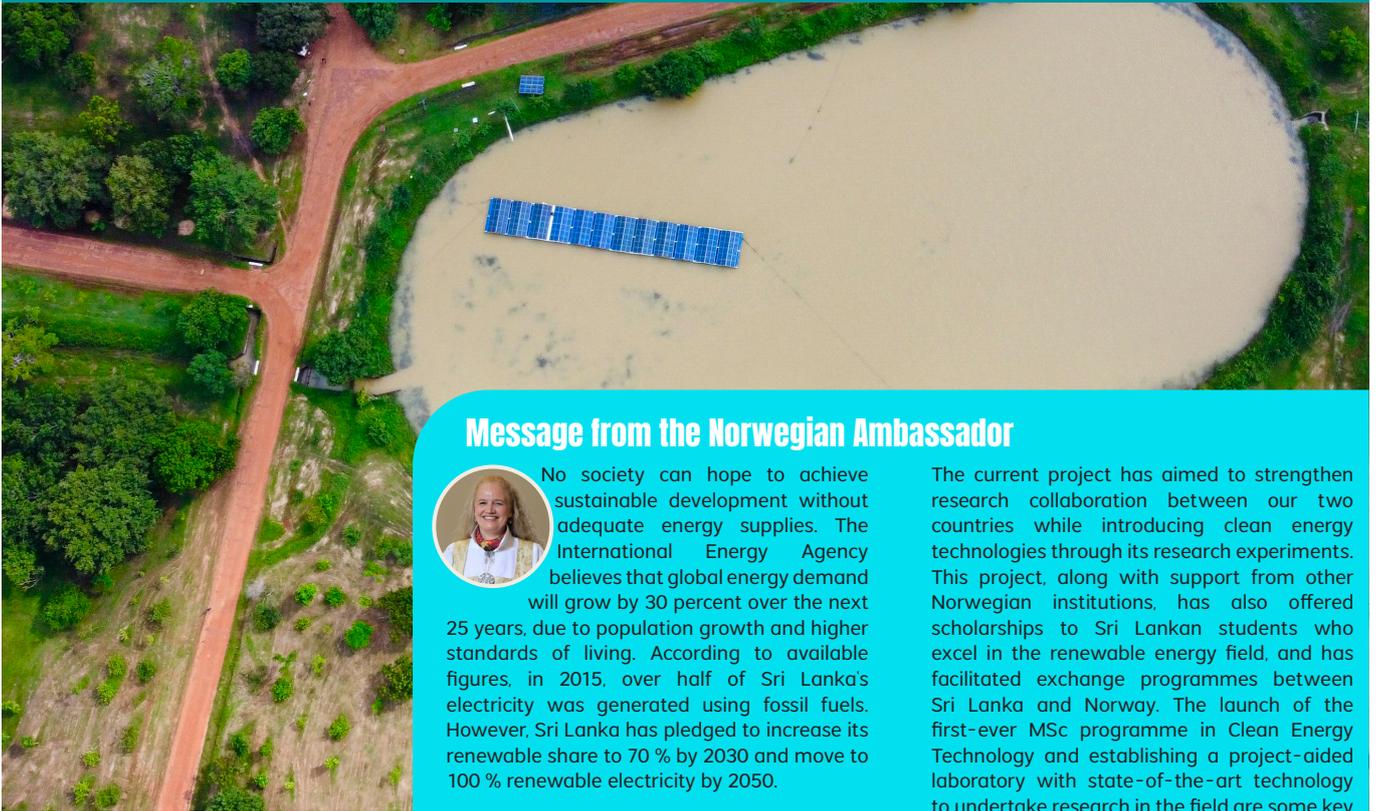




Capacity Building and Establishment of a Research Consortium

Higher education and Research collaboration on Nanomaterials for Clean Energy Technologies (HRNCET)

HRNCET-NORPART Project Journey 2017 - 2021



Message from the Norwegian Ambassador



No society can hope to achieve sustainable development without adequate energy supplies. The International Energy Agency believes that global energy demand will grow by 30 percent over the next 25 years, due to population growth and higher standards of living. According to available figures, in 2015, over half of Sri Lanka's electricity was generated using fossil fuels. However, Sri Lanka has pledged to increase its renewable share to 70 % by 2030 and move to 100 % renewable electricity by 2050.

Within the next three decades, we need to secure access to energy for everyone, but at the same time, we also need to reduce greenhouse gas emissions. We need to achieve both the UN Sustainable Development Goals and the goals agreed upon in the Paris Climate Agreement. The goals can only be achieved if we transform the way we produce and consume energy. The transition to a sustainable energy future challenges not just Sri Lanka or Norway, but all states around the world.

The Norwegian Embassy supported capacity building and the establishment of a research consortium between the Western Norway University of Applied Sciences and the University of Jaffna, and together with other like-minded academic research institutions in Sri Lanka have been promoting research into clean energy technology and innovation in the renewable energy sector. This journey started in early 2017 and is still ongoing.

The current project has aimed to strengthen research collaboration between our two countries while introducing clean energy technologies through its research experiments. This project, along with support from other Norwegian institutions, has also offered scholarships to Sri Lankan students who excel in the renewable energy field, and has facilitated exchange programmes between Sri Lanka and Norway. The launch of the first-ever MSc programme in Clean Energy Technology and establishing a project-aided laboratory with state-of-the-art technology to undertake research in the field are some key achievements of this collaboration.

