET project and the ENET results are disseminated at an international conference, with presentations from most of the ENET researchers.
- ENET will be presented at Exhibitions at UEM Research Week and at the National Trade Fair (FACIM)
- UEM will conduct one Workshop for women and the university community on solar cooking and e-cooking
- A one-day workshop will be held at AAU to showcase the activities of the ENET Project. The event will include presentations by PhD and M.Sc. students involved in the project, with posters and banners prepared for the occasion. As part of the dissemination efforts, posters featuring research abstracts from the School of Mechanical and Industrial Engineering (primarily focused on renewable energy research) will be created and displayed in designated areas on the school building floor. Efforts will be made to share the activities and the event on the university website

MORE DISSEMINATION EVENTS TO UPDATE FOR 2025 ?

	
The latent heat mini-cooker has come on display at Science Museum, Oslo	Meeting with the EiT-M Management, MU, 2025
	
MAK-Expo in October 2023- The MAK team organized	

an exhibition stand with displays of the cooking technology, posters and videos.	
	 
Gashaw presenting his prototype baking pan heated by PTC elements in Bishoftu, Ethiopia during AAU research and Tech Expo week.	Gashaw presented his work during the AAU research and Tech Expo week held from May 19-23, 2025. Poster Presentation at CTBE campus during AAU research and Tech Expo week

Activities in 2025

- **MAK** participated in the Research and Innovation week at Makerere organized by the university. The event was used to showcase various innovations by different research groups at the university. It attracted several companies, NGOs, government officiants, etc. The event was opened by President Museveni.

  Our work appeared in university Research and Innovation monthly magazine for April 2025.

  A report on solar cooker was done in Makerere University on link: https://endowment.mak.ac.ug/pages/makerere-solar-cooker-poised-to-transform-clean-cooking-in-africa/

  At MAK, the EnergyNET team made a presentation to the public and academicians at the Research and Innovation week in April 2025.
- **UDSM** ENET project members participated in a meeting hosted by UDSM Management with NORAD Team from Norway Embassy in Tanzania. Progress report for ENET project at UDSM was presented and discussed during the said meeting held on 25th April 2025.

  PhD candidate (Anna Kissioki) and master candidate (Juma Msuya) exhibited the solar cooker during open Research Week held at UDSM in May 2025. They emerged as the third winner and was awarded with a certificate.
- **NTNU** presented relevant ENET activities to the Norwegian Embassies in Addis Ababa, in Dar es Salaam and in Lilongwe during project visits.
- **MU** hosted guests from NTNU, who met with EiT_M management and the ENET project coordinator. The visit assessed the university's post-Tigray conflict status, engaged PhD students under NTNU supervision, strengthened collaborations with the institute, and mapped the way forward for the ENET project's remaining years.
- **MUBAS** hosted the ENET annual meeting in Malawi. One day was dedicated to meeting with private and governmental stakeholders. The event was covered by news media in Malawi

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<tr><td>Photo: Jimmy explaining to the president about the solar cooker, 2025.</td><td>Photo: Karidewa during a panel discussion; he presentation focused on the solar cooker, 2025.</td></tr>
<tr><td>  </td><td> 
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<tr><td>UDSM PhD and Master students (Anna and Juma) participate in Research Week Exhibition, 2025.</td><td>Poster and Certificate for Research Week Exhibition at UDSM, 2025.</td></tr>
<tr><td> 
'Turn energy innovation into tangible solutions'
ERIC MTEMANG'OMBE
Senior News Analyst
Malawi must urgently shift from showcasing promising energy technologies to deploying them at scale if it is to reduce its dependency on biomass, expand electricity access, and build a resilient energy future, researchers, government officials, and private-sector innovators have said.
The call comes as pressure mounts on the national grid, deforestation accelerates and the cost of diesel-based back-up systems continues to price out both households and businesses.
Experts warn that without deliberate investment and policy alignment, Malawi risks remaining stuck in a cycle where innovation exists but impact does not.
Malawi University of Business and Applied Sciences (MUBAS) Deputy Vice-Chancellor Professor
Kosamu: These technologies can transform rural energy access
Nydal: Technogies fail because we don't maintain them. | Eric Mtemang'ombe
Tanzania and Norway have jointly developed low-cost clean cooking systems, hybrid wind–solar mini-grids and heat-storage cookers designed to replace firewood. The technologies are engineered for off-
Government officials acknowledge that past renewable projects failed because they depended on imported spare parts or lacked technicians to repair them. Off-Grid Electrification
impossible.
"With borrowing costs this high, no renewable firm can invest in equipment," he said. "We need patient capital—flexible financing that lets companies grow without</td><td></td></tr>
<tr><td>Malawi newspaper coverage during annual meeting 2025</td><td></td></tr>
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Plans for 2026

- **UDSM** is organizing the bi-annual conference in October 2026. We plan on combining attendance at the conference with the final meeting of ENET.
- **UEM** will take part in the Exhibition on UEM Research Week. Visit to CPE labs.
- **MU** will conduct a one-day ENET one-day dissemination event as well as a Stakeholder workshop event.
- **MAK** will conduct publicity events in connection with the testing of the cooker at the refugee

school. Stakeholder events will be conducted with local leaders, NGOs, government officials and the media.

Presentation based on the field tests will be prepared for international and local conferences.

The MAK public relation office will be engaged for broader dissipation.

- **AAU** will organize a Stakeholder Workshop on E-Cooking
- NTNU will update the general report and post it on the ENET web site.

Conferences and seminars

The aim is that each PhD should present their work at one international conference every year. ENET researchers have contributed with presentation at the following conferences (see list of publications).

Presentations at conferences in 2022

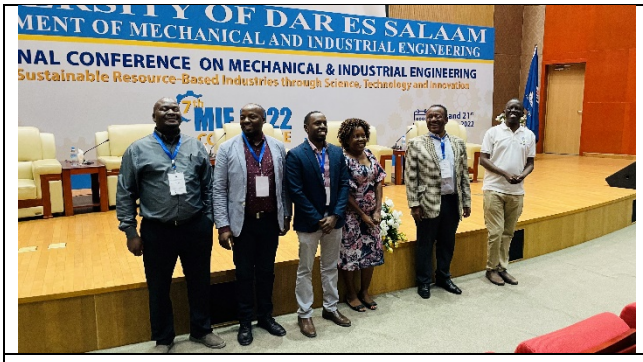
- 16th International conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT)
- 63rd International Conference of Scandinavian Simulation Society, SIMS 2022, Norway
- EuroSun2022- ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry, Germany
- 7th International Conference In Mechanical and Industrial Engineering, MIE 2022, Tanzania: The conference is organized by UDSM

Participation in other international conferences, workshops and seminars in 2022:

- SANORD 2022
  The Southern African-Nordic Centre promotes academic collaboration and organizes yearly conferences. OJ Nydal participated at the SANORD 2022 event, which appeared to be a somewhat unstructured assembly of presentations in a very broad area.
- Renewable Energy Conference organized by Ministry of Energy & Mineral Development on 3-5 November 2022 in Kampala-Uganda (Jimmy Chaciga).
- Solar energy and materials workshop in Nairobi
  Karidewa and Denis participated in 2-day workshop in Nairobi on solar energy and material science. Participants were from universities of Nairobi, Zambia, Dar es Saalam, Eldoret and Makerere. EnergyNET activities were presented. The workshop was to plan for online conference and supporting graduate studies in solar energy and material science.
- Online solar conference University of Eldoret, Kenya; 16-18 November 2022 (on-line).
  6 students (PhD and MSc) who are doing research in solar energy at MAK attended an online conference on solar energy and materials
- Seminars
  Presentation by MAK students at departmental seminars. A number of MSc students who have been doing research in the thematic areas within the project made presentations of their work at the weekly departmental seminars.
  OJ gave a seminar at UNAM, Namibia (September 2022) on ENET and the research challenges on heat storage for cooking.
  UEM (Tomás Nhabetse) presented a paper on “Experimental of an oil based solar thermal system for cooking applications” (25/5/2022), Online technical meeting.

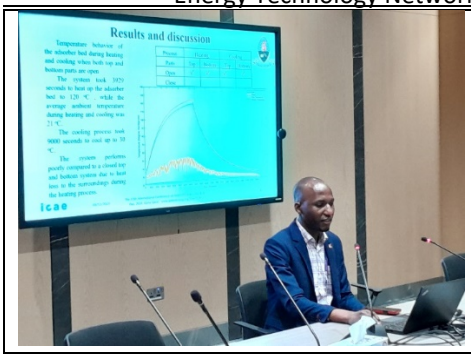
	
Renewable Energy Conference, Kampala-Uganda. (November 2022)	Workshop in Nairobi held on 12-13 September 2022

	
UNHCR representative at the ENET annual meeting for 2022 (MAK)	NORHEDII week at MAK: Participants from the various projects in the solar lab, 26 April 2022

	
UDSM organized MIE 2022 in Dar es Salaam	

Presentations at conferences in 2023

- ICAE Conference 2023.
  Three PhD students and supervisors attended the 15th International Conference on Applied Energy (ICAE) hosted by Qatar University in Doha. During the conference, ENET project contributed three conference papers as indicated in the list of publications.
- SWC 2023
  Supervisors and PhDs from AAU, MAK and NTNU participated with presentations at the Solar World Conference in New Delhi, India in 2023.

	
Mr Joseph Ibrahim PhD Student from UDSM, presenting a paper at ICAE 2023	UDSM students and supervisors at ICAE 2023
	
Fekadu from AAU presenting at SWC2023	

Presentations at conferences in 2024

UDSM organized the 8Th International Conference on Mechanical & Industrial Engineering, MIE 2024, 24-25 October 2024 at NM-AIST in Arusha, Tanzania. About 18 persons from ENET participated with several presentations. OJ Nydal gave a keynote speech on heat storage for cooking.

	
ENET group photo at MIE 2024, Arusha	Abdulkadir presentating at MIE 2024

	
Kaunda from presenting ENET during NORHED week at MUBAS., 2024	

Presentations at conferences in 2025

The plan for 2025 was to combine a project meeting with conference attendance to the Int Conf on Sustainable Energy Technology conferene in Turkey (SET2025). The conference was cancelled, and some partners managed to participate in the the World Renewable Energy Congress (WREC 2025) hosted by Manchester University in Manchester UK (UDSM and AAU) as an alternative.

	
Mr Joseph Ibrahim PhD Student from UDSM, presenting a paper at WREC 2025	UDSM students and supervisors at WREC 2025. AAU participated remotely due to visa limitations.
	 Abdulkadir participated in ISES Solar World congress 2025

	held in Fortaleza, Brazil

Plans for 2026

The plans for 2026 is to participate in the bi-annual conference organised by UDSM (MIE2026) in Tanzania, and conduct the final ENET meeting at the same time. This could be a good opportunity to present ENET as a project as well as the results of the PhDs in ENET.

Other conferences for consideration can be WREC 2026 (Australia) and SASEC 2026 (South Africa).

7 - Project coordination

Background

The guiding documents for the project coordination is the Result Framework and supporting documents.

- EnergyNET-ResultsFrameworkTable.xlsx
  is the Result Framework for EnergyNET on the Norhed template format
- EnergyNET-ProjectPlan.docx
  Gives the detailed plan for the project, to be revised when needed
- EnergyNET-TimePlan.xlsx
  gives the timelines for the activities under each Outcome in the EnergyNET-ResultsFrameworkTable, to be revised when needed

The Partner Agreement is the legal document for EnergyNET, and follows the Norhed template.

EnergyNET is coordinated with two other projects

- A NORPART mobility project (2019-2023) "UDSM-NTNU Mobility Program in Energy Technology" **https://www.ntnu.edu/ept/udsm-ntnu**
- An Erasmus+ project on PhD programs "University Network on PhD Programs in Energy Technology" which includes most partners form EnergyNET. https://www.ntnu.edu/uneterasmus/

TEAMS is chosen for project communication and for repository of the results.

Photo: Screen capture of TEAMS meeting

A log of activities throughout the year is maintained and stored on Teams, see Attachment.

Startup activities

- A kick off meeting was held on-line on 19.02.2021.
- Considerable time was spent on the budget reviews.
- The Partner Agreements were processed after the Norhed templates arrived.
- A Project Plan is prepared
- A Project Guide is prepared (reporting and administration, procedures, deadlines)
- The Result Framework was updated and detailed with a time plan for each activity
- TEAMS has been chosen as the framework for collaboration, all communication and documents are stored and available there.

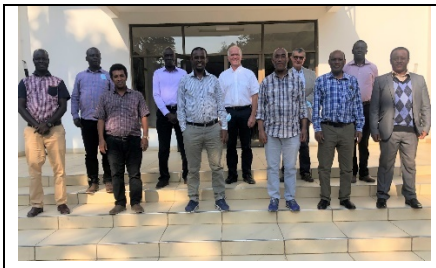
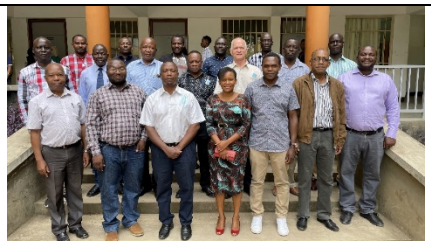
Meetings and Workshops

- Progress meetings have been conducted on TEAMS, agenda and MoM are posted on TEAMS
- Technical meetings individually for each PhD are held in between, when needed.
-

- Workshops have been conducted, in coordination with the UNET project, and if possible, with annual meetings. Some further details are given in the Appendices.

  Workshop 1, 30 Aug. to 2 Sept. 2021: Organized by UDSM and hosted by ATC in Arusha , Tanzania.
  Workshop 2, 29 Nov. to 1 Dec. 2021: Organized by UDSM and hosted by ATC in Arusha , Tanzania. The Workshop 2 was shifted from AAU to UDSM, due to the political uncertainties in Ethiopia.
  Workshop 3, 6-9 May. 2022: Organized by NTNU, Trondheim, Norway. Workshop 3 included short training events, and an open day, with 13 contributions on drivers for technology development and implementation, see Appendix. AAU missed participation due to Visa Denial.
  Workshop 4 was a pure UNET event on teaching methods and online systems, hosted by USGM in Rome, Italy
  Workshop 5, 4-7 September 2023: hosted by AAU, concerned mainly UNET issues on PhD course development, but included progress meeting on ENET.
  Workshop 6, 27-30 November 2023, hosted by MAK, was mainly a UNET event on completion of the PhD Course Catalogue, but included status reporting on the ENET PhDs.
  Workshop 7, 13 - 16 May 2024, hosted by NTNU, combined with UNET and the group of visiting PhDs.

- **Annual Meeting 2022**, 9-11 January 2023: Annual Meeting hosted by MAK, Uganda.
  Annual Meeting 2023, 11-16 February 2024: Annual Meeting hosted by UEM, Mozambique.
  Annual Meeting 2024, 2 - 6 December 2024: Annual Meeting hosted by UDSM, Mozambique.
  Annual Meeting 2025, 10-14 November 2025: Annual Meeting hosted by MUBAS, Malawi.

		
Workshop 2021 Arusha, Tanzania	Workshop 2021 Arusha, Tanzania	Workshop 2022 Trondheim, Norway
		
Annual meeting 2022 Makerere, Uganda	Annual meeting 2023 Eduardo Mondlane University, Mozambique	Workshop at AAU in 2023

		
Annual meeting 2024, Arusha, Tanzania	Workshop at NTNU 2024	
		
Annual meeting 2025, Malawi	Group picture Malawi	

Plans for 2026

The plan for 2026 is that we combine an ENET meeting with participation in an international conference organized by UDSM (MIE 2026) in October 2026.

Two PhDs are planning visits to NTNU in 2026. Mesele form MU will come to complete his PhD defence at NTNU. Tsige from MU will come for finalizing her PhD dissertation.

A video was prepared for the UNET project in 2024. A similar video was planned for ENET in 2025. This will be attempted in 2026 with testimonials from the final ENET meeting.

The ENET period has been extended to 2027, for completion of the PhDs and focus on the implementation of the results. The final reporting of ENET will therefore be in 2027.

Appendix MSc students

NTNU

Year	University	Name	Supervisor	Support	Completion
2021	NTNU	Andreas Bjørshol (M)	OJ Nydal	Laboratory support	2021
	Sensible Heat Storage for Cooking. Single Tank System A single tank oil/rock bed heat storage system has been constructed, analysed and tested. Heating power is provided from electrical heating elements and the heat transfer between the cooker and storage is by natural circulation. The system concept is explored in collaboration with MAK.				

Year	University	Name	Supervisor	Support	Completion
2021	NTNU	Gunn Helen Nylund (F)	OJ Nydal	Laboratory support	2021
	Sensible Heat Storage for Cooking. Single Tank System Joint work with Andreas Bjørshol				

Year	University	Name	Supervisor	Support	Completion
2021	NTNU	Martin Systad (M)	OJ Nydal / Abraham Parra	Laboratory support	2021
	Experiments with a latent heat storage for frying A heat storage solution for a fryer has been extended with a new fryer with 60 cm diameter. The heating is by heating elements and the heat transfer by heat pipe. The storage is PCM cylinders immersed in oil. The master student is supervised by the PhD student working on the concept (Abraham Parra). The concept is developed in communication with AAU, for injera baking purposes.				

Year	University	Name	Supervisor	Support	Completion
2021	NTNU	Joakim Ginste (M)	OJ Nydal	Laboratory support	2021
	Frying on a heat storage (project work 2021) Frying of injera has been tested on two heat storage based fryers. One is the heat pipe concept with oil/PCM as storage. The other is a PCM storage with conducting fins to the frying plate. A silicon baking sheet was used between the injera and the metal surface. Tests by a project student showed that injera could be baked with acceptable quality. The concept is developed in communication with AAU.				

Year	University	Name	Supervisor	Support	Completion
2022	NTNU	Kristina Berg (F)	OJ Nydal	Laboratory support	2022
	Small scale PV to cooking heat (project work 2021) Aspects of a three tank system has been tested, as part of a student project before the master thesis work. Heating of oil and water has been tested with and without an air volume above the surface. Evaporation reduces the rate of the temperature rise in the liquids. Long term oxidation tests have been made with several oils. **Demonstration of PV Power to High temperature Heat Storage for Solar Cookers (master thesis 2022)** Three charging methods for a heat storage are considered. The first using excess heat from PV panels, when the electrical batteries are full. The second applying power directly from PV panels to heating elements, using a dedicated mppt controller. The third combining wind and PV power for the charging of the heat storage.				