Further, the Norwegian Embassy has also witnessed increased business interest from Norwegian companies in Sri Lanka, as this project also partly aims to bring Norwegian investments to Sri Lanka's clean energy sector. The launch of the first-ever floating solar project at the University of Jaffna-Kilinochchi Campus is another great example of the project's successful partnerships with the private sector.

Renewable energy and climate remain top priorities for the Norwegian government. We are happy to support university cooperation between Norway and developing countries in this field. We believe research cooperation is fruitful both for our own country and for Sri Lanka and that we all have a shared responsibility to reduce carbon emissions if we are to achieve our common global targets.

Her Excellency Trine Jøranli Eskedal
Ambassador, Norwegian Embassy, Colombo

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- ▣ Industrial Collaborations
- ▣ Project Outputs & Impacts



Funded by :

Norwegian Partnership Programme for Global Academic Cooperation (NORPART), Norwegian Directorate for Higher Education and Skills & Norwegian Embassy in Colombo

Inauguration of HRNCET project

In March 2017, a high-level delegation from the Western Norway University of Applied Sciences (HVL), including the Vice Rector of HVL visited and signed a MOU and Collaborative agreement with the University of Jaffna. Prof. R.Kumaravadivel represented the University Grants Commission and the Deputy Ambassador Knut Nyflot represented the Royal Norwegian Embassy at the inaugural function along with academics, students and well-wishers.



On 07.07.2017, the project coordinators Prof. Dhayalan Velauthapillai and Prof.P.Ravirajan, signed an Institutional Technical Assistance Contract on Capacity Building and Establishment of a Research Consortium in Nanomaterials for Clean Energy Technologies in relation to the above project at the Royal Norwegian Embassy in Colombo in the presence of the Norwegian Ambassador, His Excellency Thorbjørn Gaustadsæther. This collaborative initiative was funded by the Royal Norwegian Embassy, Ministry of Foreign Affairs, Norway as part of its development cooperation programme.

The main objective of the project

To strengthen the collaboration between the partner institutions (Western Norway University of Applied Sciences, Universities of Adger and Bergen, Norway, Coimbatore Institute of Technology (CIT), India and Universities of Peradeniya & Jaffna) in educational and research activities, and implement student and staff mobility within the field of clean energy technologies. Further the project funded by the Royal Norwegian Embassy aimed to strengthen the existing collaboration between the partner institutions in the field of nanomaterials for energy technologies and to establish a clean energy consortium that includes private enterprises from Norway and Sri Lanka.

GOALS

GOAL - 01: Institutionalization of student and staff exchange by creating mobility windows.

GOAL - 02: Increasing the quality of higher education and research through mobility programs, joint supervision and guest lecturing (at the Faculties of Science, Engineering and Technology) in the field of Nanomaterials for Clean Energy Technologies.

GOAL - 03 : Development of a joint course on Nanomaterials for clean energy applications at Master / PhD level as part of the existing Master programme at Western Norway University of Applied Sciences / University of Bergen and part of a new Master programme for Clean Energy Technologies at UoJ.

GOAL - 04: Exchange of knowledge in Nanomaterials for Clean Energy Applications through joint research, supervision and dissemination activities

Message from the Vice-Rector/HVL



Prof. Gro Anita Fønnes Flaten,
Vice-Rector/HVL

The UN's 2030 Agenda for sustainable development has identified 17 development goals - the SDGs. Goal number 7 is to Ensure access to affordable, reliable, sustainable and modern energy for all. Both Norway and Sri Lanka are committed to the UN sustainable development goals. As higher educational institutions, we are obliged to help our countries to become carbon neutral by 2050. Our joint educational and research activities will contribute positively to achieving this goal. The extensive cooperation between the University of Jaffna and the Western Norway University of Applied Sciences, especially in the field of clean energy technologies has lasted for almost six years.

The first MoU between our institutions was signed in 2017. The cooperation between our universities has generated many important results.

- An active research cooperation
- Cooperation on education and
- Extensive student exchange

We have had the privilege to have many students from the University of Jaffna at our Western Norway University of Applied Sciences, which we call as HVL. These students have been contributing immensely to our research activities and the international environment here in Bergen.

We [HVL] are also happy to contribute to the development and implementation of the first Master and MPhil programs in clean energy technologies in Sri Lanka. With the current energy crisis in the world, green energy transition is becoming more important than ever and education and research on new energy technologies are of utmost importance. Our research students and professors are working together in realising cheap, flexible and efficient energy technologies that will have a high impact in the near future.

It is great that we have succeeded in including the private sector in our collaboration which has resulted in the first Floating PV in Sri Lanka based on Norwegian technology. We had brought several representatives from both higher educational institutions and industrial partners from Norway to Sri Lanka and conducted clean energy seminars/workshops and an International Conference in the project period. For a smooth green energy transition, public awareness on clean energy technologies is of importance, and our students and staff have carried out a variety of outreach activities both in Sri Lanka and Norway. Through the NORPART project, HRNCET 2.0, we will enhance our education and research collaboration, expand our collaborative network with the partners, the University of Bergen, the University of Peradeniya, the NIFS and the private sectors in Norway and Sri Lanka.