Year	University	Name	Supervisor	Support	Completion
2022	NTNU	Andrea Austjord Vik (F)	OJ Nydal	Laboratory support	2022

	Joint work with Kristina Berg

Year	University	Name	Supervisor	Support	Completion
2022	NTNU	Alexander Peter Olsen (M)	OJ Nydal	Laboratory support	2022
	Heat storage for cooking (project work 2021) The single tank storage system for a cooker has been improved and tested as part of a student project before the thesis work. A modified version has been designed, with the cooker now positioned outside of the heat storage. tank. **Design and testing of a natural circulating heat storage for cooking (master thesis)** The system with separated storage unit and cooker unit has been constructed and tested. The system is based on natural circulation and seems to perform well. The cooker can be operated directly with power on the heating element or indirectly with heat extracted from the storage. A solution for a pumped system was demonstrated using a propeller in the lower pipe. The system is the basis for prototyping and was further tested with rock bed during a visit by PhD researcher Jimmy Chaciga from MAK. The system concept will be further explored in collaboration with MAK.				

Year	University	Name	Supervisor	Support	Completion
2023	NTNU	Marte Maria Tømterud (F)	OJ Nydal / Mulu Bayray	Laboratory support	2023
	Technology from Africa to Norway: heat storage for off-grid cottages (project work 2022) One of the concepts in the network project has been to direct excess power from PV systems to heat storage units (heat batteries). A student project work considers the applicability of this sort of technology to the case of Norwegian off-grid cottages. PV systems which provide light and power small appliances for cottages are available, but as the cottages are not used for long periods (often weeks) the PV power is not used after the electric batteries are fully charged. **Solar Water Heater with Temperature Control for 90°C Water Requirements. Designed for the Rural African Environment (master thesis 2023)** A solar hot water system to deliver water at 90˚C was developed, tested and verified to work. The system is according to a requirement from an African hospital. Solar evacuated tube collectors (ETC) heated a water tank which contained an automobile thermostat valve. During the day, the tank then collects water at 90 degrees C.				

Year	University	Name	Supervisor	Support	Completion
2023	NTNU	Torbjørn Mjåtveit (M)	OJ Nydal / Mulu Bayray	Laboratory support	2023
	Small scale wind power to heat storage (project work 2022) Small scale wind turbines are used for charging of electrical batteries. One aim of a student project work is to evaluate a commercial small scale wind turbine at EPT for diversion of excess power to a high temperature oil-based heat storage. The student work shall also give an overview of direct wind-to-heat solutions (both mechanical and electrical solutions). **Wind power for cooking. Small scale wind power to heat storage (Master thesis 2023)** The continued work in a master thesis was based on tests of a wind generator in bench – where the torque and RPM could be set manually. The excess energy in a battery setup was dumped to a heating element in a small, insulated cylinder filled with Duratherm 630 oil, as a demonstration of the general case of using a high temperature heat storage as a dump load.				

Year	University	Name	Supervisor	Support	Completion
2023	NTNU	Henrik Lund Finsås (M)	OJ Nydal / Mulu Bayray	Laboratory support	2023
	Joint work with Torbjørn Mjåtveit				

Year	University	Name	Supervisor	Support	Completion
2023	NTNU	Andreas Grodås Jørs (M)	Trygve Eikevik	Laboratory support	2023
	Cold storage for an adsorption-based refrigeration cycle in Africa (project work 2022) An adsorption-based refrigeration cycle can operate in batch mode, with ice generation during the night and				

	regeneration during the day, using solar power. A prototype system has been built before and another one at UDSM. There is, however, a need for a temperature-controlled storage on the cold side, such that the cold storage can provide constant temperature in a refrigeration chamber on a continuous basis. A student project concerns the cold part of the system, where the objective is to consider an ice bath for n the cold side. **Cold storage for an adsorption-based refrigeration cycle in Africa (master thesis 2023)** An adsorption refrigeration system was constructed and tested, in good communication with visiting NORPART students (Joseph Ibrahim, PhD from UDSM and Neema Wilfred Muhogolo, MSc from UDSM). The batch system is based on the carbon-methanol pair, and requires no electric power or control. The idea is use ice/water as cold storage. The system will be studied further with following students.

Year	University	Name	Supervisor	Support	Completion
2023	NTNU	Adrian Danielsen (M)	Trygve Eikevik	Laboratory support	2023
	Joint work with Andreas Grodås Jørs				

Year	University	Name	Supervisor	Support	Completion
2023	NTNU	Martin Egerdahl (M)	Ole Jorgen Nydal	Laboratory support	2023
	Testing of controllers for PV2Heat (project report 2022) **PV-to-Heat: Control and monitoring methods (master thesis 2023)** Power controllers for PV to heating elements were tested, one commercial and one in-house. An Arduino based data logger was assembled and options for remote data access were investigated. The data logger for temperatures and PV power was housed in a 3D printed container.				

Year	University	Name	Supervisor	Support	Completion
2024	NTNU	Åsmund Nordskog (M)	Ole Jorgen Nydal	Laboratory support	2024
	Small scale wind power to heat. Optimizing power output by implementing a DC-DC converter (project 2023) A DC-DC converter was tested between a wind generator in bench and a resistive load. This gives improvements in the efficiency of the energy collection from a wind generator in the form of heat, but is limited to the accepted input band on the voltage The thesis work in the spring 2024 concerned testing of a load controller for a small scale wind turbine. Three heating elements were arranged with parallel and serial connections, and an AC load controller was made on the Arduino base and the system was successfully tested in bench.				

Year	University	Name	Supervisor	Support	Completion
2024	NTNU	Olav Torsvik (M)	Ole Jorgen Nydal	Laboratory support	2024
	Joint work with Åsmund Nordsko				

Year	University	Name	Supervisor	Support	Completion
2024	NTNU	Eli Enes (F)	Ole Jorgen Nydal	Laboratory support	2024
	Clean cooking in rural African areas (project 2023) The performance of a single tank oil/rock bed system with a new regulator is investigated. A funnel based system is controlled with a wire arrangement, such that the cooking power and temperature can be regulated. **Performance evaluation of Photo Voltaic clean cooker with oil based heat storage (master thesis 2024)** The thesis work in the spring of 2024 concerned testing of the system with external cooker, using an immersed PTC element, which is self regulating. The MPPT controller had a cut-off voltage which reduced the power from the PV panels. The benefit with the PTC element is that overheating of the oil is not possible, but the penalty is less power.				

Year	University	Name	Supervisor	Support	Completion
2024	NTNU	Une Skogen (F)	Ole Jorgen Nydal	Laboratory support	2024
	Joint work with Eli Enes				

Year	University	Name	Supervisor	Support	Completion
2024	NTNU	Elias Kolle Roskild (M)	Trygve Eikevik/OJ Nydal	Laboratory support	2024
	Develop an off-grid refrigerator for rural Africa (project 2023) Design and modeling of an adsorption based refrigeration cycle. Evaporation during the night creates ice and solar regeneration during the day. **Solar-based adsorption refrigeration systems for subzero cold storage (master thesis 2024)** A Methanol-carbon adsorption system was designed and constructed. The system was tested in the lab using high power lamps to simulate sunshine. The cooling power was less than expected and a model also supported the conclusion that scale-up is needed if the pair is to be used for practical solutions.				

Year	University	Name	Supervisor	Support	Completion
2024	NTNU	Ingvild Høilo Ongstad (F)	Trygve Eikevik/OJ Nydal	Laboratory support	2024
	Joint work with Elias Kolle Riskild				

Year	University	Name	Supervisor	Support	Completion
2024	UNAM/NTNU	Cecilia Ndafaanhu Naule (F)	Ole Jorgen Nydal	Laboratory support	2024
	Design and performance evaluation of an oil/rock bed heat Storage system for solar cooking A small scale oil based cooker was developed at University of Namibia, based on the experiences from the NTNU laboratory. Cecilia spent one semester at NTNU working with Arduino based data logger, whcihc enabled her to do experiments at UNAM after her return to Windhoek.				

Year	University	Name	Supervisor	Support	Completion
2025	NTNU	Mina Andrea Torvanger (F)	Ole Jorgen Nydal	Laboratory support	2025
	Adsorption refrigeration systems in sunny areas (project 2024) Experiments have previously been made with methanol and carbon as working pairs in an adsorption refrigeration system. The performance in the lab was not convincing. A new system was created, made of steel instead of copper, to accommodate ammonia as working fluid. Initial tests showed improved performance. **Optimization of Adsorption Refrigeration Systems for Sustainable Cooling in Sunny Areas (master thesis 2025)** Tests were made with the ammonia-carbon adsorption system showing improved performance. The setup was later shipped to UDSM for further work.				

Year	University	Name	Supervisor	Support	Completion
2025	NTNU	Ida Fredrikke Harsem (F)	Ole Jorgen Nydal	Laboratory support	2025
	Joint work with Mina Andreas Torvanger				

Year	University	Name	Supervisor	Support	Completion
2025	NTNU	Isak Johan Berggren (M)	Ole Jorgen Nydal	Laboratory support	2025
	Testing of a natural-circulating closed heat storage system for cooking (project 2025) A closed version of the dual-tank system was constructed and tested with a PTC heating element. The system has a valve instead of a floater for regulation of the flow rate. The system works, but the PTC element has a too early shutoff temperature, the system could reach about 180 degrees C on the oil.				

UDSM

Year	University	Name	Supervisor	Support	Completion
2022	UDSM	Neema Muhogolo (F)	Cuthbert Kimambo	Tuition Fee Laboratory Support	Mid 2025
	Cold Storage for Adsorption refrigeration system The main objective of this research work is experimental investigation of cold storage for reduction of variation of temperature in evaporator for the adsorption refrigeration system.				

Year	University	Name	Supervisor	Support	Completion
2023	UDSM	Juma Msuya (M)	Joseph Kihedu	Laboratory Support	Mid 2025
	Development of improved natural circulating thermal energy storage for a cooking application The dissertation will support PhD work which requires to use developed cooker. The main objective is to develop oil-based cooker with thermal storage based on improved natural circulating.				

Year	University	Name	Supervisor	Support	Completion
2024	UDSM	Stephen Kahabi (M)	Joseph Kihedu	Laboratory Support	Mid 2026
	Performance Evaluation of a Controller for Solar PV modules connected to Heating Element The dissertation will support ENET laboratory rigs for Sensible Oil Cooker and Adsorption Refrigeration which requires to use solar PV to heat as an alternative test source in addition to grid power. The main objective is to evaluate the performance of MPPT controller prototype connected to a solar PV module for heating applications				

AAU

Year	University	Name	Supervisor	Support	Completion
2022	AAU	Amir Nassir (M)	Dr.Ing Demiss Alemu and Fikadu Geremu	Scholarship and Laboratory Support	March 2023
	Effectiveness of heat exchange in two tank system with thermosiphon circulation The main objective of this research is the evaluation of the heat exchange effectives between the two tanks with thermosyphon circulation by using two experimental cases.				

Year	University	Name	Supervisor	Support	Completion
2022	AAU	Tihun Birhanu (F)	Abdulakdir Aman and Kamil Dino	Scholarship and Laboratory Support	March 2023
	Design and Simulation of Institutional Clean Cookstove Using Thermal Storage System The general objective of the research is to design, and simulate an institutional cookstove with thermal energy storage system. The performance of the developed institutional cook will be validated using existing institutional cookstove and national standard. The pot to be used has a diameter of around 600 mm for the preparation of sauce – 'wot'.				

Year	University	Name	Supervisor	Support	Completion
2022	AAU	Meseret Alemju (F)	Abduladadir Aman and Gashaw Getnet	Scholarship and Laboratory Support	June 2023
	**Numerical investigation on charging-discharging of a PCM using PV and thermal oil for injera baking application** The main objective of this research work is to numerically investigate the charging and discharging of a PCM using solar PV and thermal oil for injera baking applications. The EnergyNET project supported research and fellowship costs. She is currently working in Diredawa University in Ethiopia.				

Year	University	Name	Supervisor	Support	Completion

2022	AAU	Amir Nassir (M)	Dr.Ing Demiss Alemu and Fikadu Geremu	Scholarship and Laboratory Support	March 2024
	Effectiveness of heat exchange in two tank system with thermosyphon circulation The main objective of this research is the evaluation of the heat exchange effectives between the two tanks with thermosyphon circulation by using two experimental cases.				

Year	University	Name	Supervisor	Support	Completion
2022	AAU	Tihun Birhanu Beyene (F)	Abdulakdir Aman and Kamil Dino	Scholarship and Laboratory Support	March 2023
	**Design and Simulation of Institutional Solar Powered Cookstove Using Thermal Storage System** The general objective of the research is to design, and simulate an institutional cookstove with thermal energy storage system. The performance of the developed institutional cook will be validated using existing institutional cookstove and national standard. The pot to be used has a diameter of around 600 mm for the preparation of sauce – 'wot'. The EnergyNET project supported research and fellowship costs. She is currently working in Haramaya University.				

Year	University	Name	Supervisor	Support	Completion
2023	AAU	Abdisa Biruk (M)	Dr. Yilma Tadesse and Dr. Abdulkadir Aman	Tuition Fee Laboratory Support	2025
	Design and build a Solar Powered Cold-Storage System with Integrated Control and monitoring System				

Year	University	Name	Supervisor	Support	Completion
2023	AAU	Biruk Asrat (M)	Dr. Abdulkadir Aman and Gashaw Getnet	Tuition Fee Laboratory Support	2025
	experimental Investigation of a PV-Based Injera Baking System with Oil as Thermal Storage				

Year	University	Name	Supervisor	Support	Completion
2023	AAU	Dina Yacob (M)	Dr. Abdulkadir Aman and Dr. Yilma Tadesse	Tuition Fee , Scholarship and Laboratory Support	2025
	Experimental and numerical investigation of a solar PV cooker with thermal storage for energy saving				

Year	University	Name	Supervisor	Support	Completion
2024	AAU	Antehunegn Amare (M)		Tuition Fee Laboratory Support	2026
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				

Year	University	Name	Supervisor	Support	Completion
2024	AAU	Seid Nasser (M)		Tuition Fee Laboratory Support	2026
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				

Year	University	Name	Supervisor	Support	Completion
2024	AAU	Eyerusalem Yilma (F)		Tuition Fee ,Scholarship and Laboratory Support	2026

	She is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program

Year	University	Name	Supervisor	Support	Completion
2025	AAU	Bewketu Atalele Andualem (M)		Tuition Fee, scholarship and Laboratory Support	2027
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				

Year	University	Name	Supervisor	Support	Completion
2025	AAU	Elyakem Negestat Melisew (M)		Tuition Fee, scholarship and Laboratory Support	2027
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				

Year	University	Name	Supervisor	Support	Completion
2025	AAU	Endale Eyasu Beriso (M)		Tuition Fee, scholarship and Laboratory Support	2027
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				
Year	University	Name	Supervisor	Support	Completion
2025	AAU	Funny Aliye Yuya (F)		Tuition Fee, scholarship and Laboratory Support	2027
	She is currently engaged in coursework as a first-year student, and her thesis title will be defined in the second year of his study program				
Year	University	Name	Supervisor	Support	Completion
2025	AAU	Tazebew Tamiru Zerihun (M)		Tuition Fee, scholarship and Laboratory Support	2027
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				
Year	University	Name	Supervisor	Support	Completion
2025	AAU	Yohannis Dereje Mekonnen (M)		Tuition Fee, scholarship and Laboratory Support	2027
	He is currently engaged in coursework as a first-year student, and his thesis title will be defined in the second year of his study program				

MAK

Year	University	Name	Supervisor	Support	Completion
2022	MAK	Justine Mugala (F),	Karidewa Nyeinga Ndugu Nelson	Scholarship Laboratory Support Tuition Fee	
	Single tank heat storage simulation using Comsol. Developing proposal **Status:** Writing thesis; she delayed because of maternity leave. Thesis submitted for examination.				

Year	University	Name	Supervisor	Support	Completion

2022	MAK	Adons Agumenitwe (M)	Nicholas Kwarikunda Karidewa Nyeinga	Laboratory Support Tuition Fee	Graduated in January 2025
	MSc topic: Characterization of defects in photovoltaic modules using electroluminescence imaging and current-voltage curve measurement techniques Status: Adons completed in 2024 and graduated in January 2025.				

Year	University	Name	Supervisor	Support	Completion
2022	MAK	Robinson Omony (M)	Denis Okello Karidewa Nyeinga	Laboratory Support	2022
	Development of thermal energy storage system integrated with a cooking unit. The EnPe project supported his research and he continued and graduated in ENET. Robinson is Assistant lecturer at Gulu University. Gulu and Kabale are public universities				

Year	University	Name	Supervisor	Support	Completion
2022	MAK	Francis Ochola (M)	Nicholas Kwarikunda Karidewa Nyeinga	Laboratory Support	2022
	Automatic electronic photovoltaic heating system for charging thermal energy storage tank. The EnPe project supported his research and he continued and graduated in ENET. Francis is Assistant lecturer at Gulu University. Gulu and Kabale are public universities				

Year	University	Name	Supervisor	Support	Completion
2022	MAK	Rebecca Nambuya (F)	Prof. Kirabira	Scholarship Laboratory Support Tuition Fee	
	Status: she completed proposal; collecting data. In 2025: her progress has been slow.				

Year	University	Name	Supervisor	Support	Completion
2022	MAK	Pamella Sinia (F)	Prof. Eric Ochen Awic	Scholarship Laboratory Support Tuition Fee	
	Status: The student delayed; however, she is finalising the proposal and will start data collection within 3 months Status in 2025: student working on writing thesis; but progress is slow.				

Year	University	Name	Supervisor	Support	Completion
2022	MAK	Maseera Busiku Geofrey(M)	Dr. Erik Ochen Awic Dr. Firminus Mugumya Dr. Julius Omona	Scholarship Field work Tuition Fee	Completed in 2025, graduated on 27 February 2026
	Challenges and opportunities of access to clean and affordable cooking energy among refugee households in Bidibidi. Carry out field work in Bidibidi refugee camp, Yumbe. Status: Finalising comments on thesis; expected to submit within two months.				

Year	University	Name	Supervisor	Support	Completion
2024	MAK	John Kivumbi (M)		Research activities	
	Development of TES system based on PTCs for Chapati frying; currently developing proposal & running simple tests in the lab. Status in 2025: carrying out experiments and data analysis.				

Year	University	Name	Supervisor	Support	Completion
2024	MAK	Noah Kawooya (M)		Research activities	
	Performance analysis of 2kW wind turbine; currently developing proposal and collecting data. Status in 2025: proposal approved, carrying out experiments.				

UoJ/MAK

Year	University	Name	Supervisor	Support	Completion
2022	UoJ / MAK	Yak Mathok Kuc Baak(M)		Scholarship Laboratory Support Tuition Fee	
	Still on course work Dropped out of study in 2023 due to family reasons. Not sure he will return in 2024				

UEM

	Fully Financed		**Tuition Fees Financed**
1	Neima Sibia (F)	1	Amélia Sique (F)
2	Ilídio Oliveira (M)	2	Marsílio De Andrade (M)
3	Celma Mahunguele (F)	3	Fernando Beira (M)
4	Edvânia D'Uamba (F)	4	Samuel Buvane (M)
5	Carlino Chey (M)	5	Reis Chirinze (M)
6	Cármen de Castro (F)	6	Édgar Bobotela (M)
7	Otília Hilário Jonasse (F)	7	Erika Machirica (F)
8	Arão Macuácua (M)	8	Salima Salimo (F)
		9	Denise Vilanculo (F)
		10	Juliana Francisco (F)
		11	Taira Pene (F)
		12	Mário Chelengo (F)

Student Name / email	Specialization	Theme title	Supervisor
Ilídio Fernando Moisés Oliveira (M) ilidiooliveira441@gmail.com	Solar Energy	Environmental repercussions of solar energy - product chain and Projection PV Modules waste Management - case of Mozambique	**Alberto Tsamba** aj.tsamba@uem.mz
Amelia Antonio Sique (F)	Biomass Energy	Renewable resources for energy within ecological sustainability restrictions in Mozambique.	
Marsílio de Andrade marsilioneves@gmail.com (M)	Solar Energy	Analysis of the relationship between access to electricity and entrepreneurship - A literature study.	
Neima Lázaro Sibia (F) sibianeimalazaro@gmail.com	Biomass Energy	Technical viability studies for the installation of a biodigester in the future landfill of Matlemele	Rosa Chilundo rosychilundo@gmail.com
Edvania Ana Paulino D'Uamba (F)	Biomass Energy	Syn Gas production from coconut residues as a	Miguel Uamusse

edvania.d'uamba@uem.ac.mz		sustainable alternative of recycling	miguelmeque@gmail.com
Fernando Malanguisse Beira (M) fernandobeira11@gmail.com	Biomass Energy	Biogas production in humid zones	Alberto Tsamba aj.tsamba@uem.mz
Celma da Conceição Luís Mahunguele (F) celmamahunguele@outlook.com	Biomass Energy	Pre-carbonization of Jatropha seeds Shell for the production of brickets	Adolfo Condo condo.a1143@gmail.com
Reis Bernardo Chirinze (M) reisbirnardo@gmail.com	Solar Energy	Simulation of a low-cost solar thermal system for buildings cooling in Maputo City	
Édgar João Bobotela (M) edgarbobotela@gmail.com	Solar Energy	Projecto de um Sistema Híbrido Solar Térmico-Gás Natural para o Aquecimento da Piscina Josina Machel	Geraldo Nhumaio geraldo.nhumaio@gmail.com Doutor Valter Manjate (wvaltemanjate@gmail.com)
Mário Chelengo (M)	Energy Systems Economic Management	Energy acess challenges in the peri-urban areas of Mozambican town-the impact of georeferencing the electrical power losses	Alberto Júlio Tsamba aj.tsamba@uem.mz
Cármen Agapito de Castro (F)	Energy Systems Economic Management	Technical and economic feasibility study for power generation using Hulene dumping site Urban Waste as feedstock	Carlos Lucas (clucas33@yahoo.com), Cardoso Muendane (sics@sics.co.mz) and Adolfo Condo (condo.a1143@gmail.com)
Otília Jonasse (F)	Energy Systems Economic Management	Economic Feasibility Study of a Wind Power Park in Marracuene District	Rosa Chilundo (rosa.chilundo@edm.co.mz), and Valter Manjate (wvaltemanjate@gmail.com)
Érika Machirica (F)	Energy Systems Technical Management	Study of the use of pico-hydro power for irrigation water pumping-the case of Boane District	Geraldo Nhumaio geraldo.nhumaio@gmail.com
Arão Moniz Macuacua (M)	Energy Systems Technical Management	Economic and Technical Feasibility study of the installation of small biodigesters in Zimpeto Wholesales Market	Carlos Lucas e Adolfo Condo
Taira Otédia Pene (F)	Energy Systems Technical Management	Economic and Technical feasibility and receptivity study of solar thermal powered desalinisation models-the case of Chicualacuala District (Gaza)	Genito Maure Genito.maure@uem.mz
Denise Xavier Vilanculo (F)	Energy Systems Technical Management	Cost-benefit analysis of small projects with energy storage systems for electricity-the case of the Solar PV Power plant in Mapulanguene	Manuel Sibia mansibia@hotmail.com
Juliana Jennifer Francisco (F)	Solar Energy	Contribution of Solar Photovoltaic System for energy transition in project for supplying and desalination of drinking water.	Luís Chea
Samuel Buvane (M)	Solar Energy		To be submitted
Salima Amade Salimo (F)	Energy Systems Economic Management	Economic Feasibility Analysis for the installation of a biodigester to generate biogas for chicken litter	Cardoso Muendane and Carlos Lucas
Carlino Tam Ming Chey (M)	Biomass	National potential in marine biomass for biodiesel production	Alberto Júlio Tsamba aj.tsamba@uem.mz

Appendix Publications and conferences

2025

Jimmy Chaciga, Denis Okello, Karidewa Nyeinga, Ole J. Nydal.(2025). *Experimental analysis on a solar photovoltaic indoor cooker integrated with an energy storage system: A positive step towards clean cooking transition for Sub-Saharan Africa*; Solar Compass; https://doi.org/10.1016/j.solcom.2025.100109

Karidewa Nyeinga, Jimmy Chaciga, Denis Okello (2025). S*olar Photovoltaic cooker: A Technical Analysis of a system suitable for institutional cooking*. Energy 360 4 (2025) 100047 https://doi.org/10.1016/j.energ.2025.100047

Okello, D., Chaciga, J., Nydal, O. J., & Nyeinga, K. (2025). *Experimental Thermal Performance of Air-Based and Oil-Based Energy Storage Systems*. Energy Storage and Applications, 2(4), 15.

Pamella K. Kajumba, Jimmy Chaciga, Ole J. Nydal, Denis Okello, Karidewa Nyeinga. *Experimental and simulation analysis for different pot-in-pot indirect heating scenarios for cooking applications*, Tanzania Journal of Science: Vol. 51: Vol. 51: Iss. 4, Article 21. https://doi.org/10.65085/2507-7961.1129

Mwasubila IJ, Nydal OJ, Kimambo CZM, Kihedu JH (2025) *Performance Dynamics of Activated Carbon-Methanol Pair in Adsorption Refrigeration Systems*. Special Issue of 8th International Conference on Mechanical and Industrial Engineering. Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 44 No 2, pp 377-385. https://doi.org/10.52339/tjet.v44i2.1313

Nyirenda, EJ, Nielsen TK, Kihedu JH, Kimambo CZM (2025) *Potential use of Pump as Turbine Coupled to Self-Excited Induction Generator for Micro-hydro Cooking and Cooling Applications*. Special Issue of 8th International Conference on Mechanical and Industrial Engineering. Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 44 No 2, pp 331-339. https://doi.org/10.52339/tjet.v44i2.1309

Sharishoy AK, Kihedu JH, Kimambo CZM (2025) *Comprehensive Review of Sensible Thermal Storage Systems for Cooking Applications. S*pecial Issue of 8th International Conference on Mechanical and Industrial Engineering. Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 44 No 2, pp 239-255. https://doi.org/10.52339/tjet.v44i2.1279

Kihedu JH, Msuya J (2025) *Prospects of Clean Cooking Energy in Africa - Transition Pathways and Implications.* Special Issue of 8th International Conference on Mechanical and Industrial Engineering. Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 44 No 2, pp 19-40. https://doi.org/10.52339/tjet.v44i2.1260

Ole Jorgen Nydal, Peter Mashingo, Gunn Helen Nylund, Andreas Bjørshol, Alexander Peter Olsen and Jimmy Chaciga (2025) *Passive temperature regulation in a heat storage for cooking with internal natural oil circulation* Front. Energy Res., 18 August 2025. Volume 13 - 2025 https://doi.org/10.3389/fenrg.2025.1627862

Casiana Blasius Lwiwa and Ole Jørgen Nydal (2025) *Experiments on a discretized 3D compound parabolic concentrator with a sensible heat storage* Author links open overlay panel Next Energy, Volume 7, April 2025. https://www.sciencedirect.com/science/article/pii/S2949821X24001297

24th edition in Manchester, UK, from August 26-29,
I presented remotely at the World Renewable Energy Congress (WREC).

Tihun Birhanu Beyene, Abdulkadir Aman Hassen and Kamil Dino Adem (2025), *Design and Simulation of Institutional Solar-Powered Cook Stove With Thermal Energy Storage System*, ISES Solar World Congress 2025, 03 - 07 November in Fortaleza, Brazil

Zelalem Teshome and Abdulkadir Aman Hassen, (2025) Design, and Experimental Investigation of Indirect Solar Thermal Cooker for Street Food Cooking,ISES Solar World Congress 2025, 03 - 07 November in Fortaleza, Brazil

Abdulkadir A. Hassen, Gashaw G. Birhanu , Demiss A. Ambie , Ole J. Nydal, (2025) *Long-Term Performance Analysis of a Solar PV-Based Injera Baking System with Thermal Storage* , World Renewable Energy Congress 2025, Manchester, United Kingdom- August 26-29,2025

Mohammedamin Gemeda , Abdulkadir Aman Hassen, *Development of PV/T Heat Pump Dryer Systems with Thermal storage for Drying Agricultural Produce: A review.* (2025) World Renewable Energy Congress 2025, Manchester, United Kingdom- August 26-29, 2025

Gashaw G. Birhanu, Demiss A. Ambie , Abdulkadir A. Hassen, Ole J. Nydal, (2025) *Experimental and Numerical Investigation of a Heating Unit for PV Based Injera Baking Application*, World Renewable Energy Congress 2025, Manchester, United Kingdom- August 26-29, 2025

Fikadu Geremu Bodena, Demiss Alemu Amibe, Ole Jorgen Nydal, and Trygve Magne Eikevik, (2025) *Experimental Analysis of Small-Scale Photovoltaic-Powered Simultaneous Milk Pasteurization and Cooling Utilizing Heat Recovery with Thermal Storage*, World Renewable Energy Congress 2025, Manchester, United Kingdom- August 26-29, 2025

2024

Jimmy Chaciga, Karidewa Nyeinga, Denis Okello, Ole J. Nydal. 2024. *Experimental analysis on a solar photovoltaic indoor cooker integrated with an energy storage system: A positive step towards clean cooking transition for Sub-Saharan Africa. Solar Compass* (2025), doi: https://doi.org/10.1016/j.solcom.2025.100109

Ole Jorgen Nydal (2024) *Heat Storage for Clean Cooking* Keynote Presentation 8Th International Conference on Mechanical & Industrial Engineering, MIE 2024, 24-25 October 2024 NM-AIST, Arusha, Tanzania. https://www.youtube.com/watch?v=WDO2SOfnGgQ

Mwasubila, I.J., Kimambo, C.Z.M., Kihedu, J.H. and Nydal, O.J. (2024) '*Heating and Cooling Performance of Adsorber Bed Powered by Solar Lamps*', *International Conference on Applied Energy Proceedings*, 42, pp. 1–5. Available at: https://doi.org/10.46855/energy-proceedings-10999

Mwasubila, I.J., Kimambo, C.Z.M., Kihedu, J.H. and Nydal, O.J. (2024) '*Performance Dynamics of Activated Carbon Methanol Pair in Adsorption Refrigeration systems*', *TJET Special Issue for MIE Conference 2024* (Accepted for publication)

Meseret Alemu Abinet, Abdulkadir Aman Hassen & Gashaw Getnet, *Numerical Investigation on Charging–Discharging of a PCM Using PV and Thermal Oil for Injera Baking Application*, International

Journal of Photoenergy, Volume 2024, Article ID 5561719, 14 pages, https://doi.org/10.1155/2024/5561719

Daniel Asrat Mestesalem, Abdulkadir Aman Hassen(2024) *Performance Improvement of Electric Injera Mitad* 8Th International Conference on Mechanical & Industrial Engineering, MIE 2024, 24-25 October 2024 NM-AIST, Arusha, Tanzania

Nyirenda E, Nielsen TK, Kihedu JH, Kimambo CZM. (2024) *A Bibliometric Analysis of PAT-SEIG Evolution as an Alternative Energy Generation Method.* Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 43 No 4, pp 22-35. https://doi.org/10.52339/tjet.v43i4.1000

Nyirenda E, Kihedu JH, Kimambo CZM, Nielsen TK. (2024) *Optimization Pump as Turbine Coupled to a Self-Excited Induction Generator Using Multi-Objective Genetic Algorithm.* Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 43 No 1, pp 134-143. https://doi.org/10.52339/tjet.v43i1.983

Nyirenda, Nielsen TK, EJ, Kihedu JH, Kimambo CZM (2024) Transient Behaviour of Pump as Turbine Coupled to Self-Excited Induction Generator Under Variable Load Conditions. Energy Proceedings, Volume 39, Energy Transitions towards Carbon Neutrality Part II, ISSN 2004-2965 (13th International Conference on Applied Energy, Doha, Qatar). https://doi.org/10.46855/energy-proceedings-10927

2023

Ole Jorgen Nydal (2023) *Experiences on developing heat storage for cooking*. Fifth International Conference CONSOLFOOD2023 Advances in Solar Thermal Food Processing 12-13-14 July 2023, A Coruna, Spain.https://www.youtube.com/watch?v=2pBCK3VCPbg&list=PLhg5QcqkbudToUMKfiQFHKCjsHC3Uwnj9&index=15&pp=iAQB

Ole Jorgen Nydal (2023) *Heat Storage for Cooking: A Discussion on Requirements and Concepts.* Energies 2023, 16(18), 6623; https://doi.org/10.3390/en16186623

Abraham Parra and Ole Jorgen Nydal (2023) *Latent heat storage for solar frying* Solar World Conference SWC 2023, 30th Oct – 4th Nov 2023, New Delhi, India.

Nyirenda, EJ, Kihedu JH, Kimambo CZM (2024) *Transient Behaviour of Pump as Turbine Coupled to Self-Excited Induction Generator Under Variable Load Conditions.* Energy Proceedings, Volume 39, Energy Transitions towards Carbon Neutrality Part II, ISSN 2004-2965 (13th International Conference on Applied Energy, Doha, Qatar). https://doi.org/10.46855/energy-proceedings-10927

Mwasubila IJ, Kimambo CZM, Kihedu JH, Nydal OJ (2024) *Heating and Cooling Performance of Adsorber Bed Powered by Solar Lamps.* Energy Proceedings, Volume 42, Energy Transitions towards Carbon Neutrality Part V, ISSN 2004-2965 (13th International Conference on Applied Energy, Doha, Qatar). https://doi.org/10.46855/energy-proceedings-10999

Emanuel J. Nyirenda, Joseph H. Kihedu, Cuthbert Z.M. Kimambo (2023). *Performance Behaviors of PAT-SEIG when Operating Under Variable Load Conditions*. Renewable Energy and Environmental Sustainability (accepted for publication)

J. Chaciga, K. Nyeinga, D. Okello, and O. J. Nydal, *Design and experimental analysis on a 52 single tank energy storage system integrated with a cooking unit using funnel system* J Energy 53 Storage, vol. 79, Feb. 2024, doi: 10.1016/j.est.2023.110163.

Jimmy Chaciga, Karidewa Nyeinga, Denis Okello, Ole J. Nydal. *Experimental Analysis on a Single Tank Energy Storage System Integrated with a Cooking Unit.* ISES Solar World Congress, New Delhi India, 29 Oct – 5 Nov 2023.

Swaleh Tusiime, Karidewa Nyeinga, Denis Okello and Ole J. Nydal. 2023. *Thermal Performance of a Mechanical Thermostat for Charging an Energy Storage System*. Tanzania Journal of Science. Vol. 49(2), DOI: https://dx.doi.org/10.4314/tjs.v49i2.1

Fikadu G. Bodena , Ole J. Nydal, Trygve M. Eikevik, and Demiss A. Amibe (2023). *Long-Term Performance Analysis of Ice Thermal Cold Storage with Photovoltaic-Powered DC Refrigeration System for Milk Cooling Through Computational Model*. ISES Solar World Congress, New Delhi, India (to be published)

Gashaw G. Birhanu, Ole J. Nydal, Demiss A. Ambie, Abdulkadir A. Hassen (2023). *Development of a Thermal Storage System for Solar PV Based Injera Baking Application*. ISES Solar World Congress, New Delhi, India (to be published)

Abdulkadir A. Hassen, Mintesinot Yohannes Jorgaa (2023). *Design and Development of Double Exposure Solar Cooker with Finned Cooking Vessel*. ISES Solar World Congress, New Delhi, India (to be published)

2022

Casiana Blasius Lwiwa, Ole Jørgen Nydal (2022) *3D Ray tracing for optimizing a mirror tiled Compound Parabolic Concentrator*. Proceeding of the 16th International conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT), 8-10 August, 2022, Online

Casiana Blasius Lwiwa, Ole Jørgen Nydal (2022) *A Ray tracer for optimizing solar concentrating systems: the case of discretized Compound Parabolic Concentrator* Proceedings of the 63rd International Conference of Scandinavian Simulation Society, SIMS 2022, Trondheim, Norway, 20-21 September 2022

Casiana Blasius Lwiwa, Ole Jørgen Nydal (2022) *Interception on Solar Absorbers: Ray Tracing for Comparison between a Parabolic Reflector and a Compound Parabolic Concentrator* Proceedings of the EuroSun2022- ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry, Kassel, Germany, 25-29 September 2022

Tomás Nhabetse (2022) *Experimental study of an oil based heat pipe evacuated tube collector for cooking applications*, September 2022, Kassel, ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry

Casiana Blasius Lwiwa, Ole Jørgen Nydal (2022) *Sensible heat bean cooker* Tanzania Journal of Engineering Technology (TJET), Volume XX, 2023, Pages xxx-xxx. (Presented in the 7th International Conference In Mechanical and Industrial Engineering (MIE 20-21 October 2022), New Library, UDSM-Tanzania

Denis Okello, Robinson Omony, Karidewa Nyeinga, and Jimmy Chaciga. (2022). *Performance Analysis of Thermal Energy Storage System Integrated with a Cooking Unit*. Energies 2022, 15, 9092. https://doi.org/10.3390/en15239092 (results from EnPe project)

Pamella K. Kajumba, Denis Okello, Karidewa Nyeinga, and Ole J. Nydal. (2022). *Assessment of the energy needs for cooking local food in Uganda: A strategy for sizing thermal energy storage with cooker system*.

Energy for Sustainable Development 67 (2022) 67–80. https://doi.org/10.1016/j.esd.2022.01.005 (results from EnPe project)

Nyirenda, EJ, Kimambo CZ, Kihedu J (2022) *Performance Behaviors of PAT-SEIG when Operating Under Variable Load Conditions*. Proceedings of the 6th International Conference on Mechanical and Industrial Engineering, University of Dar es Salaam*, Tanzania* (presentation only)

Raymond J, Kihedu JH, Kimambo CZM. (2022) *A Model for Sustainable Adoption of Solar Photovoltaic Technology in Tanzania.* Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 41 No 2, pp 16-33 (publication from previous EnPe program of the network).