I and the Western Norway University of Applied Sciences would like to thank The University of Jaffna for our close cooperation over the past years and look forward to working with all our partners in the next five years. We would like to thank the Norwegian Embassy in Colombo for your valuable moral and financial support. Finally, we would like to thank The Directorate for Higher Education and Competence for financing a second project period

Message from the Vice Chancellor, University of Jaffna



People of Norway and the government of Norway have long standing fruitful relationship with people of Sri Lanka. People of Sri Lanka are ever grateful to people of Norway and government of Norway for their immense contribution in providing technical and financial support for many development projects in Sri Lanka especially in the marine and energy sectors for more than last four decades. University of Jaffna is a relatively young Higher Education Institution, inaugurated in 1974, growing fast and providing undergraduate and postgraduate education in many disciplines including Science, Technology, Engineering and Medicine (STEM).

As a consequence of unsettled conditions prevailed in the region for more than last three decades, UoJ suffered and had limited infrastructure and laboratory development. With the end of the conflict in the last decade, UoJ has been seeking for collaborative research engagements with other universities both in Sri Lanka and abroad to catch-up the contemporary developments. In this respect, NORPART project collaboration between UoJ and HVL, worth of many million LKR, inaugurated in 2017 and running over the last five years, is a blessing to the UoJ to erect state-of-art laboratories and technically resourceful personals.

NORPART -HRNCET project outcome has drawn the attention of energy industries and authorities due to its novel findings in solar cell design, floating panel generators, and related higher studies in clean energy production. UoJ is happy that based on the performance of HRNCET project in the last five years, Norwegian government has chosen the project proposal HRNCET-2.0 of UoJ and HVL as one of the sound proposals to receive substantial financial support among the highly competitive proposals submitted. In this regard, UoJ is grateful to Prof. Dhayalan Velauthapillai for masterminding the project development by engaging the Scientists of HVL and UoJ.

Right knowledge is the ultimate solution for all the problems. Lord Krishna said "Little advancement of knowledge may save you from the greatest fear of life". In this regard the success of HRNCET project is a testimony for catering the future generation with clean and sustainable energy generation. On behalf of the Sri Lankan project partners at the UoJ, I wish to express my sincere gratitude to Norwegian ambassador Her Excellency Trine Jøranli Eskedal and Pro-Rector of HVL Prof. Gro Anita Fønnes Flaten and their team for gracing the inauguration of the HRNCET-2.0 project which would be running for another five years from 2022 to produce research personals through PhD programmes

All glories to God

Prof. Sivakolundu Srisatkunarajah
Vice Chancellor/ UoJ

Message from Project-Coordiators

Universities are not merely institutions that only engage in teaching and learning. Engagement in research and dissemination of the research findings to society in productive ways are an important role for any university.

In this regard, the Western Norway University of Applied Sciences (HVL) and the University of Jaffna (UoJ) have jointly secured multiple funds from Directorate for Higher Education and Skills (HK-Dir) formerly known as DIKU and the Royal Norwegian Embassy in Sri Lanka over a period of six years (2017-2022) for projects on Higher education and Research collaboration on Nanomaterials for Clean Energy Technologies (HRNCET) and Capacity Building and Establishment of a Research Consortium, respectively (<http://project.jfn.ac.lk/hrncet/>).

The two projects have progressed very well even when some of our mobility activities were hampered due to the Corona situation. It is a pleasure for us to report through this bulletin the project activities during the past five years and the resulted outputs. We clearly observe the positive impacts of the two projects both at the partnering institutions, collaborative industries and society in general.

As the energy demand has reached to highest levels, and clean energy transition is expected to become more crucial day by day, the Higher Education Institutions (HEIs) are obliged to play a major role

in knowledge development, knowledge sharing, innovation and research, and dissemination of new knowledge to the society. Through the partnership with our collaborators the University of Bergen, University of Agder, University of Oslo, University of Peradeniya, National Institute of Fundamental Studies and institutions from India, we have created a broad network of students, researchers and academics in the field of nanomaterials for clean energy and health applications. We have also been successful in setting a platform for a research consortium that consists of HEIs and the private sector from Norway and Sri Lanka to work on joint research and business ventures in the field of clean energy technologies. We have been successful in arranging multiple workshops, seminars and conferences in this regard to enhance and broaden the collaborative network through dialogue, meetings etc.

We have carried out a number of student/ staff mobilities between Norway and Sri Lanka that have given valuable experience in working in a multicultural, international research environment for all those who are involved. Joint teaching/supervision and a high number of joint research publications in reputed journals have increased the quality of education and research at our institutions. First-ever Master program in clean energy technologies established in Sri Lanka under our projects will ensure the



flow of skilled academics/researchers in the field of clean energy technologies. In collaboration with the private sectors, we envision contributing positively through collaborative industrial clean energy projects to ensure the goals set by Norway and Sri Lanka to become zero net carbon nations by 2050.

Our sincere gratitude goes to HK-Dir for the funding from 2017 to 2023 and new funding from 2022-to 2026 that has made this collaboration possible. We thank also the Norwegian Embassy in Colombo for the moral and financial support in realizing a well-equipped Clean Energy Research Laboratory at the University of Jaffna, for supporting our MPhil/PhD research students with scholarships and for organising the clean energy seminars. We are looking forward to working in the coming years with HK-Dir, Norwegian Embassy in Colombo and all our university and industrial partners to enhance the higher education/research activities to the highest level that can result in innovative industrial projects for the benefit of the civil society.