2021

Casiana B. Lwiwa and Ole J. Nydal (2021). *3D ray tracing for optimizing the size of surface tiles on a compound parabolic concentrator* SASEC 2021 Southern African Sustainable Energy Conference 17-19 Nov. 2021, Stellenbosch, South Africa

Tomas M. Nhabetse, Boaventura C. Chongo, Claudio L. Tingote and Ole J. Nydal (2021) *Temperature profile of an oil based evacuated tube solar collector for cooking application* SASEC 2021 Southern African Sustainable Energy Conference 17-19 Nov. 2021, Stellenbosch, South Africa (presentation only)

Tomás Nhabetse (2021) *Design solar PV for topping up energy of an oil based solar thermal collector for cooking applications,* 3rd International Conference on Solar Technologies and Hybrid Minigrids to improve energy access, September 2021, Mallorca, Palma, Spain;

John M, Kimambo CZ, Nydal OJ, Kihedu JH (2021) *Performance of Calcium Chloride-Ammonia Adsorption Refrigeration System.* Tanzania Journal of Engineering and Technology, UDSM-CoET, ISSN: 2619-8789; Vol. 40 No 1, pp 39-49 (publication from previous EnPe program of the network)

Other dissemination

2023

MAK

Jimmy Chaciga summarized the Arduino based data logger as a tutorial for others at UNET Workshop.

MAK staff participated in a Renewable Energy Conference and Expo 2023 in Uganda organized by Ministry of Energy and Mineral development, MEMED November 2023.

Jimmy Chaciga organized a stand presenting the MAK work on heat storage for cooking at the UNDP and Makerere University Expo 2023.

2024

UNET

https://ntnu.cloud.panopto.eu/Panopto/Pages/Viewer.aspx?id=8152e3cf-8f7a-4d84-b3fc-b29900d45131

Maren Agdestein published in Norwegian SciTech News:
Cooking with solar ovens in sub-Saharan Africa

https://norwegianscitechnews.com/2024/06/cooking-with-solar-ovens-in-sub-saharan-africa/

Nancy Bazilchuk from the NTNU communication division prepared a pod cast:
https://shows.acast.com/63-degrees-north/episodes/old-flames-die-hard

Appendix Project log

Time log of EnergyNET meetings

Date	Name	Event
27.01.2021	OJ	NTNU information meeting on Norhed projects and consolidated management
18.02.2021	OJ	UNETAfrica.net domain established and hosted by Wordpress.com
19.02.2021	Partners	Kick-off meeting on TEAMS
26.02.2021	NTNU students	Presentation of status on single tank system
05.03.21	NTNU Students	Presentation of PCN fryer system
08.03.21	OJ, Tonje, Camilla	EnergyNET adm systems and budget revision
09.03.21	OJ, Tonje, Norad	Meeting with Vibeke Sørum in Norad on budget revision
12.03.21	Partners	Progress meeting. Budget revision.
19.03.21	Demis, Abdulkadir	Technical discussions on AAU milk pasteurization/chilling system
23.03.21	UNIMA, UDSM ++	Discussion on PAT PhD plans. for UNIMA candidate (Emmanuel) at UDSM
24.03.21	MAK ++	Discussion on solar system for PhD at MAK (Jimmy)
26.03.21	Mulu, Thomas, OJ	Discussion on hybrid system: PV/thermal/wind
23.04.21	Partners	Progress meeting instead of workshop
07.05.21	Partners, MSc stud	MSc students at NTNU presents single tank cooker
10.05.21	Partners, MSC stud	MSc student at NTNU presents PCM fryer
12.05.21	NTNU Norhed	Information meeting on partner agreements
25.05.21	NTNU	Template Partner Agreement ready
15.06.21	NTNU, Camilla	First version of partnership contract ready, saved in the folder “partnership contract”
06.07.21	NTNU,UDSM	Telephone meeting Workshop1
08.09.21		Last signature on PA received (MU on hold). Fund transfers have been executed after each signature
30.08-03-09	Partners	Workshop organized by UDSM, hosted by ATC, Arusha, Tanzania
30.09.21	Partners	Technical meeting on MAK PhD Jimmy: single tank heat storage system
09.11.21	NTNU	NTNU seminar with all NTNU NorhedII projects
30.11.21	Partners	Workshop organized by UDSM, hosted by ATC, Arusha, Tanzania
2022		
14.01.22	Partners	Startup meeting 2022
24.01.22	NTNU	Norhed NTNU meeting on reporting. Templates posted
26.01.22	NTNU	Information on Audition - templates for requests on auditors
26.01.22	OJ	Templates for financial and narrative reports posted
11.02.22	Partners	Progress meeting on reporting, Teams
11.02.22	OJ	Framework for ENET report 2021 for updating by all
18.03.22	AAU/UDSM	Technical meeting on refrigeration systems at AAU and UDSM
25.03.22	UEM	Technical meeting on the results from the solar heat collection with evacuated tube collectors
18.03.22	AAU,partners	Technical meeting on Electric Injera Baking
01.04.22	AAU	Technical Meeting on refrigeration system at AAU
08-04-2022	AAU	Technical Meeting on Injera Fryer
08.04.22	Partners	Progress meeting, Workshop, Teams
25-28.04.22	MAK	MAK hosted an overall Norhed seminar week at Makerere, 21 MAK projects.
06.05.22	NTNU	Open day at Workshop3, 13 contributions on drivers for technology development and implementation
9-10.05.22	Partners	Workshop3 hosted by NTNU
10.05.22	MAK	Jimmy stays at NTNU for one month working on the single tank system
16-20.05.22	MAK	Workshop8 at MAK on PV and biogas
25.05.22	All	Audit Report Templates received and posted on Teams. Rechecked signature dates
31.05.22	All	Rechecked signature dates on Audit Report Templates and notified all on need for processing
24.06.22		Technical meeting
29.06.22	NTNU	Norhed NTNU meeting
01.09.22		Norhed seminar Oslo
10.09.22	NTNU	OJ research period Tanzania
20.09.22	NTNU, UDSM	MIE2022 conference UDSM
25.09.22	NTNU	OJ Research period Uganda
20.10.22	UDSM	MIE 2022 Conference organized by UDSM. OJ attended.
19.10.22	NTNU	OJ visit AAU
09.11.22	UEM, NTNU	Social-scientific PhD at UEM: Cândida Bila. Working meeting with Inês Raimundo and Govert Valkenburg, will continue weekly.
5-12.12.22	UEM	OJ attended SANORD conference and visited UEM and UniSAVE

2023		
9-11.1.23	MAK	MAK hosted annual meeting for 2022
9-11.1.23	MAK	MAK hosted annual meeting for 2022
18.01.23	NTNU	Update meeting with Ingvild Heggstad, Norhed coordinator NTNU
02.02.23	NTNU, Norad	Status update on Ethiopia
02.02.23	NTNU	Templates for reporting for 2022
9-10.02.23	All	Norhed zoom meetings with all NTNU coordinated projects: reporting for 2022
15.02.23		Implementation plan and budget 2023 submitted
21.02.23	MAK	Jimmy Chaciga presented status on PV cooking tests at MAK on Teams meeting
27-28.2.23	UDSM	UDSM hosted the Third NORPART Stakeholders meeting in Arusha, Tanzania.
8.2-7.5.23	UDSM	Two PhD candidates visited NTNU under the NORPART Project
8.2-7.6.23	UDSM	Four master students visited NTNU under the NORPART Mobility Project support.
10-14.4.23	UDSM	Four UDSM supervisors visited NTNU under the NORPART Mobility Project support.
4.8.2023	All Partners	EnergyNET progress review online meeting on Teams platform.
10.8.23	UDSM	OJ Nydal visited UDSM and met with Project Coordinator, Team and students.
30.8-28.11.23	UDSM	One PhD candidate visited NTNU under the ENET Project
4-7.9.23	All Partners	Fifth Workshop of EU Erasmus - UNET project at AAU.
28-9-23	UDSM/NTNU	NTNU, UDSM and SJTU online meeting on possible collaboration.
9-13.10.23	UDSM/NTNU	NORHED II Week in Dar es Salaam, Tanzania - hosted by UDSM.
15-18.11.23	UDSM	Hosting visitors from UEM.
27-30.11.23	MAK	Hosted UNET Workshop at Kampala Uganda.
9-6.12.23	UDSM	Supervisors and three PhD students attended ICAE Conference in Doha, Qatar.
2024		
17.01.24	UDSM	PhD seminar online
31.01.24	UDSM	PhD seminar online
07.02.24	UDSM	PhD seminar online
12-16.02.24	UEM	Annual meeting hosted by UEM, Maputo
21.02.24	MAK	PhD seminar online
06.03.24	MU/NTNU	PhD seminar online
13.03.24	UEM	PhD seminar online
20.03.24	AAU	PhD seminar online
08-12.04.24	NTNU	Arrival PhDs from AAU, UDSM, MAK, MU 3 month stay at NTNU
10.04.24	UEM	PhD seminar online
17.04.24	AAU	PhD seminar online
24.04.24	MU	PhD seminar online
16.05.24	NTNU	Workshop7 at NTNU – after UNET Workshop 13-15 May PhD presentations
21.05.24	NTNU/MU	PhD visit from MU
26.02-19.04	UEM	ENET PhDs at UEM during UNET training
18.03-19.04	UDSM	ENET PhDs at UDSM during UNET training
08.07-31.08	MAK	ENET PhDs at MAK during UNET training
23.09-23.11	AAU	ENET PhDs at AAU during UNET training
30.09-06.10		NORHED week Malawi
18.09.24	NTNU	PhD seminar online
09.10.24	MU	PhD seminar online
16.10.24	UEM	PhD seminar online
23.10-24.10	UDSM	Presentations from ENET PhDs on MIE2024 conference, Arusha (UDSM organized)
16.09-27.09	MAK	OJ participate at MAK during PhD UNET visits to MAK
02-06-12-24	UDSM	Annual meeting during Workshop Tanzania
2025		
7-11.01.25	AAU, MAK	Visit Karidewa and Abdulkadir to NTNU
20.01.25	NTNU	PhD defence Casiana Lwiwa at NTNU.
3-14.02.25	NTNU	OJ visit to Tanzania; including VETA ; Moshi, Iringa, Dodoma
17-21.02.25	NTNU	OJ visit Makerere
21.03.25	MAK	PhD Defence Jimmy Chaciga, Makerere
26.03.25	MAK	PhD presentation Jimmy
02.04.25	UEM	PhD presentation Tomas
09.04.25	AAU	PhD presentation Gashaw
30.04.25	UDSM/MUBAS	PhD presentation Emanuel
08-10.04.25	MAK	Presentation of the ENET work during the Makerere University Research and Innovation week
07.05.25	MU	PhD presentation Tsige
14.05.25	MAK/UoJ	PhD presentation Tito

21.05.25	NTNU	PhD presentation Casiana, summary of her work
28.05.25	NTNU	Discussion on load switching with PTCs, OJ
10.06.25	UEM	Discussion on scope of work for Paulino, UEM
11.06.25	AAU	PhD presentation Fekadu
18.06.25	UDSM	PhD presentation Ibrahim
06.25	UDSM	Ibrahim Joseph visit for one month at NTNU
06.25	UDSM	Joseph Kihedu visit for one week at NTNU
20.08.25	NTNU	Coordinators meeting
03.09.25	UDSM	PhD presentation Ibrahim, summary of his PhD
10.09.25	NTNU	Weekly meeting. Update annual meeting
15.09.25	NTNU	OJ present ENET at Norwegian Embassy in Dar es Salaam during visit to UDSM
17.09.25	UDSM	PhD presentation by Anna. Report from innovation week Dar es Salaam
19.09.25	NTNU	OJ present ENET at Norwegian Embassy in Addis Ababa during visit to AAU and MU
24.09.25	UDSM/MUBAS	PhD presentation by Emanuel, summary of the PhD
01.10.25	MUBAS	Update on annual meeting
08.10.25	NTNU	Reporting on load switching
15.10.25	NTNU	General update meeting
10-12.2025	AAU, UEM	Gashaw, Fikadu, Paulino visit to NTNU 3 months
22.10.25	MUBAS	Update annual meeting, Tito presentation, ntraAfrica call
10-14.11.25	MUBAS	Annual meeting in Malawi. Stakeholders included. Visit to micro-grid.
28.10.25	NTNU	Weekly meeting. CCAC call proposals
07.11.25	AAU	Fikadu presentation refrigeration system
25.11.25	NTNU	Weekly meeting, update on reporting and on CCAC proposal
03.12.25	NTNU	Weekly meeting. No-cost extension. CCAC update
09.12.25	MAK	Review on CCAC proposal
15.12.25	NTNU	Meeting on proposal for excess funds

Appendix PhD researchers

Title: Investigation of the Performance of Adsorption refrigeration System Utilising Low-Grade Heat Sources

Name: Joseph Ibrahim Mwasubila
University: University of Dar es Salaam (UDSM), Tanzania
Supervisors: Cuthbert Kimambo, and Joseph Kihedu (UDSM), Trygve Eikevik and Ole Jorgen Nydal (NTNU)

Baseline

Lack of cold storage facilities for ensuring year-round availability of food and an adequate supply of immunization vaccines is a serious challenge in many parts of the of developing countries that either have little or no access to electricity. Solar thermal refrigeration using the principle of adsorption is one of the viable ways of utilizing solar energy to power cooling systems.

Research work on solar refrigeration using the adsorption principle started at UDSM in the mid - 1980s. Currently, UDSM in collaboration with NTNU are undertaking research and development work, involving a PhD thesis on development of solar adsorption refrigeration system for off - grid application. Two pairs, namely NH3 - CaCl2 and NH3 - activated carbon have been studied. The tested laboratory adsorption prototypes attained temperatures that are sufficiently low for storage of vaccines and foods products, producing ice or in air conditioning systems by using low temperature heat source of 75 °C to 110 °C, which can be supplied by solar thermal collectors. Also, the use of waste heat in small renewable energy systems and heat generated by burning biomass materials such as agricultural waste is possible, in the remote parts of developing countries or islands where conventional cooling is difficult. The preliminary results that have been obtained so far, have prompted UDSM to seek support for the development of a full-scale adsorption refrigeration system, which can eventually be commercialized.

Objectives

The proposed PhD research will be multidisciplinary research covering technical issues related to the adsorption refrigeration systems, socio-economic, environmental and technology transfer aspects of the technology. It will involve upscaling of the system researched in the EnPe project, manufacturing and assembly at a field operation. A replicable technology transfer framework will be developed and applied to the system. A batch of the system will be manufactured for field testing and feedback obtained will be used to improve the systems and its dissemination frameworks.

Status

The candidate was recruited in late 2021. A project plan in form of a research proposal was developed and approved, as a required for PhD startup activity at UDSM. This was accomplished in communication with co-supervisors at UDSM and at NTNU. The research proposal was built on the results from previous PhD candidate from the EnPe program. The candidate managed to defend PhD research proposal before Departmental Postgraduate Committee in October 2022 and again in December 2022. The candidate successfully defended the PhD research proposal before the Special Postgraduate Panel in January 2023 and received permission to proceed with data collection. In March 2025, the candidate successfully defended his thesis before the Departmental Postgraduate Panel.

The candidate visited NTNU between February and April 2023 and then again from August to November. At NTNU, the candidate developed two experimental rigs and conducted tests from which adequate data has been obtained. At Makerere University, the candidate attended two trainings in heat transfer and solar technologies between August and October 2024.

Dissemination activities:

1. Participated in two international conferences: International Conference of Applied Energy (ICAE) and the International Conference in Mechanical and Industrial Engineering 2024 (MIE 2024) with oral presentation of two research papers.

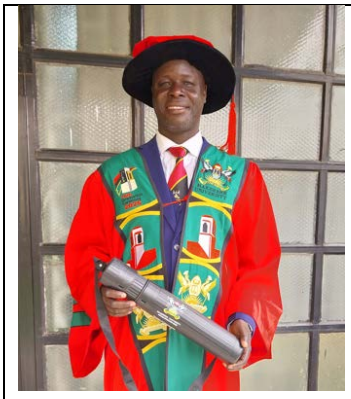
Publications

2. Mwasubila, I.J., Kimambo, C.Z.M., Kihedu, J.H. and Nydal, O.J. (2024) 'Heating and Cooling Performance of Adsorber Bed Powered by Solar Lamps', *International Conference on Applied Energy Proceedings*, 42, pp. 1–5. Available at: https://doi.org/10.46855/energy-proceedings-10999
3. Mwasubila, I.J., Kimambo, C.Z.M., Kihedu, J.H. and Nydal, O.J. (2024) 'Performance Dynamics of Activated Carbon Methanol Pair in Adsorption Refrigeration systems', *TJET Special Issue for MIE Conference 2024* (Accepted for publication)

So far, the candidate is currently working on two papers: a journal paper and conference Paper.

Further work

After exchange visit to NTNU in 2023, the candidate will re-build adsorption refrigeration system utilising activated carbon ammonia and conduct laboratory experiments. Likewise, he is expected to graduate and defend his PhD by mid 2025.



Title: *Development of solar thermal energy technology for off-grid cooking application*

Name: Jimmy Chaciga
University: Makerere University, Uganda
Supervisors: Karidewa Nyeinga (MAK), Denis Okello (MAK) and Ole Jorgen Nydal (NTNU)

Baseline

The renewable energy group at Makerere University has long experience in the development and testing of small-scale solar heat storage for cooking. Some good findings from previous research/projects are very important for new research and innovations. A particular result from the EnPe project will be optimized and brought to field testing. The system uses photovoltaics as power sources to generate off-grid electricity to charge an oil & rock pebble-based heat storage to a temperature of about 250 ^{o}C by a method of funnel system to a cooker. Emphasis has been made on simplicity, robustness, safety and the potential for local production. The concept has been tested and proven at MAK and NTNU.

Objectives

The main objective was to develop a prototype of the solar cooker integrated with heat storage for immediate and later cooking after sunset. The laboratory units will mirror the system to be deployed in the field. The system should be able to be upscaled for application to a school in a refugee camp in Northern Uganda and other parts of Uganda for boiling daily food to reduce the use of firewood and charcoal. Performance tests in the field will be made, data will be collected and the results from an autonomous data logging system will be analyzed.

Status

Jimmy Chaciga successfully defended his PhD Thesis in 21st March 2025 at Makerere University. He will graduate in January 2026. Jimmy has been very active. He presented his proposal in 2021 and got full admission in 2022. He embarked on experimental work immediately after registration and has been very active in building and testing a prototype single tank cooker and Dual tank cooker with heat storage powered by PV panels. He demonstrated cooking tests in all weather conditions. The first test is conceptual, with power from the grid. The concept is similar to the one developed jointly with NTNU students, and the collaboration is very efficient with TEAMS meetings and the sharing of models and drawings.

Jimmy also visited the NTNU lab for a period of about one and half months in 2022 and 3 months in 2024 where he performed experiments on single-tank and dual-tank heat storage with rock pebbles; Cooking tests were also done.

At Makerere, Jimmy carried out tests on the solar cooker with heat storage of an oil-rock pebbles bed and tested its PV-based electrical heating using MPPT controllers. A complete dual tank system has been assembled at the Physics lab and the power source is solar PV panels. It has been tested to cook

common food items in the Uganda market. A stand-alone data logger based on Arduino was developed with the NTNU team. This can be used in remote places and does not require a computer.

A second version of the heat storage system for cooking was constructed and tested at MAK. This has been demonstrated in particular for cooking beans, which require long cooking times. The system will be the basis for pilot units to be field tested.

Dissemination activities: Publications and Conferences

1. Published on a research paper in a peer-reviewed Journal: Chaciga, J., Okello, D., Nyeinga, K., & Nydal, O. J. (2025). Experimental analysis on a solar photovoltaic indoor cooker integrated with an energy storage system: A positive step towards clean cooking transition for Sub-Saharan Africa. *Solar Compass*, 100109.
2. Published on a research paper in a peer-reviewed Journal: Title: J. Chaciga, K. Nyeinga, D. Okello, and O. J. Nydal, "Design and experimental analysis on a 52 single tank energy storage system integrated with a cooking unit using funnel system," J Energy 53 Storage, vol. 79, Feb. 2024, doi: 10.1016/j.est.2023.110163.
3. Published on a research paper in a peer-reviewed Journal: Okello, D., Omony, R., Nyeinga, K., & Chaciga, J. (2022). Performance analysis of thermal energy storage system integrated with a cooking unit. *Energies*, *15*(23), 9092.
4. Participated in the International MIE conference in Arusha Tanzania, 2024 held in Nelson Mandela International Institute of Science and Technology: Oral presentation
5. Participated in one international conference, ISES, Solar World Congress 2023 in New Delhi, India with an oral presentation of a research paper.29th Oct-04th November 2023
6. Participated in a Renewable Energy Conference and Expo 2023 in Uganda organized by Ministry of Energy and Mineral Development, MEMED November 2023.
7. Participated in the UNDP and Makerere University Expo 2023 and exhibited Mini cooker for household cooking.

Further work

To perform pilot field tests of the solar cooker prototype in schools. The aim is to initiate field tests of pilot units in a refugee camp in 2025. Then roll it all over the partner University regions.
To perform further tests on a closed system of the dual tank system.
To develop a min cooker with heat storage with PTC element for externally heating.

Title: *Design, Manufacture and Performance Test of Small Scale Milk Refrigeration and Pasteurization Unit*

Name: Fikadu Geremu Bodena
University: Addis Ababa University (AAiT, AAU), Ethiopia
Supervisors**:** Dr. Ing DemissAlemu(AAiT,AAU), Trygve Eikevik and Ole Jorgen Nydal (NTNU)

Baseline

Like any other developing countries in Africa, small holder milk farmers are major contributors of milk production in Ethiopia. According to the statistical survey for the reference period of 2014/2015, there are 11.38 million milking cows in the rural sedentary areas of Ethiopia producing 3.07 billion liters per year.

Milk being perishable and the requirement being high to urban consumption, collection and transportation of this bulk from widely scattered rural sources requires improved methods of preservation and distribution. Energy and methods for preservation is the main challenge in marketing milk surplus in rural areas. Due to the lack of proper storage and transport facilities, milk and other agricultural products in remote areas lose their value. This spoilage could be prevented at the local village level by providing pasteurization and cooling units. With low coverage of the electricity grid, such units require off-grid energy supply methods. Development of small scale distributed energy systems to power milk pasteurization and cooling units will enable the integration of rural small-scale farmers and pastorals in the milk supply chain.

Objectives

The research objective of the project is to manufacture and performance test a prototype small scale refrigeration and pasteurization system that uses solar energy (solar water heater and PV)with ice thermal storage for night cooling for application in off-grid rural areas.

A computer model for design of the refrigeration and pasteurization system has been established. A prototype will be made at AAU as a baseline for implementation of test units at selected field locations and as a base unit for further student activities on optimization and improvements.

Status

Gashaw Geremu Birhanu registered as PhD candidate at AAU in mid 2021. His scope of work has been discussed with co-supervisors at Workshop1 and on dedicated TEAMS meetings. Startup activities include coursework and detailed design of the experimental setup.

Fikadu Geremu Bodena finalized his course work in 2022 as originally planned. He also submitted conference abstract for participation in World Energy Conference which was held in Australia in December 2022. His submission was accepted but he is forced to withdraw due to the high travel costs. He is considering submission of the article to another conference and requested his travel funds to be transferred to 2023. He also co-supervised a M.Sc. student in the mainstream area of his PhD work. The Thesis is titled 'Effectiveness of heat exchange in a two tank system with thermosyphon circulation'. This work is part of his plan for 2022 to construct a stand-alone setup for pasteurization and refrigeration of milk. The lists of items required for the construction of the M.Sc. work were

purchased and prototype making is started. A detailed specification of the PV panel, support structure, MPPT and battery were also prepared and submitted for procurement.
Status in 2023
The PV unit and its accessories required to power his system is installed and waiting for the entire system to be installed and tested. The work of the M.Sc student co-supervised by Fikadu on Two tank system was constructed and tested. The test results are completed and submitted as part of the M.Sc. Thesis of the student. Fikadu also participated in ISES 2023 conference held in India and presented a paper which is currently ready for publication after review. The mobility to NTNU in 2023 was not successful due to inconveniences related to hosting supervisor at NTNU. A detailed specification was prepared for the remaining materials to purchase and produce prototypes of as per the findings from the simulation results.

Further work
Fikadu will spend three months at NTNU to work on existing facilities for refrigeration system. He will also finalize the purchase of the remaining materials to manufacture milk pasteurization and milk chilling. The plan in 2024 mainly to finalize the prototype construction and start experimentation at university compound. Fikadu is also planning to participate in at least one international conference in 2024.

Status in 2024
Fikadu visited NTNU from April to June 2024. During his time at NTNU's Department of Energy and Process Engineering Laboratory,he conducted experimental work focused on phase change materials (PCMs). He primarily explored various types of wax, specifically gel wax, rapeseed wax, and palm wax, to assess their effectiveness as PCMs.
Additionally, he visits laboratories that specialize in simultaneous heating and cooling systems provided invaluable insights that enhanced his work. He also participated in the development of an Arduino data logger, which was designed to measure critical parameters such as temperature, voltage, current, and power consumption during load testing. This device contributed significantly to his experimental work.

In 2024, he purchased and manufactured the necessary components for assembling a small-scale refrigeration system and a pasteurization system. he also assembled major parts for simultaneous milk pasteurization and cooling, utilizing a waste heat recovery system.

Status in 2025
During 2025, the planned activities were successfully executed. All necessary materials and equipment for developing the experimental setup were procured. The experimental setup was then constructed, and the system was tested under the designed operating conditions. Based on the initial results, adjustments and modifications were made to improve system performance, followed by further testing. Fikadu also participated in an international conference (WREC-25) to present his research. Although a visa was denied, participation was made possible through a pre-recorded video presentation. Fikadu spent three months at NTNU, which provided a vital period to advance his research and complete the write-up phase.

Plan for 2026

Fikadu is expected to finalize his dissertation in 2026. Ongoing tests will continue, and further evaluations are planned at both the university campus and field sites to demonstrate the functionality of the pilot technology.

Title: *Design, Development and Experimental Investigation of an Institutional Solar Fryer*

Name Gashaw Getnet Birhanu
University: Addis Ababa University (AAiT, AAU), Ethiopia
Supervisors: Dr Abdulkadir Aman (AAiT,AAU), Ole Jorgen Nydal (NTNU) and Dr. Ing Demiss Alemu Amibe (AAiT-AAU)

Baseline

AAU has been working on Injera baking under the NUFU period and promising results were obtained with use of high temperature thermal oil for baking on a new thin Ceramic baking pan. The ceramic baking pan is also tested for baking with electric power and promising efficiency improvement was recorded. The quality of the injera baked on the ceramic pan is good. A conclusion from the previous concept tests has been that an oil based heat storage system gives flexibility in terms of power sources and heat transfer, and PV systems provide simple heating solutions, although atlower energy collection efficiencies. A cost comparison (KWh cost of stored energy) between PV and thermal collectors has not been made for the high temperature case, but large scale PV power plants are less cost efficient than thermal power plants today.

Objectives

The target groups are institutions which are providing injera baking for many people on a daily basis. Several options can be considered for implementation for injera frying.

- A combined heat collector and PV system is a research topic of UEM, where water heaters are converted to oil heaters and PV powered heating elements gives the additional power needed to reach 200-250 degrees C in the storage. This concept can also be explored for injera baking.
- A combination of oil and latent heat, together with a heat pipe connection with a frying pan, has been tested at NTNU, and can be upscaled and implemented at AAU.
- A sensible heat based storage option, promoting thermal stratification for efficient heat storage and recovery, is also a technically simple system which has been tested, and can be applied for injera testing.
- A Scheffler type of concentrator can be considered, where the focal point of a solar concentrator can be positioned through a hole in a wall. The energy in the solar rays are then converted to heat at a receiver and and stored in a heat storage (sensible or latent heat).

The tasks of a PhD researcher can include:

- Determining the energy requirement for institutional cooking in remote locations (clinics, schools, correction centers or group of households) preferably located in arid zones.
- Selection of concept, designing and sizing main components of the relevant capacity.
- Constructing and testing the system, including modeling and simulation of the system.
- Implementation of the system using the AAU canteen as a test site.

Status

Gashaw Getnet registered as a PhD candidate at AAU in mid 2021. His scope of work has been discussed with co-supervisors at Workshop1 and on dedicated TEAMS meetings. Startup activities include coursework and detailed planning leading to the concept choice and the further construction of the prototype. The AAU team has particular experience in the challenge of new concepts for injera baking. Two particular concepts at NTNU also form a good basis for concepts to be taken to field testing.

Gashaw Getnet finalized his course work in 2022 as originally planned. He also submitted conference abstract for participation in World Energy Conference held in Australia in December 2022. His submission was accepted but he is forced to withdraw due to the high travel costs. He is considering submission of the article to another conference and requested his travel funds to be transferred to 2023. He also co-supervised a M.Sc. student in the mainstream area of his PhD work. The Thesis is titled 'Numerical Investigation on charging-discharging of a PCM using PV and thermal oil for Injera baking application'. He has finalized the concept selection for his system based on detailed simulation studies of three options. He has also performed experiments on metal baking surfaces which are Teflon coated. The result paves the way for future research on Teflon coated metal surfaces and Aluminum gives better quality of injera. He also collected data on institutional baking setup from Bahirdar and Debrebirhan Universities. A detailed specification of the PV panel, support structure, MPPT and battery were also prepared and submitted for procurement.

Status in 2023

Gashaw started constructing the physical system by installing the PV unit required to power his system. Casting of the thermal storage is completed and machining is underway. He is finalizing preparation to test the unit using PV power. Gashaw also participated in ISES 2023 conference held in India and presented a paper which is currently ready for publication after review. He also Co-supervised a Master student to completion. Currently a joint article is submitted for a journal and it is under review. The mobility to NTNU in 2023 was not successful due to inconveniences related to hosting supervisor at NTNU.

Further work

Gashaw will spend three months at NTNU to work on existing facilities for storage based systems for frying. He will also finalize the construction of the system at AAiT and conduct tests for injera baking. The plan in 2024 is mainly to finalize the prototype construction and start experimentation at university compound. Gashaw is also planning to participate in at least one international conference in 2024.

Status in 2024

Gashaw continued his experimental work and also completed a three-month visit to NTNU, where he engaged in the following activities during his stay

- Visited the energy laboratory to gain hands-on experience with pilot systems for solar-based injera baking.
- Developed an Arduino-based data logger for use in the AAU experimental setup.

Up on completion of his stay period and return to AAU he has participated on the following activities:

- Tested different types of heating elements for the thermal storage setup at AAU.
- Tested a heating unit for a direct PV injera fryer.

Gashaw also attended the UNET workshop and presented overall progress of the thesis, including progress presentation during the UNET and ENET meetings conducted in Arusha. He also Conducted a full test of the direct heating unit by baking injera and prepared a paper for publication.

Status in 2025

Gashaw has been working on a direct fryer with PTC elements, including an integrated heat storage system. Initial test results indicate promising performance, and further refinement of the tests is planned. Gashaw also participated in the WREC 2025 international conference. Although his visa was denied, he was able to present his work virtually through a pre-recorded video.

Plan for 2026

Ongoing tests have produced promising results. The year 2026 will be focused on field testing and further refinement of the findings. Gashaw is expected to complete his studies by mid-2026, and pilot testing of the units at community sites is also planned during this period.

Title: *Reconstructing life and energy after disaster*
RECONSTRUCTING LIFE BY IMPROVING THE ENVIRONMENT USING ENVIRONMENTALLY FRIENDLY STOVES IN THE LIMPOPO VALLEY

Name: Cândida Bila
University: Eduardo Mondlane University (UEM), Mozambique
Supervisors: Govert Valkenburg (NTNU), Inês Raimundo (UEM)

Baseline
The work of Cândida Bila fills in a broader need to connect energy and technology research with social-scientific and cultural research. A case study is selected where tensions are studied between reconstructing social and economic life after two decades of disasters, the need to transition towards clean, renewable and accessible energy, and the establishment of governance practices (top-down versus bottom-up). Connection to the more technology-oriented research and education in the consortium is secured by a focus on cooking practices and the feasibility of solar cookers.

Objectives
A PhD will be trained in social science through the conducting of a case study in the Limpopo valley, Mozambique. The area is regularly struck by disasters, significantly displacing its population. At the same time, moving towards clean energy use is an urgency broadly felt. Through interviews, focus groups and the reporting of life histories (oral history), the candidate will investigate how meaning is given to climate change, disaster, and a deeply cultural practice such as cooking. In terms of its theoretical embedding, an explicit aim is to build on intellectuals from the Global South, rather than replicating the Western canon.

The study aims to gain knowledge about the various factors that drive the adoption of ecological fire Stoves and analyze the socio-economic aspects that impact the adoption of solar cooking.

Activities 2023

The candidate started work only towards the end of 2022. She participated in two workshops:

1. UNET - ENET Workshop 6 in MAK, Uganda, where she had the first interaction with the supervisor.
2. Kigali Workshop, Rwanda (II LEAP – RE Stakeholder Forum) with the presentation of a communication.

Work on the Research project and preparation for the internship at NTNU.

Activities carried out

- KULT8860/8861, Social Science Methods- Course.
- KULT8860/8861, Social Science Methods -Course
- Participation in the department's doctoral project presentation workshops – KULT-NTNU
- Participation in the Green Energy shifters Networking event;
- Face-to-face meetings with the supervisor

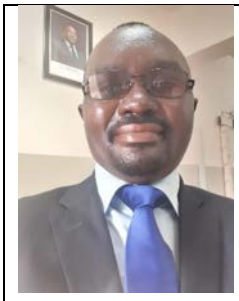
- From April 18th to 21st, in Johannesburg, I participated in the in-person workshop of the scientific article writing course, which I have been participating in since November 2023, accompanied by Professor Inês
- I produced an article entitled Clean Cooking and Forest exploitation in disaster-prone Areas Versus Achievement of Sustainable Development Goals 15 with the supervision of Professor Inês Macamo Raimundo
- The aforementioned article will be published via the Center for African Studies of the Tokyo University of Foreign Affairs as one of the results of participation in the conference co-organized by this university and with the University of Ghana.
-

Plan for 2024

- Two month internship at NTNU
- Attendance of a Course on Social Sciences Methodology at NTNU;
- Drafting of a first paper.
- Attend two training courses offered by NTNU-KULT
- Work with supervisor
- Start producing a scientific article
- Participate in the Article writing course
- Approval of the research project
- Start data collection in the field
- Attend two training courses offered by NTNU-KULT
- Work with supervisor
- Start producing a scientific article

Plan 2025

- Implementation of the theoretical framework developed in 2023-2024;
- Field work;
-



Title: *Experimental Investigations of an Oil Based Solar Thermal Collectors for Cooking application*

Name: Tomas Nhabetse
University: Eduardo Mondlane University (UEM), Mozambique
Supervisors: BoaventuraCuamba, António Leão and AmósVeremachi (UEM), OJ Nydal (NTNU)

Baseline

UEM has been building research capacity on both the PV and the solar thermal side. Rock bed systems with solar concentrators have been explored in NUFU/EnPe projects. A concept for study at UEM is the use of a commercially available solar thermal collectors which can be converted to oil systems to provide high temperature energy for cooking. A question is whether top-up PV heating is required or not, to reach heat storage temperatures which are suitable for cooking.

Objectives

The objective is to experimentally study water heaters converted to oil heaters regarding capacity (oil temperatures) and energy efficiency (the fraction of solar energy converted to heat). The work will conclude on whether stand-alone converted water heaters can provide heat storage for cooking (hot oil) or whether hybrid systems are required (top-up energy from PV or wind). The heat storage should then be designed to accept several types of heat sources.

Status

The work of Tomas was initiated during the EnPe project. The experimental work is completed showing oil temperatures could reach up to 140-170 degrees C, depending on flow rates. Evacuated tubes perform better than flat plate collectors.

A PV system for topping up the energy to higher temperatures has been designed. Higher temperatures in the oil-based heat storage gives more efficient cooking. Storage temperatures in the order of 150 degrees C, from a converted water heater, can be used for cooking but the time for water heating may be large depending on the amount to cook.

Tomas Nbatetse's participation in the project has ended in June 2023 although the submission of the thesis will happen only at the beginning of 2024.

Plan for 2024

Submission of his thesis and examination.

Title: Modelling and simulation of hybrid heat sources for charging thermal energy storage system integrated with multiple cookers.

Name: Akire Tito
University: University of Juba, South Sudan
Supervisors: Denis Okello and Karidewa Nyeinga (MAK), Ole Jorgen Nydal (NTNU)

Baseline

University of Juba is the main university in South Sudan. The impact of the long war in the country affected training programmes at the university. The majority of the staffs do not have PhD training; in many departments, the staffs have only bachelor degrees. In addition, the departments lack laboratory facilities and technicians. This has greatly affected the quality of training at the university. In most cases, staffs have to seek for training opportunities abroad. There is urgent need for capacity building (at both MSc & PhD levels) and equipping the laboratories to improve the quality of training.

Objectives

University of Juba will recruit one PhD candidate. The student will undertake PhD studies at Makerere at the Department of Physics, in the research group on solar thermal systems. Tito will complement the work on solar heat storage for cooking with contributions on the computational side. COMSOL Multiphysics will tentatively be used for heat transfer analysis of the storage systems based on natural circulation of hot oil. Multiple energy sources (wind and solar) and multiple cookers with a single heat storage concept is open for analyzing as well.