Prof. Dhayalan Velauthapillai and Prof. Punniamoorthy Ravirajan
Coordinators
HRNCET & CBERC Projects

Academics involved in developing Curricula of Master Degree programmes in Clean Energy Technologies

☐ <http://project.jfn.ac.lk/hrncet/index.php/researchers>



Prof. K. Kandasamy



Prof. V. Dhayalan



Prof. P. Ravirajan



Prof. A. Atputharajah



Prof. S. Meena



Prof. S. N. Surendran



Prof. T. Thiruvanan



Prof. K. Vignarooban



Dr. K. Thabotharan



Dr. T. Pathmathas



Prof. G. Sashikesh



Dr. A. Anbruvell



Dr. U. Sutharshini



Dr. A. Thevakaran



Dr. B. Ketheesan



Dr. D. N. Subramaniam



Dr. S. Yohi



Dr. K. Ahilan



Mr. S. Senthuran



Ms. R. Rohini



Dr. M. Thanihaiselvan

HVL Academics and Students under the project



Prof. V. Dhayalan



Prof. Arnt Fløysand



Dr. Sjun Zhang



Dr. M. Rasukkannu



Dr. M. Keikhaei



Dr. Said Bentouba



Håkon Eidsvåg



H. Sherief N Musthafa



Nanthini Nagarajah



Fatemeh Heidari Gourji



P. Santhakumaran

MPhil/PhD Research Students under the project

☐ <http://project.jfn.ac.lk/hrncet/index.php/researchers>



Mr. A. Malikaramage
Dye Sensitized Solar Cells
Completed PhD



Mr. S. Uthayaraj
Perovskite Solar Cells
Completed MPhil



Mr. T. Rajaramanan
Dye Sensitized Solar Cells
Completed MPhil



Mr. A. Pirashanthan
Hybrid Polymer Solar Cells
Awaiting for viva



Ms. S. Sivagowri
Hydrogen production
Awaiting for viva



Ms. T. Kajana
Photo capacitors
Awaiting for viva



Ms. N. Nanthini
Energy Policies



Ms. C. Wanniarachchi
Simulation of
nanomaterials



Mr. T. Thivakararaj
CdTe Solar cells



Mr. V. Jerron
Tissue Engineering



Mr. G. Abiram
Perovskite FETS



Mr. Y. Eilana
H₂ production via water
splitting

Master of Clean Energy Technologies- First batch of students



Mr. A. Krishnananthan



Ms. R. Theivanithy



Mr. J. Thivasen



Ms. T. Suthajini



Mr. S. Arun



Mr. K. Anojan



Mr. R. Thanushan



Ms. S. Sivarathika



Mr. P. Sumanthiran



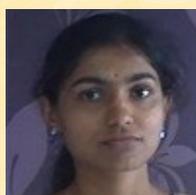
Ms. K. Lojana



Mr. S. Senthilkumaran



Mr. W. K. Gnanasuthan



Ms. S. Layanthini

Collaborating Institutions



1.0 Curriculum Development:

Master degree programmes in Clean Energy Technologies

The University of Jaffna and the Western Norway University of Applied Sciences (HVL) jointly developed the curriculum under HRCNET and CBERC projects (<http://project.jfn.ac.lk/hrcnet/index.php/inauguration-of-master-of-clean-energy-technologies-programme/>). New Master degree programme in Clean Energy Technologies was the first of its kind in Sri Lanka and was approved by the Quality Assurance Council of the UGC in 2019. Since Sri Lanka is foreseeing a clean energy future, the Master programme will help to produce the required technical workforce to accelerate clean energy technologies in Sri Lanka. Duration of the taught Master of Clean Energy Technologies [MCET] degree programme is one year, while Master of Science in Clean Energy Technologies [MSc(CET)] is a two-year programme with a research components of 20 Sri Lankan credits (40 European Credit Transfer and Accumulation System- ECTS). Students who excel in this master degree will have an opportunity to continue with PhD partnership PhD programme in Norway.



Inauguration of the first Master degree programme

Her Excellency Trine Jøranli Eskedal, the Ambassador of Norwegian Embassy in Colombo and the Vice-Chancellor, University of Jaffna, Professor S. Srisatkunarajah inaugurated 'Master of Clean Energy Technologies' Programme in collaboration with Western Norway University of Applied Sciences on 19.09.2020. In the first batch, sixteen students (15 from Sri Lanka and 1 from Norway) enrolled for the degree programme. Due to the pandemic situation, lectures were conducted through zoom by lecturers from the University of Jaffna, University of Moratuwa, University of Peradeniya, Western Norway University of Applied Sciences, University of Washington, USA, Arizona State University, USA, University of Technology Sydney, Australia, Coimbatore Institute of Technology, and PSG College of Technology, India and Chalmers University, Sweden. Dr. M. K. Ahilan and Dr. T. Pathmathas have been serving as joint coordinators of the programmes since September 2020.