Status in 2025:

Tito has carriedout simulation of several cases of TES system. He is working on two manuscripts which should be submitted for publication in early 2026.

Status

Tito was admitted for his PhD in October 2022; and he started work in November 2022 and defended his proposal in April 2024. He has performed preliminary simulation of single tank systems, single tank with multiple cooking units and a mini cooker. In all cases rock and oil are used as heat storage and heat transfer fluid. In his preliminary work, he noticed unexpected long staggered or abaft stop in simulation which was initially thought of as a lack of enough processing power of the computer. However, a critical examination of this situation leads to observation that these are caused by overheating of the fluid in the funnel when maximum temperature (Tmax) of heat transfer fluid is exceeded, a state in which both the density and mobility (viscosity) are constant. Thus, there is either very limited or no more fluid expansion in the funnel which results into overheating in the funnel and eventual stop in circulation. To overcome this problem the following options are suggested:

- Introduction of thermal controller to keep the temperature in the funnel just below Tmax of the HTF
- Numerically model the power source to decrease as the temperature approaches Tmax
- Varying the diameters of the pipe to the Tank to increase the flow rate. This will allow the overheated oil to flow to the tank

Tito is working to incorporate the above solution into COMSOL. Once successful he will incorporate wind power as heat source to heat energy storage.

Further work

Tito will make use of COMSOL multiphysics to evaluate the heat storage-cooker system with natural circulation. A particular aspect is the conditions when circulation can stop prematurely and the effect of

increasing the length between the storage and the cooker. Thereafter, a concept with several cookers connected to a single storage can be computationally analyzed. The mini-cooker configuration is also suitable for flow analysis with COMSOL. Tito will join a visiting group of PhDs to NTNU in 2025.

Title: *Performance Optimization of PAT-SEIG Operating in an Off-Grip Energy Generation Setup*

Name: Emmanuel Jack Nyirenda
University: University of Malawi (MUBAS), Malawi
Supervisors: Cuthbert Kimambo and Joseph Kihedu (UDSM), Torbjorn Nielsen (NTNU)

Baseline

The Malawi University of Business and Applied sciences (MUBAS) has a postgraduate programme in Renewable Energy whose goal is to meet the national demand for appropriately trained people in the field of renewable energy technologies and applications. It is envisaged that the programme will achieve effective training in renewable energy technologies, acquisition of advanced knowledge and understanding in the selected specialist areas of renewable energy and broadening the knowledge of engineers and scientists in areas of renewable energy specializations. The area of developing Renewable Energy technologies is a top priority, and hydro power is a relevant area where post graduate training is important.

Objectives

A PhD will be trained in the hydro power technology by developing and testing small scale systems where commercial pumps can be converted to turbines. A setup for this will be available at UDSM, as a result of the EnPe Capacity5 and the NORPART project. A practical result could be the development of design guidelines for converting mass produced asynchronous motors to turbines, testing with Electronic Load Controller together with a dump loading arrangement where the waste power is accumulated in the form of heat storage for cooking.

Status

The PhD researcher was recruited at MUBAS and registered as PhD candidate at UDSM in 2021.
The scope of work was discussed during the Workshop in Arusha, with the participation of MUBAS staff.
Emmanuel produced a project plan in form of a research proposal, as a PhD startup activity. This was accomplished in communication with co-supervisors at UDSM and at NTNU. The candidate managed to defend the PhD research proposal before the Departmental Postgraduate Committee in September 2022 and again in November 2022. The candidate finalized the defence of the PhD research proposal before the Special Postgraduate Panel in January 2023.

A Pump as Turbine test setup (PAT) to be used by the candidate, was shipped from NTNU under the NORPART project, and was received at UDSM in January 2022. An Electric Load Controller is also part of the received PAT system. The new PAT system has been installed at UDSM and currently the candidate is conducting some tests on the rig.

The candidate visited NTNU from 23 April to 19 June 2024, where he started drafting his thesis report. The candidate also had time to visit the lab and experience how other PhD candidates from Makerere and Ethiopia were conducting experiments. The other activity involved discussion with the Professors on the behaviours of the ELC and further study on the machine was recommended.

So far, the candidate has managed to publish one conference paper and two journal papers. The candidate further presented a conference paper at MIE conference held in Arusha in October 2024. The conference proceedings are yet to be published.
Further work The candidate is expected to work with two master's students to further the research on ELCs The candidate is expected to submit the thesis document for examination. The candidate is expected to graduate in November 2025.

Title: Performance Improvement of Oil-Based Sensible Thermal Storage (STS) System for Cooking Application

Name: Anna Kisioki Sharishoy

University: University of Dar es Salaam (UDSM), Tanzania

Supervisors: Cuthbert Kimambo, and Joseph Kihedu (UDSM) and Ole Jorgen Nydal (NTNU)

Baseline

Solar resource has been proven to be well adopted technologically to collect energy for cooking but its widespread application has been limited by the intermittent nature of sunshine; this results in poor cooking performance. Researchers reviewed and developed solar cookers but not considered as best option for all seasons and all societies due to their limitation on indoor cooking.

The research aims to improve the STS system for cooking applications by conducting laboratory experiments of the existing setup at NTNU and identifying the areas that needs improvement. The prototype will be developed and tested at the workshops and laboratories of College of Engineering Technology (CoET) at the University of Dar es Salaam. The analysis on performance indicators will be conducted based on the existing and the improved STS system. The stakeholders and other beneficiaries will be involved to ensure the practicality, scalability and sustainability of the STS system.

Objectives

The main objective of this research is to improve the performance of the oil-based sensible thermal storage system for cooking applications. In details, this work will involve investigation of the performance of the STS system available at NTNU laboratory for cooking applications. Then the simulation will be done followed up by the development of a prototype at UDSM. Finally, comparison of performance of the improved STS system with performance of existing system will be done.

Status

The candidate was recruited in late 2022. A project plan in form of a research proposal has been made, as a required PhD startup activity. The research proposal was built on the results from previous PhD candidate from the EnPe program. The candidate has spent three months at NTNU Norway, between February and April 2023 where she worked on laboratory scale oil-based cooker. The small-scale STS system has already developed at UDSM and tests are going on.

The candidate managed to defend PhD research proposal before Departmental Postgraduate Committee in January 2023 and again in August 2023. Also, the candidate defended PhD research proposal before Special Postgraduate Panel in February 2024 and finalized in July 2024.

So far, the candidate has managed to publish one conference paper, presented another paper at MIE conference in October 2024 and submitted the final manuscript for review. Currently the candidate working with the journal paper.

Further work

The candidate will improve design of oil-based cooker.

Thereafter, she will build oil-based cooker at UDSM and conduct/field tests.

Title: *Solar Thermal Energy: 3D Compound Parabolic Concentrator with Heat Storage*

Name: Casiana Lwiwa
University: Norwegian University of Science and Technology (NTNU)
Supervisors: Ole Jorgen Nydal (NTNU), Cuthbert Kimambo (UDSM)

Baseline

A drawback with using solar concentrators for high temperature heat collection is that they need solar tracking. This is technically fully feasible but does reduce the robustness of such heat collection systems. A Compound Parabolic Concentrator (CPC) is a device that is designed to be stationary and still concentrate sun rays for a range of acceptance angles. A simple system could be that an insulated CPC reflector is placed on top of a heat storage and left in the sun. After charging the heat storage, the reflector can be removed and replaced by an insulator for the heat storage. Cooking can then be on the top surface when needed. A PhD was initiated from NTNU Energy, with the purpose of exploring the use of CPC for charging a heat storage for cooking.

Objectives

The objectives of the work is to analyze different CPC concepts for cooking, select a concept and build a small scale prototype for testing. A challenge is to simplify the design by using flat mirror tiles to represent the reflecting CPC surface.

Status

Casiana defended her PhD at NTNU on 20 January 2025.

The Assessment Committee was: Professor Ashmore Mawire, North West University, South Africa (1. Opponent), Associate Professor Habtamu Bayera Madessa, OsloMet, Norway (2. Opponent), Professor Trygve Eikevik, NTNU

Abstract

The key objective of this thesis is the design, construction and testing of a 3D Compound Parabolic Concentrator (CPC) with a heat storage.

The 3D CPC with reflecting surface may be difficult to construct, therefore, the surface has been simplified by using two sets of 4 flat mirrors in a squared channel arrangement. The system should be low cost, robust, safe, and technically simple to construct and operate as a small-scale solution for storing heat for cooking. The CPC was designed such that no solar tracking is required. However, tilting of a concentrator at intermediate times during a day can be accepted.

As the CPC can be build using mirror tiles or as a smooth surface, a sensitivity analysis regarding the dimensions of mirror tiles on the CPC surface was performed. A ray tracing analysis showed that uniform and square tile sizes up to 15 cm gave quite similar solar interception ratios (less than 10 % changes) compared with the smooth surface. For the strongly simplified case of only 8 flat mirrors, the

height separating the 4 lower mirrors from the 4 upper mirrors was optimized using an in-house ray tracer. The optimal dividing position of the mirrors was found to be 25 % of the height of the CPC.

A comparison of the 3D CPC with a normal Parabolic Reflector (PR) for similar concentration ratios was also performed. The comparison was made using ray tracing, by scanning sun angles over the acceptance angles and comparing the interceptions on a cylindrical absorber between the two systems. The results showed that for systems with low concentration ratios, the performances of the two reflectors were similar, with around 10 % improvements in interception ratios with the CPC compared to the PR.

Tests on the simplified CPC system with a heat absorber were performed both during sunshine and in the laboratory. For the case of CPC tests during sunshine, the discretized CPC consisted of 8 mirrors, with a 0.2 m diameter and 0.3 m length cylindrical absorber placed inside the CPC. The maximum temperature reached on the cylindrical absorber was about 140 ℃. The experimental work in the laboratory included testing of the insulated iron cylinder for storing heat for cooking. The system was constructed and demonstrated for the case of boiling water and cooking beans. Cooking beans is a particular important case because the cooking time is long and charcoal is currently the most common energy source for cooking beans in Tanzania. The iron cylinder was heated by grid-powered heating elements to about 220 ℃. After heating the cylinder, a cooking pot was placed on top of the cylinder and cooking of beans was successfully demonstrated. A computational analysis also indicated that cooking can also be made at the lower temperatures experienced in the CPC heating case.

The present study forms the basis for further improvement of the concept and considerations of the designed and simplified CPC for storing heat for cooking.

Further work could be on field tests of similar systems in the more favorable solar conditions in Tanzania. The idea with the system is that a light weight CPC can be placed over a heat storage for charging during sunshine hours. The CPC can then be replaced with an insulating cover over the heat storage for heat retention. The heat storage can then be moved for indoor cooking at times when needed.

Publications/Conferences

Paper 1 *3D Ray tracing for optimizing the size of surface tiles on a Compound Parabolic Concentrator*. Casiana Blasius Lwiwa, Ole Jørgen Nydal Published in: Proceeding of the Southern African Sustainable Energy Conference (SASEC), Cape town, South Africa. Year: 2021

Paper 2 3*D Ray tracing for optimizing a mirror tiled Compound Parabolic Concentrator* Casiana Blasius Lwiwa, Ole Jørgen Nydal Published in: Proceeding of the 16th International conference on Heat Transfer, Fluid Mechanics and Thermodynamics (HEFAT), Online. Year: 2022

Paper 3 *A Ray tracer for optimizing solar concentrating systems: the case of discretized Compound Parabolic Concentrator* Casiana Blasius Lwiwa, Ole Jørgen Nydal Published in: Proceedings of the 63rd International Conference of Scandinavian Simulation Society, SIMS 2022, Trondheim, Norway. Year: 2022

Paper 4 *Interception on Solar Absorbers: Ray Tracing for Comparison between a Parabolic Reflector and a Compound Parabolic Concentrator* Casiana Blasius Lwiwa, Ole Jørgen Nydal Published in: Proceedings of the EuroSun2022- ISES and IEA SHC International Conference on Solar Energy for Buildings and Industry. Year: 2023

Paper 5 *Sensible heat bean cooker* Casiana Blasius Lwiwa, Ole Jørgen Nydal Published in: Tanzania Journal of Engineering Technology (Tanz. J. Engrg. Technol.) 2023, 42 (1), 79- 84. (Presented in the 7th International Conference In Mechanical and Industrial Engineering (MIE), New Library, University of Dar es Salaam-Tanzania). Year: 2023

Paper 6 *Experiments on a Discretized 3D Compound Parabolic Concentrator with a Sensible Heat Storage*
Casiana Blasius Lwiwa, Ole Jørgen Nydal Published in: submitted to Next Energy journal, Elsevier Year: 202

Title: *Development of direct and indirect solar fryers*

Name: Mesele Hayelom Hailu
University: Norwegian University of Science and Technology (NTNU)
Supervisors: Ole Jorgen Nydal (NTNU), Mulu Bayray Kahsay (MU)

Baseline

Mesele Hayelom is a PhD candidate from the EnPe Capacity5 project, who was hindered to return to NTNU after a period at MU, due to the global COVID-19 situation and a subsequent political unrest and warfare in Ethiopia. Parts of his rest budget was approved for use in the Norhed II project period, for him to return to NTNU and complete the PhD thesis.

Objectives

Development and investigation of direct and indirect solar fryers for Injera baking applications

Status

Mekelle University started to come back in normal operations in 2023 and Mesele has taken up his PhD work again.

Experiments with direct frying of injera using a parabolic concentrator was first made in Trondheim and then taken further in Mekelle. A number of solar fryers models have been developed in Mekelle and performance of the prototypes has been investigated experimentally. This has given valuable experimental results on direct frying. These results have been presented through once conference paper and one journal paper. The data is being analysed with the help of a numerical model, which Mesele has implemented in the Matlab framework and Ansys simulation software. The intention is to use the model for optimization of frying systems.

An Oil based Indirect frying of injera has also been developed and tested in Mekelle. The developed system performance was investigated through a number of experimental tests. . These results have been presented through once conference paper. A further performance investigation of the developed system by considering different operational conditions is being undertaken currently. The result of these experimental evaluations for different operational conditions is planned to contribute one more journal paper.

Solar radiation data has also been recorded for a period of nearly two years at Mekelle, and the data analysed and a prediction model has been tuned to the data.

Publications/Conferences

Paper 1

A Direct Solar fryer for Injera baking application

Authors: Mesele H. Hailu, Mulu B. Kahsay, Asfafaw H. Tesfay, Ole J. Neydal;

Published in: Solar World Congress SHC 2017 IEA SHC Solar Heating and Cooling Conference 2017, 29 October - 02 November, 2017. AbuDhabi, UAE. SWC2017/SHC2017 proceedings, pp. 1475-1485.

Year: 2017

Paper 2

An oil based indirect Solar fryer for Injera baking application

Authors: Mesele H. Hailu, Mulu B. Kahsay, Asfafaw H. Tesfay, Ole J. Neydal;
Published in: SOLARTR 2018 Solar conference and Exhibition, November 29-30, 2018. Istanbul, Turkey. SOLARTR 2018 proceeding book, pp. 109- 118.
Year: 2018

Paper 3

An Experimental Comparative Study of Large-Sized Direct Solar Fryers for Injera Baking Applications
Authors: Mesele Hayelom Hailu, Mulu Bayray Kahsay, Asfafaw Haileslassie Tesfay, Ole Jørgen Nydal
Published in: Energies 2024, 17(19), 4949; https://doi.org/10.3390/en17194949
Year: 2024

Plan for 2025

The aim is for Mesele to complete his PhD thesis in 4th quarter of 2025. Work on publications is ongoing. The fund transfer from the previous EnPe program gives Mesele the opportunity to come to NTNU for finalizing the dissertation and the defence.

Title: *Aerodynamic and Structural Analysis of Wind Turbine Blade: Mitigation Extreme Wind Loads and Applying Single-Blade Design Concept for Structural Integrity Enhanced Performance and Cost Efficiency*

Name: Hailay Kiros
University: Norwegian University of Science and Technology (NTNU)
Supervisors: Torbjørn Nielsen (NTNU), Mulu Bayray (MU)

Baseline

Hailay Kiros is a PhD candidate from the EnPe Capacity5 project, who was hindered to return to NTNU after a period at MU, due to the political unrest and warfare in Ethiopia. Parts of his rest budget was approved for use in the NorhedII project period, for him to return to NTNU and complete the PhD thesis. The situation in Mekelle was such that experimental work could not be made, and the methodology was therefore shifted to purely computational analysis using the ANSYS software.

Objectives

The objectives of the work is to support implementation of medium scale wind turbines by structural analysis of the blades under different wind conditions.

Status

Hailay defended his PhD at NTNU on 11. December 2024.
The Assessment committee was Associate Professor Martin O.L.Hansen, DTU, Denmark (1. Opponent) Dr. Paul E. Thomassen, Simis AS, Norway (2. Opponent) and Associate Professor Tania Bracchi, NTNU

Abstract

This thesis aims to enhance the performance, structural integrity, and cost-efficiency of wind turbine blades through comprehensive aerodynamic and structural analysis, focusing on four key areas:

First, the study investigates the aerodynamics of site-specific wind turbine blades using the Blade Element Momentum (BEM) method with various enhancements validated through computational fluid dynamics (CFD). By incorporating pitch angle and cost of energy as design parameters, the study achieved significant performance gains, reducing energy production cost and promoting the broader adoption of small wind turbines in renewable energy systems.

Second, the thesis explores the application of a single-blade concept for designing wind turbine blades customized for diverse wind conditions across different sites. By using the Weibull distribution to characterize site-specific wind patterns and applying a weighted average of wind power densities, the study developed a representative wind distribution for the sites under investigation. It also redefined the cost of energy by considering lifetime cost variations of turbine components relative to rated power. The findings showed high power coefficients and capacity factors for both low and high wind conditions, enabling the design of cost-effective single-blade turbines that maintain enhanced performance across diverse sites.

Third, the research proposes a novel beam/cable support system to enhance structural integrity under extreme wind conditions. This support system mitigates the impact of extreme wind loads, leading to optimized use of fiber materials. Structural analyses conducted using ANSYS-ACP and ANSYS Static Structural (version 2023 R2) reveal substantial improvements in total deformation, equivalent-stress levels, and failure criteria across different fiber layup thicknesses. These enhancements strengthen the structural integrity of wind turbine blades under extreme wind conditions, with the potential to reduce fiber material usage and lower production costs.

Finally, the thesis presents a modal analysis and dynamic response study of wind turbine structures subjected to turbulent wind loads, using ANSYS Modal (version 2023 R2), stochastic analysis, and computational methods in both time and frequency domains. By employing frequency domain analysis and time domain simulations, the study accurately simulates dynamic responses and natural frequencies, validating the results with experimental data. This analysis provides a valuable insights into optimizing wind turbine structural dynamics and ensuring operational safety.
Overall, this thesis introduces innovative solutions for optimizing the aerodynamic and structural performance of wind turbine blades. By enhancing aerodynamic efficiency, reducing energy production costs, and significantly improving structural integrity, the research paves the way for more efficient, reliable, and cost-effective wind energy systems. The findings provide valuable insights into renewable energy, highlighting the potential for more affordable and effective wind turbine implementations, particularly in areas with low and medium wind potential.

Title: *Performance Analysis of Hybrid Wind-Solar Power Generation System for Rural Electrification*

Name: Tsige Gebrgergs Tesfay

University: Mekelle University, Ethiopia

Supervisors: Mulu Bayray Kahsay and Ole Jorgen Nydal (NTNU)

Baseline

There is a continuous increment of power supply demand from time to time and the existing grid is struggling to fulfil the customer's demand. In addition to that since most of the Ethiopian population is located in rural areas access to the grid extension lines is limited and using an off-grid renewable power generation system is a viable solution. Wind and solar are among the most common renewable energy resources. However, there is a lack of practical and experimental evaluation indicating the performance of hybrid systems for rural electrification. Therefore, this research aims to establish a hybrid wind-solar power generation system with battery and thermal energy storage and analyse the performance.

Objectives

The general objective of the research is to conduct tests and analyze the performance of a hybrid-wind solar power generation system for rural electrification.
Specific Objectives:

- Conduct pilot testing of a hybrid wind-solar power generation system
- Conduct a performance test of a hybrid wind-solar power generation system.
- Develop an optimization method for sizing a hybrid wind-solar power generation system.
- Identify sites for off-grid hybrid wind-solar power generation in the Tigray region.

Status

The candidate registered as a PhD student in 2019. The initial objective was first to conduct a pilot testing of hybrid Wind-Solar power at Mekelle University and then based on these preliminary results the setup could then be implemented in a rural area for the purpose of rural electrification which was the main intention. The pilot testing was conducted and the results were published in a conference prepared by Mekelle University.

The research was interrupted for more than two and half years due to the war on Tigray. The candidate resumed the PhD in 2024 starting by participating in the mobility of students hosted by the University of Eduardo Mondlane.

Between April and June 2024, the candidate visited NTNU. During her stay at NTNU, the candidate assembled an Arduino data logger to be used back home and conducted tests on PTC heating elements to determine if they could be used as a load with hybrid wind-solar power, and the results seem to be promising but requires a special structural design to fit the low power heating elements to a structure to be used as a storage. Most of the setup components from the pilot testing needed to be replaced and the purchase of the ordered pieces of equipment was finalized in November of 2024. And the test on the hybrid system was started again. During the months of December and January, the wind was almost non-existent and the power was coming from only solar but toward the end of January and the

beginning of February the wind was blowing but the power coming from the wind was not much. The wind turbine was on a standstill for more than three years and seeing the result it had to be brought down for check-up testing and maintenance.

The fourth objective of identification of sites has been done with solar radiation and wind speed data and a manuscript has been drafted.

So far, the candidate has managed to publish one conference paper and currently working on a journal paper.

Further work

The remaining tasks are: Conduct a test on a setup of PV, Battery, and thermal energy storage for cooking applications with oil as a sensible thermal energy storage

Conduct a test on the performance of the hybrid setup (after the maintenance of the turbine) with and without thermal energy storage.

Write up manuscripts for conference and journal publication

Write up the dissertation.

	Title: ***Latent heat storage with a heat pipe frying pan***

Name: Abraham Parra
University: Norwegian University of Science and Technology (NTNU)
Supervisors: Ole Jorgen Nydal (NTNU)

Baseline

The case for study is the heat transfer from a heat storage to a frying pan. One particular method is by phase change, where a working fluid evaporates in the heat storage and condenses at the frying pan. This is a very efficient mode of heat transfer and it is a method which can support several frying pans on a single heat storage. The concept for testing is a thermosyphon, where the return of the condensate to the evaporator is by gravitational flow.

Objectives

To arrive at a suitable system for a large diameter fryer powered with energy from a latent heat storage.

Status

The work started with an assessment of using a computational method developed for the flow dynamics in oil/gas pipelines for the particular case of a pulsating heat pipe for the heat transfer. Some trial experiments indicated this was difficult to achieve in large diameter tubes (5-10 mm).
The further work was experimental. Cylinders with a Phase Change Material (PCM) were immersed in a container with a thermal oil, where heating elements were placed. The evaporator was in the oil and connected to a hollow frying pan.
The system was constructed and successfully tested.
Some additional experimental work has also been made with flow analysis of natural circulation with air in a rock bed heated directly with heating elements.

Plan for 2024

Abraham has been largely self financed and his work has therefore been extended in time. The work has been presented at a conference, and needs to be published in a journal paper, as part of his thesis. The aim is that the thesis will be completed in 2024.

Appendix Workshops and annual meetings

Workshop August 2021, Tanzania

Time: 30 August to 2 September 2021
Place: Arusha, Tanzania
Organizer: University of Dar es Salaam (UDSM)
Host: Arusha Technical College (ATC)

Workshop
The EnergyNET workshop is held in conjunction with a Erasmus+ project status meeting: " University Network on PhD Programs in Energy Technology, UNET". UNET concerns PhD curriculum and training facilities, ENET concerns research. UNET and ENET includes many of the same partner universities.

The aim of the Workshop is to present and discuss the project status and plans, in particular related to

1) MSc programs on Renewable Energy and needs for reviews
2) Status on PhDs: Scope of work, recruitment and needs for equipment

Reviews of Renewable Energy MSc programs

- **UDSM** gave an overview of the MSc program status, as it has evolved from the original NOMA program (2008). The program was reviews in 2011. It is a challenge to maintain 6 specializations for a limited number of students.
- The MSc program on renewable Energy has recently been reviewed at **MAK** (Department of Mechanical Engineering). The master program in physics has a solar part, which attracts very good interest among the students.
- The master program in Thermal Engineering at **AAU** (AAiT) has been revised 4 times, with surveys on relevance and usefulness of courses. Updating of the research and demonstration facilities are needed.
- **UEM** has established a master program as part of the previous EnPe program. The program now attracts a good number of students during the startup of the program.

Conclusion on review of master programs
Harmonizing programs between the ENET partners may be challenging, whereas collaboration on course level can be directly bettween the course responsible persons. An ENET Working Group for the master programs was established.

PhD programs and equipment
The PhD programs at the ENET partners were presented, with general comments on plans and needs. The PhD proposal for about 10 ENET candidates were reviewed together with the status on the recruitment. The detailed specification of the equipment is deferred to after the UNET process, in order to optimize the synergies between the projects.

Workshop 1 pictures, Tanzania

Workshop November 2021, Tanzania

Time: Monday 29 November to 1 December 2021
Place: Arusha, Tanzania
Organizer: University of Dar es Salaam (UDSM)
Host: Arusha Technical College (ATC)

Workshop
The venue for the Workshop was shifted first from the original plans at NTNU (entry limitations), then from Addis Ababa (escalating political tensions in Ethiopia). Given the short notice for change, the ongoing pandemic travel limitations (Mozambique closed), visa time requirements, the most convenient place to meet was in Arusha, Tanzania.

The aim of the Workshop is to present and discuss the project progress. The Workshop was organized together with the Erasmus+ UNET project.

Project progress
The scope of work for the PhDs were discussed in detail at Workshop1. The review at Workshop2 was mainly on the recruitment status, many of the PhDs have been initiated already.

The MSc program at UDSM was presented in detail, together with an evaluation given by Prof. Kimambo. There is a need to review the program form the mismatch between the number of courses (28) and specialization offered (5) and the yearly number of students (about 5).

UDSM presented draft tools for Tracer Studies among students and employers. The questioners can be

reviewed and made use of by all the universities.

A Working Group for the ENET web pages was established. The framework for the web pages are prepared, more content is needed.

Pictures

Thanks to Arusha Technical College (Dr. Peter Mashingo) who hosted our meeting venue!

Workshop 2 pictures Tanzania

Workshop May 2022, Norway

Time: Friday 6 May - Tuesday 9 May 2022
Place: Trondheim, Norway
Organizer: Norwegian University of Science and Technology (NTNU)
Host: Department of Energy and Process Engineering, Strategic Area NTNU Energy

Workshop

The EnergyNET workshop is held in conjunction with the Erasmus+ project status meeting: " University Network on PhD Programs in Energy Technology, UNET". UNET concerns PhD curriculum and training facilities, ENET concerns research. UNET and ENET includes many of the same partner universities.

The aim of the ENET part of the Workshop is

1. Progress Reviews and Short training sessions and an
2. Open Day with external presentations on the topic resent and discuss the partner contributions related to the questions:
   1) How can small scale energy systems be developed?
   2) How can new technology be implemented?

The group in front of the Hydro Power Laboratory, NTNU

1 Progress Reviews and Training Sessions

The progress of 12 ENET PhDs, master students and other ENET activities were reviewed.
The following training events on Systems and Programs were given:

- PhD administration systems and regulations (Runa Nilssen)
  The PhD management systems and regulations at the Faculty of Engineering was introduced to ENET partners. The introduction covered all aspects from initiation to thesis defence, both on the academic and the administrative side. A "PhD Handbook – Quality in PhD Education" includes the relevant information, and is available for all partners.
- Laboratory administration systems (Morten Grønli)
  PhDs often make use of laboratories in experimentally oriented research tasks. The Department of Energy and Process Engineering maintains extensive and advanced laboratory facilities, which are used for both PhD research tasks as well as for external contract research (e.g. SINTEF and others). The laboratory has about 100 projects every year. This requires efficient management systems, including resource management (staff and material), procurement systems and financial management systems. The management systems were presented for the partners. Microsoft TEAMS has recently been introduced as an efficient communication tool between laboratory staff and the users.
- Purchase Systems (Marianne Trælnes)
  Operation of efficient procurement systems is a challenge for many universities. An introduction on how this is made at NTNU was given by the procurement officer at Department of Energy and Process Engineering. Tender procedures are invoked for purchases above NOK 100.000. NTNU has framework agreements with suppliers for a range of products. Purchases are handled centrally at the department, based on forms submitted by the user, where each purchase needs a project number.
- PhD supervision training courses (Kristin Skjeldestad)
  An introduction to how training for PhD supervisors is made at NTNU was given during a Workshop with all partners in May 2022. NTNU has three levels of support for supervisors: 1) the Uniped pedagogical program has one module on professional guidance, 2) a Central NTNU PhD supervision seminar is given two times each year and 3) seminars/courses are also provided at Faculty levels.
  The NTNU central PhD supervision seminar was presented. It is a 2-3 day event which covers a range of aspects of PhD supervision and includes group work among the participants.

	
TTO at NTNU	Laboratory management

2 Open Day, Friday 6 May 2022

Presentations

The ambition of ENET is to jointly develop small scale energy technology concepts for implementation in rural Africa. Towards that end, we have invited experts and stakeholders to give their views on drivers for change: **1) How can small scale energy systems be developed?** and **2) How can new technology be implemented?**

Introduction	NTNU, EPT	Ole Jorgen Nydal
Design driven	NTNU, Design	Manisha Rayaprolu
Research driven: Social Science	NTNU, Multicultural	Govert Valkenburg
Research driven: Natural Science (on-line)	NWU, South Africa	Ashmore Mawire
Individual driven (on-line)	Simply-Solar, Germany (Scheffler)	Heike Hoedt
University driven: NTNU	NTNU, Innovation	Per Arne Wilson
Industry driven (Monday 8 May)	NABA and NTNU	Karl Klingsheim, Kjersti Blauenfeldt, Mathilde Emilie Thue
Public funding driven (on-line)	Innovation Norway	Therese Marie Uppstrom Pankratov
Development collaboration driven (on-line)	NORAD	Anette Løken
Public funding driven (on-line)	NTNU, EU	Patrick Reurink
Humanitarian Engineering driven	EWB	Heidi Hovland Bergfald
Civil Society driven (on-line)	CARE	Morten F. Thomsen
Environment and conservation driven	NTNU, Conservation	Eivin Røskaft

Open Day presentations and discussions

- **Design driven**. Early involvement of end users can be important for a successful implementation of new technology. A research group at NTNU advocates design driven technology development. **Manisha Rayaprolu (NTNU)** presented the aims and examples of design driven development in Asia based projects, which may be equally applicable in Africa

- **Industry driven**. For cases where there is a commercial market, new technology can be developed and implemented based on private investments. NABA (Norwegian African Business Association) promotes investments in Africa. **Karl Klingsheim (NTNU), Kjersti Blauenfeldt (NABA) and Mathilde Emilie Thue (NABA)** presented some views on the question: Can small scale technology be a case of interest for NABA members?

- **Research driven.** University staff have some opportunities to define their own research directions. Some project members will comment on the question of researchers as driving forces for the small scale technology development. Are researchers also interested in being drivers for the implementation?. The drivers can come both from the technical and the social side. **Govert Valkenburg (NTNU)** participates in the collaboration project and gave views from the social side. **Ashmore Mawire (North West University, South Africa, on-line)** presented his long research experience on solar solutions for cooking.

- **University driven**. Innovation and entrepreneurship are frequent words also on the agenda of universities. Can our Small Scale Technology Development be driven by innovation programs at universities? **Per Arne Wilson (NTNU Strategic Area Innovation)** presented examples of programs promoting innovation at NTNU.

- **Public funding driven.** Grant programs are sometimes directed towards innovation and the energy transition challenge, at EU and at national levels (Research Councils). Are such funding schemes relevant for our Small Scale Technology Development for the African context**? Patrick Reurink (NTNU) on-line** is a contact point for the collaboration with universities in Low Middle Income Countries (LMIC). Patrick gave some views on opportunities in EU programs. **Therese Marie Uppstrom Pankratov (Innovation Norway) on-line** presented the Humanitarian Innovation Programme at Innovation Norway.

- **Humanitarian Engineering driven.** Engineers are challenged by the need for technical solutions which can improve efficiencies, reduce costs and therefore presumably lead to better living conditions. Engineers Without Borders (EWB) target the cases where the purchasing power is low and technical support is needed. Can EWB also be drivers for development of new technology? **Heidi Hovland Bergfald (EWB)** and Ida Fuchs from NTNU presented the organization together with examples of projects and activities.

- **Development collaboration driven.** NORAD programs include collaboration on education and research. Can NORAD take on a role as a driver, or facilitator, for implementation of research results in Small Scale Renewable Energy Technology as well?. **Anette Løken (Norad) on-line** presented the Norad Strategy with particular comments on the relevance for universities.

- **Civil Society driven.** Can the various organizations on development collaboration also be partners in development and implementation of small scale energy systems? **Morten Fauerby Thomsen**

(CARE Norge) - on-line presented experiences from the CAMP+ project, which includes energy systems designed for refugee camps in Uganda.

- **Environment and sustainability driven.** Sustainability, conservation, natural environment and climate are rising on the political agendas. Can these be major drivers for the development and implementation of small scale energy systems?. **Eivin Røskaft (NTNU)** Eivin Røskaft gave his views based on his more than 30 years of experience in Conservation projects in Tanzania.

- **Individuals driven.** Individual persons who have the dedication and resilience to pursue ideas and goals, often outside an institutional base and funding, and often on an idealistic basis. The internet access to knowledge and communication, as well as backyard workshops, makes this "Boot-strap" driver today a worldwide option. **Heike Hoedt (Simply Solar) on-line** have almost a life time of experiences on development and application of the Scheffler Reflector system for various energy needs at various scales. They will give a brief overview of their experiences on development and implementation of the systems.

- **Round-The-Table Discussions**
  The presentations were followed by a round-the-table discussion including the presenters. A survey was then conducted on how the audience would rate the relative importance of the various aspects presented.

Mini survey

A survey among the participants was made after the presentations, as described below.

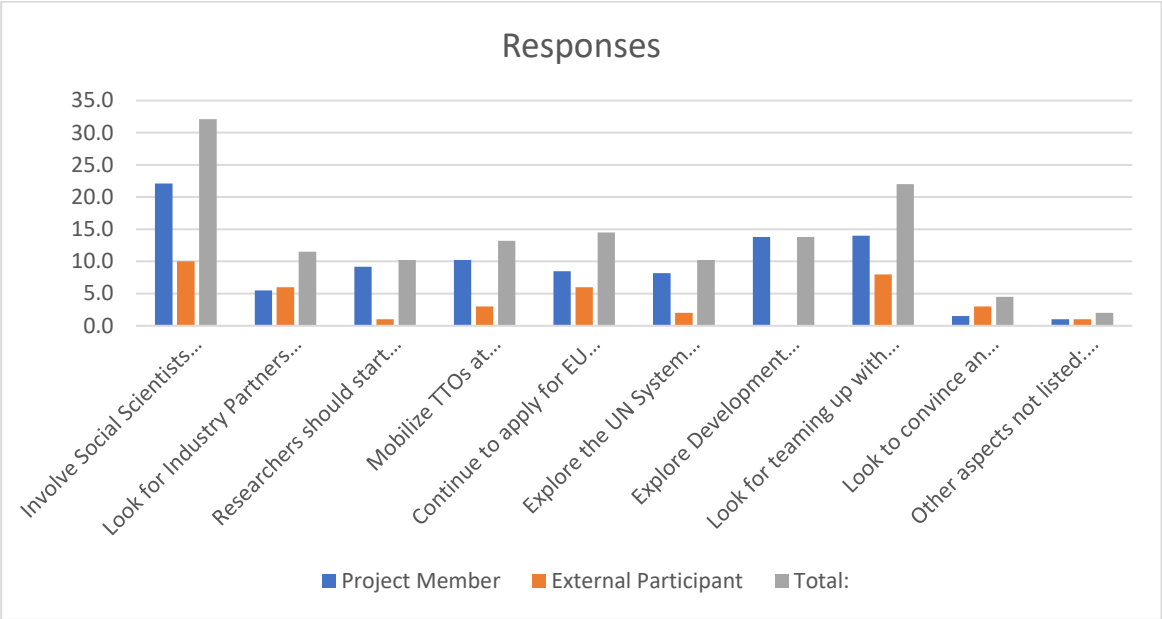
Please give 5 points on the aspects you believe should get special attention at the stage we are now.

- If you are project member: What should we at best do now? **I AM A PROJECT MEMBER** ☐
- If you are not project member: What is your advice? **I AM NOT A PROJECT MEMBER** ☐

You can spread the 5 points as you wish on several or only on a few of the aspects. The total sum of points should not exceed 5. You can also add other aspects.

Aspect	Points
Involve social scientists and designers now	
Look for industry partners now	
Researchers should start companies for implementation now	
Mobilize the TTOs at the universities to contribute to the case now	
Continue applying for EU Grant funding	
Explore UN system (UNDP etc.) for implementation support now	
Explore Development Agencies for implementation support now	
Look for teaming up with Civil Society partners now	
Look to convince an individual with dedication and willingness to take the case!	
Other	

The response of the mini survey is given below.