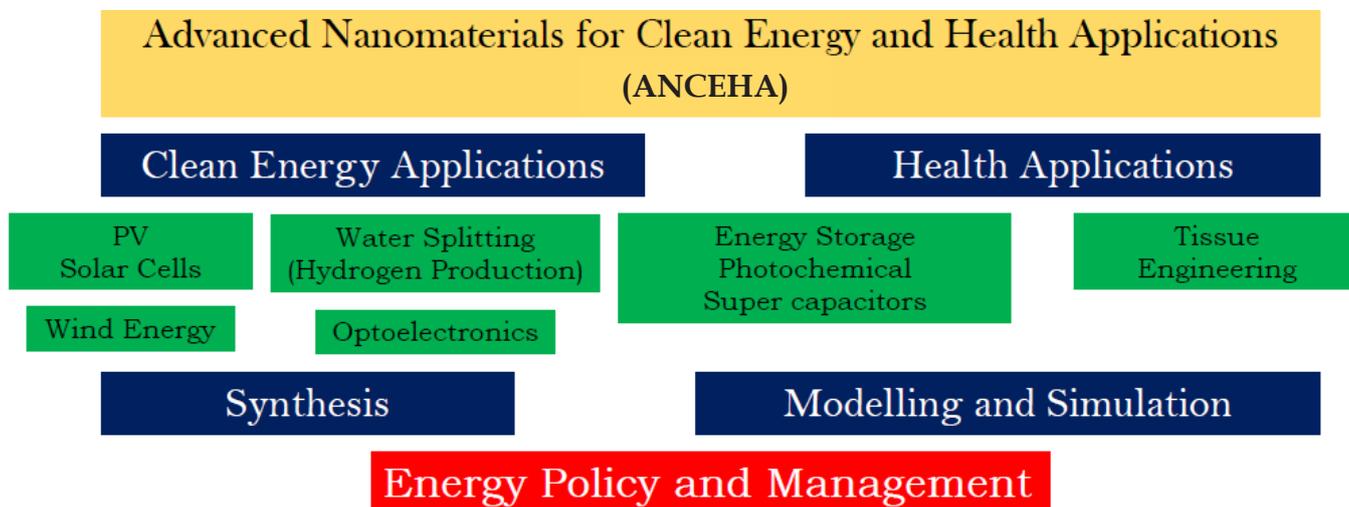


2.0 Research areas and Publications

2.1 Research areas

The research group ANCEHA created by Western Norway University of Applied Sciences, University of Jaffna and Coimbatore Institute of Technology and led by Prof. Dhayalan Velauthapillai consists of activities related to a variety of fields related to nanomaterials for clean energy and health applications. Both experimental and theoretical research are carried out on nanomaterials for emerging solar cell technologies, green hydrogen (photo-catalytic, photo-electrochemical, electrochemical), energy storage and transistor technologies as depicted in the figure below. The research group is also involved in analyzing and optimizing the floating PV plant. In addition, a number of studies are carried out on energy transition, energy management and energy policies under these projects. A new research group on simulation of materials for clean energy applications has been established at UoJ, and simulation studies on tissue engineering is carried out at HVL and UoJ in collaboration with the world-renowned Tissue engineering group led by Prof. Kamal Mustafa at UoB.

In addition, a variety of experimentally validated simulation studies on wind energy and biomass have been carried out at the Faculty of Engineering at UoJ. The low cost cabinet dryers developed under the project is an alternative to electric dryers or dryers that use LP gas as a source in many Small and Medium-sized Enterprises in Sri Lanka. The aim of this research project is to reduce the energy consumption of biomass cabinet dryers and to improve drying uniformity through an analysis based on experimentally validated CFD computations.



2.2 Publications

2.2.1 Science Citation Indexed Journal Publications

Research students under the above projects published more than 70 articles or abstracts in which 22 articles are published in SCI expanded journals (<http://project.jfn.ac.lk/hrncet/index.php/publications/>), and one special issue related to AMCEHA 2019 (<http://conf.jfn.ac.lk/amceha/>) was published in Elsevier journal. This was the first of its kind published at UoJ.

- JPS 2022: T. Kajana, A. Pirashanthan, A. Yuvapragasam, D. Velauthapillai, P. Ravirajan, and M. Senthilnathanan, "Bimetallic AC/Ag₂CrO₄/SnS heterostructure photoanode for energy conversion and storage: A self-powered Photocapacitor," J. Power Sources, vol. 520, 2022, doi: 10.1016/j.jpowsour.2021.230883.Scopus, SCI expanded, Impact factor: 9.127
- NM 2022: A. Pirashanthan, T. Kajana, D. Velauthapillai, Y. Shivatharsiny, and P. Ravirajan, "Roles of Interfacial Modifiers in Inorganic Titania/Organic Poly(3-hexylthiophene) Heterojunction Hybrid Solar Cells," Nanomaterials 2022, 12(5), 8202022, doi: 10.3390/nano12050820. Scopus, SCI expanded, Impact factor: 5.076
- SCR 2022: Abiram, G., Gourji, F. H., Pitchaiya, S., Ravirajan, P., Murugathas, T. and Velauthapillai, D. (2022) 'Air processed Cs₂AgBiBr₆ lead-free double perovskite high-mobility thin-film field-effect transistors', Scientific Reports. Nature Publishing Group UK, 12(1), pp. 1-8. doi: 10.1038/s41598-022-06319-z. Scopus, SCI expanded, Impact factor: 4.379