The tendencies from the external participants is to look for involvement of social scientist and teaming up with industry and civil society partners. The participants are more evenly spread out, but do also point to collaboration and also to exploration of funding options.

Appendix Curriculum of MSc. in Renewable Energy at UDSM

The MSc. REN has been offered as an 18-month full - time (regular mode) programme. However, after 16 years of running the programme, several drawbacks were observed, which necessitated a major review of the programme curriculum. Among the major deficiencies observed in the curriculum is the fact that it did not provided sufficient advance/specialized knowledge and skills in all the potential renewable energy sources and technologies available in Tanzania and elsewhere in the world. The design of the curriculum also did not provide efficient use of resources, especially considering the relatively low number of students enrolled in the programme and the many specialisations that were offered. Another weakness of the programme is that it lacked engineering rigour as it was designed to include applicants with non-engineering backgrounds.

The curriculum review process, which was implemented between November 2022 and January 2024, started with a consultation process and involved a tracer study, SWOT analysis and stakeholders' validation workshops. The target of the tracer study was gathering of stakeholders' evaluation on adequacy and appropriateness of imparted knowledge, developed skills and attitudes enhancement. It was conducted utilizing online and field data collection methods and involving graduates and employers. The data collection was followed by data analysis, preparation of a report and stakeholders validation Workshop. The College of Engineering and Technology (CoET) organized a validation workshop for the tracer study finding, for external and internal stakeholders, which was held on Saturday, 24th June 2023. The Workshop was organized in two sessions; a plenary session for all CoET internal and external stakeholders, and departmental breakaway sessions for each department to discuss their report with their specific internal and external stakeholders. Both sessions discussed the report in details, and recommended it with specific recommendations.

The Self-Assessment / SWOT Analysis involved self-reflection of programme by internal stakeholders (academic staff, technical staff and students). The objective of the analysis was to compliment information provided by tracer study report towards informed curriculum review. It was carried out through desk analysis at the campus. The SWOT matrix was designed based on Inter-University Council of East Africa (IUCEA) Handbook for QA in Higher Education - Guidelines for Internal and External Programme Assessment, Section 4: Programme Assessment Tool. The exercise was conducted in July 2023.

Teams of experts related to the courses being offered under the programme embark on the painstaking task of reviewing the programme curriculum, including all the courses that would be offered under the programme. Through a series of working many sessions involving experts from other related fields, the team came up with a draft curriculum document that is in line with the TCU Curriculum Development Framework of November 2021. The draft curriculum was submitted to Stakeholders Validation Workshop for Curriculum Review. This Validation Workshop on Curriculum Review for CoET was held on Saturday, 2nd December 2023. It was organized in the same manner as the one for the tracer study.

The employment status of graduates in the period of 0-6 months to 6 years and above after graduation show that graduate of MSc. REN perform best as shown in **Error! Reference source not found.** shows the details.

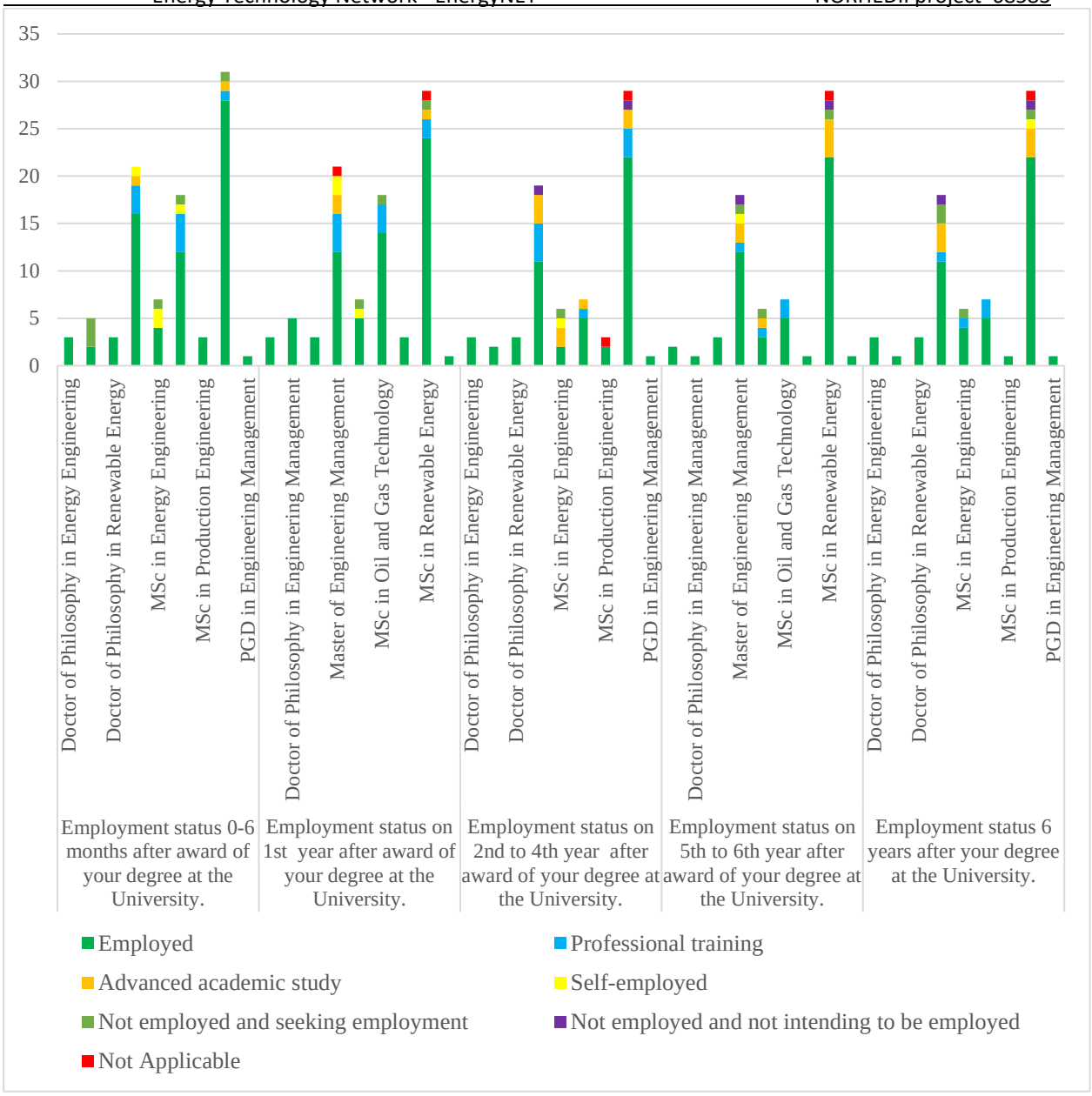


Figure 1: Employment Status after Graduation for Postgraduate Respondents

Figure 2 shows the Relevancy of Education to the Occupation for Postgraduate, whereby the MSc. REN programme also performs well.

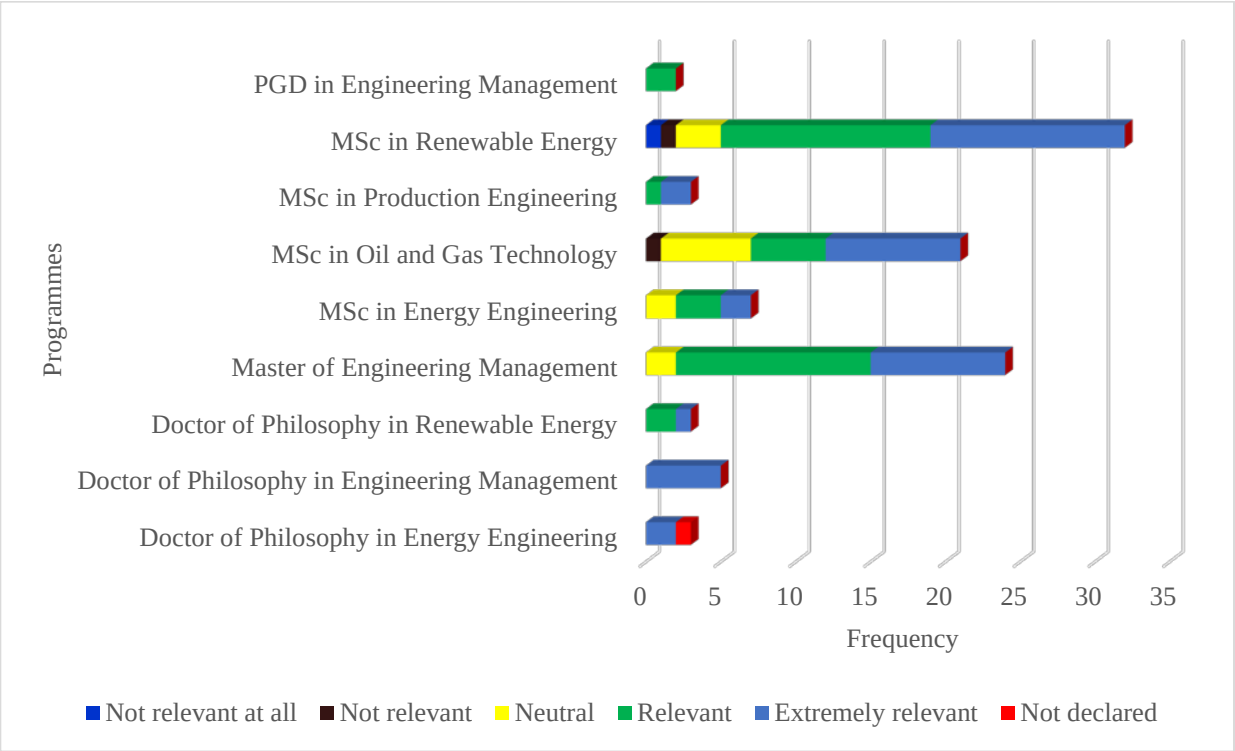


Figure 2: Relevance of Education to the Occupation for Postgraduate Programmes

Table: Comparison Matrix for Old and Reviewed Curriculum

Existing/Old Courses		*Revised/New Courses*	
Course Tittle	*Core/ Elective*	*Course Tittle*	*Core/ Elective*
Statistics and Research Methods	Core	Research Proposal Formulation	Elective
Bioenergy	Core	Bioenergy	Core
Solar Energy	Core	Solar Thermal Energy	Core
Hydropower	Core	Hydropower	Core
Mathematical Methods	Core	Applied Mathematics in Energy Engineering	Elective
Energy Policy and Planning	Elective	Energy Policy and Economics	Elective
Computational Fluid Dynamics	Elective	Experimental and Computational Methods for Engineers	Core
Project Management	Elective	Engineering Project Management	Elective
Entrepreneurship Development	Elective		
Electrical Energy Systems	Core		
		Thermal Turbo - Machinery and Internal Combustion Engines	Core
		Environmental Management and Climate Change	Elective
Other Forms of Renewable Energy	Elective	Wind Energy	Core
		Geothermal Energy	Core
		Ocean Energy	Core
Thermo-Chemical Conversion Processes	Core	Bioenergy	Core
Biochemical Conversion Processes	Core		
Design and Modelling of Thermal	Core	Design and Modelling of Energy Systems	Elective

Existing/Old Courses		*Revised/New Courses*	
Course Tittle	*Core/ Elective*	*Course Tittle*	*Core/ Elective*
Power Systems			
Hydropower Mechanical Equipment	Elective	Thermal Turbo - Machinery and Internal Combustion Engines	Core
Solar Thermal Technology	Elective	Solar Thermal Energy	Core
Hydropower Electrical Machines	Elective	Hydropower	Core
Hydraulic Structures in Hydropower	Core		
Development of Small Hydropower	Elective		
Solar Cell Technology	Elective	Solar Photovoltaics	Core
Electrical Energy Conversion in PV Systems	Elective		
Sustainable Building	Elective	Energy Efficiency and Management in Buildings	Elective
Thermal Comfort in Buildings	Elective		
Lighting in Buildings	Elective		
Smart Grid Technologies	Elective	Mini and Smart Grid Technologies	Elective
Renewable Energy Hybrid Systems	Elective		
Energy Storage Systems	Elective		
Renewable Energy Pricing and Financing	Elective		
		Occupational Health and Safety Engineering	Elective
Dissertation	Core	Dissertation	Core
		Selected Topics in Energy Engineering	Core

Currently, the curriculum has been approved at the department and College level and has been submitted to University level for further processing and approval by the Senate, before submitting it to TCU for accreditation. It is expected that the revised curriculum would be ready for implementation by the beginning of the 2024/25 academic year.

Workshop May 2024, Norway

Time: 13 - 16 May 2024
Place: Trondheim, Norway
Organizer: Norwegian University of Science and Technology (NTNU)
Host: Department of Energy and Process Engineering, Strategic Area NTNU Energy

Add summary here

Appendix First Photovoltaic training at University of Juba

University of Juba
School of Applied & Industrial Sciences
Department of Physics
First Photovoltaic training conducted in the University of Juba with the support from NORHED II - ENET
Executive summary Report on Photovoltaic training conducted in the University of Juba-South Sudan

Name of the Project	Photovoltaic Training
Duration of the Training	Jan. 29th - 31st, 2024
Funding agency	NORHEDII-Energy Technology Network
Objective for the training	i. To introduce solar energy basics and photovoltaic system components. ii. To equip the participants with design and installation practices of photovoltaics. System iii. To impart safety skills in the management of the solar panels
Training Location	STEM Center, University of Juba South Sudan.
Target Group	Staff & Students from the Department of Physics, University of Juba South Sudan. 45 Males 5 Females
Institution	University of Juba (Host) Mr. Konjo Francis Pote (ENET Project Coordinator) Tel: +211926591456/ +211918666400 Email: konjofrancis81@gmail.com
Partners	Makerere University (Partner) 1-Mr. Micheal Musoke Mob: +256706921069 Email: musokem@yahoo.com 2-Aguminetwe Adons Mob: +256700780484 Email: agumenitweadons@gmail.com

This report was made to detail the results of the Photovoltaic technical training conducted by E-NET in the department of Physics, School of Applied and Industrial Sciences. It was a 3-day session that started on January 29th - 31st, 2024. Photovoltaic training included education on solar energy and photovoltaic systems. This training typically includes understanding solar energy basics, learning about PV system components, design and installation practices. The purpose of training was to give the students and the staff in the department of Physics and School of Applied and Industrial Sciences a foundation for careers in design, installation, maintenance, and management of Photovoltaic Systems which will give them a chance to contribute to the global transition toward cleaner and more sustainable energy solutions.

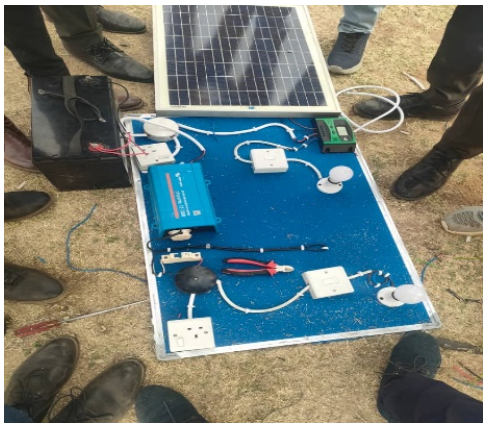
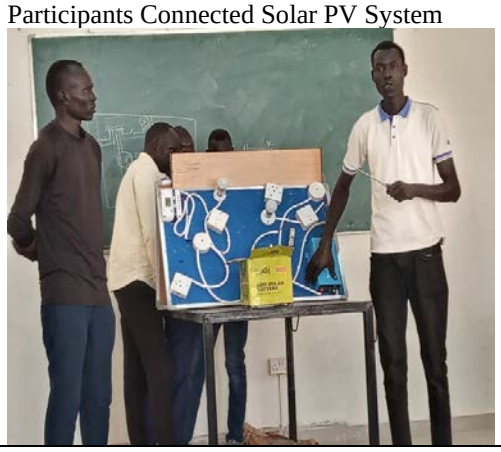
Scope:
The training basically concentrated on solar energy basics, Photovoltaics System Components, Design and Installation of Photovoltaic System

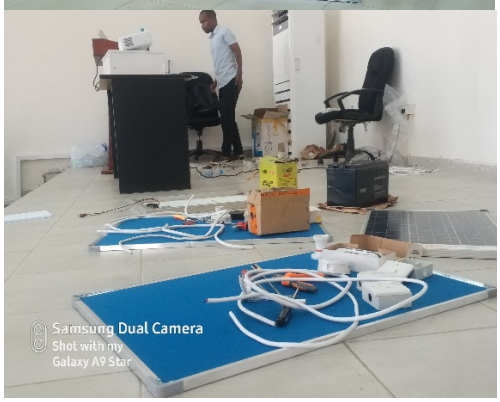
Methodology:

a) The training was delivered in two ways that is, through oral presentations detailing the theoretical background of solar energy and PV system components.
b) The presentations were accompanied with hands-on activities by the participants with the support of Facilitors.

Training programs and skills acquired:
The training started with opening remarks from Dean school of applied and industrial sciences who officiated the commencement of the training.

Day one	**Responsible**	**Activities**	**Skills acquired and comments**
	University of Juba	Welcoming remarks	 Official Opening by the Dean School of Applied Industrial Sciences-University of Juba
	Makerere University	Introduction to Basic Electronics	
		Use of digital multimeters and other tools • Continuity measurements • Electrical parameters such as voltage, current, power etc. • Connection of the switch in an electrical system • Measurement of the semiconductor diode being a key component in PV module	

Day 2	Makerere University	• PV system planning and sizing • Installation of DC and AC PV systems	
Day Three	Participants	• demonstrating and explaining the skills they acquired throughout the course of the training.	 Participants Connected Solar PV System 

			 Participants reporting on what they learn
Use of electrical equipment and connection of PV system		Equipment were bought using Enet Fund. Some of the equipment were taken from Makerere University. Provided in the tool box are equipment such as, • PV modules (commonly known as solar panels) • Charge controllers • Batteries • Inverters	  Trainers from Makerere demonstrating how to connect PV components

We thank the NORHEDII who provided the fund under the ENET project. It is the first training on Photovoltaic ever done in the University of Juba-South Sudan. It provided the basic skills students wanted in this modern time. One of the students in the Department of Physics said;

This is a great opportunity for me. It is the first time in my life I ever had hand-on training. Will you please coordinator do this training again?

In his closing remarks the Dean stressed the need for continuity of the training to the secondary schools. It was noted that the gender participation was very low. There is n need to include more gender in the PV training.

Group photos:

Participants taking notes of basics electrical theory：

Report by the ENET Coordinator Univ. of Juba: Mr. Konjo Francis (+211926591456)

Facilitators from our Partner (Makerere University):

Musoke Michael (+256 706921069)

Agumenitwe Adons (+256700780484)