- SOE 2021: Pirashanthan, A., Thanihaichelvan, M., Mariappan, K., Velauthapillai, D., Ravirajan, P. and Shivatharsiny, Y. (2021) 'Synthesis of a carboxylic acid-based ruthenium sensitizer and its applicability towards Dye-Sensitized Solar Cells', *Solar Energy*. Elsevier Ltd, 225(March), pp. 399-406. doi: 10.1016/j.solener.2021.07.056. Scopus,SCI expanded, Impact Factor:5.742
- SCR 2021: Pirashanthan, A., Velauthapillai, D. and Robertson, N. (2021) 'Lithium doped poly (3 - hexylthiophene) for efficient hole transporter and sensitizer in metal free quaterthiophene dye treated hybrid solar cells', *Scientific Reports*. Nature Publishing Group UK, pp. 1-8. doi: 10.1038/s41598-021-99762-3. Scopus, SCI expanded, Impact Factor: 4.379
- MSSP 2021: Rajaramanan, T., Kumara, G. R. A., Velauthapillai, D., Ravirajan, P. and Senthilnathanan, M. (2021) 'Ni/N co-doped P25 TiO2 photoelectrodes for efficient Dye-Sensitized Solar Cells', *Materials Science in Semiconductor Processing*. Elsevier Ltd, 135(June), p. 106062. doi: 10.1016/j.mssp.2021.106062. Scopus, SCI expanded, Impact Factor: 3.927
- CAT 2021: Rajaramanan, T., Shanmugaratnam, S., Gurunathanan, V., Yohi, S., Velauthapillai, D., Ravirajan, P. and Senthilnathanan, M. (2021) 'Cost effective solvothermal method to synthesize zn-doped tio2 nanomaterials for photovoltaic and photocatalytic degradation applications', *Catalysts*, 11(6). doi: 10.3390/catal11060690. Scopus, SCI expanded, Impact Factor: 4.146
- CAT 2021: Shanmugaratnam, S., Selvaratnam, B., Baride, A., Koodali, R., Ravirajan, P., Velauthapillai, D. and Shivatharsiny, Y. (2021) 'SnS2/TiO2 Nanocomposites for Hydrogen Production and Photodegradation under Extended Solar Irradiation.', pp. 1-12. Scopus, SCI expanded, Impact Factor: 4.146
- ENG 2021: Shanmugaratnam, S., Yogenthiran, E., Koodali, R., Ravirajan, P., Velauthapillai, D. and Shivatharsiny, Y. (2021) 'Recent Progress and Approaches on Transition Metal Chalcogenides for Hydrogen Production', pp. 1-37. Scopus, SCI expanded, Impact Factor: 3.004
- ENR 2021: Bentouba, S., Bourouis, M., Zioui, N., Pirashanthan, A. and Velauthapillai, D. (2021) 'Performance assessment of a 20 MW photovoltaic power plant in a hot climate using real data and simulation tools', *Energy Reports*. Elsevier Ltd, 7, pp. 7297-7314. doi: 10.1016/j.egy.2021.10.082. Scopus, SCI expanded, Impact Factor: 6.870
- JPPA 2020: Kajana, T., Velauthapillai, D., Shivatharsiny, Y., Ravirajan, P., Yuvapragasam, A. and Senthilnathanan, M. (2020) 'Structural and photoelectrochemical characterization of heterostructured carbon sheet/Ag2MoO4-SnS/Pt photocapacitor', *Journal of Photochemistry and Photobiology A: Chemistry*. Elsevier B.V., 401, p. 112784. doi: 10.1016/j.jphotochem.2020.112784. Scopus,SCI expanded, Impact Factor: 4.291
- M.Lett 2020: Pirashanthan, A., Murugathas, T., Mariappan, K., Ravirajan, P., Velauthapillai, D. and Yohi, S. (2020) 'A multifunctional ruthenium based dye for hybrid nanocrystalline titanium dioxide/poly(3-hexylthiophene) solar cells', *Materials Letters*. Elsevier B.V., 274, p. 127997. doi: 10.1016/j.matlet.2020.127997. Scopus, SCI expanded, Impact Factor: 3.423
- SCR 2020: Pitchaiya, S., Eswaramoorthy, N., Natarajan, M., Santhanam, A., Asokan, V., Madurai Ramakrishnan, V., Rangasamy, B., Sundaram, S., Ravirajan, P. and Velauthapillai, D. (2020) 'Perovskite Solar Cells: A Porous Graphitic Carbon based Hole Transporter/Counter Electrode Material Extracted from an Invasive Plant Species Eichhornia Crassipes', *Scientific Reports*, 10(1), pp. 1-16. doi: 10.1038/s41598-020-62900-4. Scopus, SCI expanded, Impact Factor: 4.011
- ENE 2020: Rajaramanan, T., Natarajan, M., Ravirajan, P., Senthilnathanan, M. and Velauthapillai, D. (2020) 'Ruthenium (Ru) Doped Titanium Dioxide (P25) electrode for dye sensitized solar cells', *Energies*, 13(7), pp. 1-13. doi: 10.3390/en13071532. Scopus, SCI expanded, Impact Factor: 3.004
- M.Lett 2020: Siva, U., Murugathas, T., Yohi, S., Natarajan, M., Velauthapillai, D. and Ravirajan, P. (2020) 'Single walled carbon nanotube incorporated Titanium dioxide and Poly(3-hexylthiophene) as electron and hole transport materials for perovskite solar cells', *Materials Letters*. Elsevier B.V., 276, p. 128174. doi: 10.1016/j.matlet.2020.128174. Scopus,SCI expanded, Impact Factor: 3.423
- POLY 2019: Pirashanthan, A., Murugathas, T., Robertson, N., Ravirajan, P. and Velauthapillai, D. (2019) 'A Quarterthiophene-Based Dye as an Efficient Interface Modifier for Hybrid Titanium Dioxide/Poly(3-hexylthiophene)(P3HT) Solar Cells', *Polymers*, 11(11), p. 1752. doi: 10.3390/polym11111752. Scopus,SCI expanded, Impact Factor: 4.329
- PPA 2019: Prabavathy, N., Balasundaraprabhu, R., Balaji, G., Malikaramage, A. U., Prasanna, S., Sivakumaran, K., Kumara, G. R. A., Rajapakse, R. M. G. and Velauthapillai, D. (2019) 'Investigations on the photo catalytic activity of calcium doped TiO 2 photo electrode for enhanced efficiency of anthocyanins based dye sensitized solar cells', *Journal of Photochemistry and Photobiology A: Chemistry*. Elsevier B.V., 377, pp. 43-57. doi: 10.1016/j.jphotochem.2019.03.038. Scopus,SCI expanded, Impact Factor: 4.291
- MAT 2019: Shanmugaratnam, S., Velauthapillai, D., Ravirajan, P., Christy, A. A. and Shivatharsiny, Y. (2019) 'CoS2/TiO2 nanocomposites for hydrogen production under UV irradiation', *Materials*, 12(23), pp. 1-9. doi: 10.3390/MA12233882. Scopus, SCI expanded, Impact Factor: 3.623
- POLY 2019: Thanihaichelvan, M., Loheeswaran, S., Balashangar, K., Velauthapillai, D. and Ravirajan, P. (2019) 'Polymer/fullerene blend solar cells with cadmium sulfide thin film as an alternative hole-blocking layer', *Polymers*, 11(3). doi: 10.3390/polym11030460. Scopus,SCI expanded, Impact Factor: 4.329
- MAT 2019: Uthayaraj, S., Karunaratne, D. G. B. C., Kumara, G. R. A., Murugathas, T., Rasalingam, S., Rajapakse, R. M. G., Ravirajan, P. and Velauthapillai, D. (2019) 'Powder pressed cuprous iodide (CuI) as a hole transporting material for perovskite solar cells', *Materials*, 12(13), pp. 1-9. doi: 10.3390/ma12132037. Scopus,SCI expanded, Impact Factor: 3.623
- M.Lett 2018: Balashangar, K., Paranthaman, S., Thanihaichelvan, M., Amalraj, P. A., Velauthapillai, D. and Ravirajan, P. (2018) 'Multi-walled carbon nanotube incorporated nanoporous titanium dioxide electrodes for hybrid polymer solar cells', *Materials Letters*, 219, pp. 265-268. doi: 10.1016/j.matlet.2018.02.088. Scopus,SCI expanded, Impact Factor: 3.423.
- JMC 2017: Prashanthan, K., Thivakarasarma, T., Ravirajan, P., Planells, M., Robertson, N. and Nelson, J. (2017) 'Enhancement of hole mobility in hybrid titanium dioxide/poly(3-hexylthiophene) nanocomposites by employing an oligothiophene dye as an interface modifier', *Journal of Materials Chemistry C*, 5(45), pp. 11758-11762. doi: 10.1039/c7tc02225e. Scopus,SCI expanded, Impact Factor: 6.641
- POLY 2017: Thanihaichelvan, M., Sri Kodikara, M. M. P., Ravirajan, P. and Velauthapillai, D. (2017) 'Enhanced performance of nanoporous titanium dioxide solar cells using cadmium sulfide and poly(3-hexylthiophene) co-sensitizers', *Polymers*, 9(10), pp. 1-10. doi: 10.3390/polym9100467. Scopus,SCI expanded, Impact Factor: 4.329

Summary of the high impact journals where the research articles are published

Aberr.	Journal Name	Publisher	Country	SJR 2019, Q (Scimago)	Impact factor (2019)	¹ Index journal (listed SCI index)	² No. of issues per annum
SCR	Scientific Reports	Nature publishing group	UK	1.34, Q1	3.998	Yes	48
JPS	Journal of Power Sources	Elsevier	Netherlands	2.14, Q1	9.127	Yes	35
POLY	Polymers	MDPI	Switzerland	0.70, Q1	3.426	Yes	12
MAT	Materials	MDPI	Switzerland	0.65, Q2	3.057	Yes	24
M.Lett	Material Letters	Elsevier B.V.	Netherlands	0.75, Q1	3.371	Yes	23
ENE	Energies	MDPI	Switzerland	0.64, Q2	2.702	Yes	24
JPPA	Journal of Photochemistry and Photobiology A: Chemistry	Elsevier B.V.	Netherlands	0.62, Q1	3.419	Yes	17
JMS	Journal of Material Science: Material in Electron.	Springer Nature	USA	0.48, Q2	2.220	Yes	24
CAT	Catalysts	MDPI	Switzerland	0.80, Q2	4.146	Yes	12
MSSP	Materials Science in Semiconductor Processing	Elsevier	UK	0.70, Q1	3.927	Yes	16
SOL	Solar energy	Elsevier	UK	1.34, Q1	5.742	Yes	17

2.2.2 Proceedings of the "International Conference on Advanced Materials for Clean Energy and Health Applications" - 2019 (AMCEHA -2019) appeared in prestigious Elsevier publications

<https://www.sciencedirect.com/science/article/pii/S2214785319328937>

materialstoday:
PROCEEDINGS
Volume 23, Part 1, 2020, Page 1



Part of special issue:

Advanced Materials for Clean Energy and Health Applications (AMCEHA), University of Jaffna, Jaffna, Sri Lanka, 6-8 February, 2019

Edited by Smagul Karazhanov, Vishnukanthan Venkatachalapathy, Meena Senthilnathanan

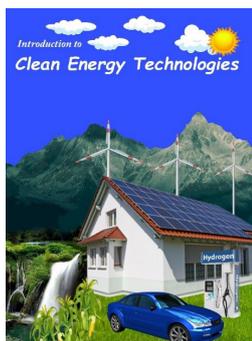
Other articles from this issue

Improved method to extract kinetic parameters ...
2020, pp.

Proceedings of the international conference on advanced materials for clean energy and health applications (AMCEHA 2019)

Smagul Karazhanov, Vishnukanthan Venkatachalapathy, Meena Senthilnathanan

2.2.3 Handbook on Clean Energy Technologies



Clean Energy Technologies

Compiled and Edited by
Prof. P. Ravirajan,
Department of Physics, University of Jaffna
Prof. (Mrs.) M. Senthilnathanan & Dr. (Ms.) S. Rasalingam,
Department of Chemistry, University of Jaffna



Jaffna Science Association

Introduction to Clean Energy Technologies

Compiled and Edited by:
Prof. P. Ravirajan, Department of Physics, University of Jaffna
Prof. (Mrs.) M. Senthilnathanan, Department of Chemistry, University of Jaffna
Dr. (Ms.) S. Rasalingam, Department of Chemistry, University of Jaffna

Edition : 1st Edition, 11 May 2018

Published by :
Jaffna Science Association (Guarantee) Limited
88, College Road
Nerampiyai, Jaffna
Sri Lanka

Computer Editing: Mr. Siva Lithayari

Cover Design : Mr. T. Rajaraman

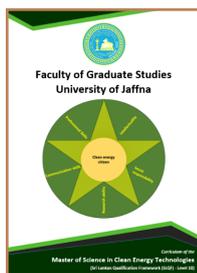
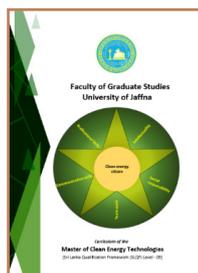
Pages : 53 + iii

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Handbook on Clean energy technologies - a good reference to understand the basics of technologies.

2.2.4 Handbook for Master degree students

Handbook includes the UGC approved structure and syllabi of the Master of Clean Energy Technologies [MCET] and Master of Science in Clean Energy Technologies [MSc(CET)].



2.2.5 Proceedings of the Abstracts - "International Conference on Advanced Material for Clean Energy and Health Applications"



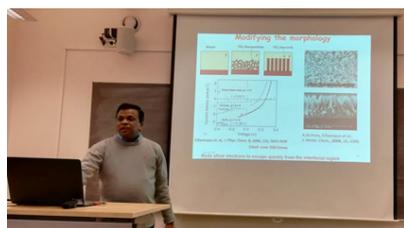
3.0 International mobility programme for staff and students

With the commencement of the HRNCET-NORPART project in March 2017, staff and students of the project from the University of Jaffna (UoJ), University of Peradeniya (UoP) and National Institute of Fundamental Studies (NIFS), Sri Lanka have been mobilized to undertake their research works and research stays at the Western Norway University of Applied Sciences (HVL), University of Bergen (UiB), Norway and the Coimbatore Institute of Technology (CIT), India. Similarly, students from HVL had short visits and their research stay at the UoJ. These research exchange programmes have been instrumental in capacitating staff, students, and the research institutions at both ends. These exchange programmes facilitated exposure to different learning techniques, academic knowledge exchange and research facilities

through seminars, workshops, short courses, research days, discussions and demonstrations with various research scholars, academics, and industrialists. This has especially helped the exchange students to continue their research activities with not only international exposure and experience on the variations in the practice of research methodology but also to have different cultural experiences. These students have been able to demonstrate their research to different external collaborators of the research group attached to the academic and industrial network in Norway during their visits to the research laboratories. These visits have helped to expand the network of the research group, and also provided opportunities for the students to get recognition for their research activities and experiments.



Staff mobility: Dr. S. Yohi (UoJ) at HVL lab assisting students from UoJ, UoP and CIT in experimental work during her research stays in 2017 and 2019.



Staff mobility: Prof. Dhayalan Velauthapillai (HVL), Prof. Punniamoorthy Ravirajan (UoJ) and Prof. RMG Rajapakse (UoP) visiting the Department of Chemistry, UoB in 2017 and carrying out discussions and presentations on nanotechnology for green energy applications to the academic staff.

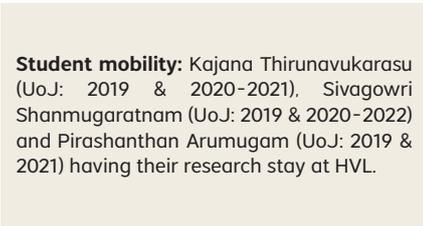


Staff mobility: Prof. Punniamoorthy Ravirajan (UoJ), Prof. RA Kumara (NIFS) and Prof. RMG Rajapakse (UoP) visiting HVL in 2018 conducting workshops and demonstrations on solar cells for students and providing guidance for students from UoJ, UoP, CIT and HVL.

Staff mobility: Academic and non-academic staff from HVL and UiB visiting UoJ and participating in meetings, workshops, and conferences in 2018 & 2019.



Student mobility: Uthayaraj Siva (UoJ: 2017 & 2018), AU Malikaramge (UoP: 2017 & 2018) and Rajaramanan Tharmakularasa (UoJ: 2018 & 2021-2022) having their research stay at HVL.



Student mobility: Kajana Thirunavukarasu (UoJ: 2019 & 2020-2021), Sivagowri Shanmugaratnam (UoJ: 2019 & 2020-2022) and Pirashanthan Arumugam (UoJ: 2019 & 2021) having their research stay at HVL.



Student mobility: Chapa Pamodani Wanniarachchi (UoJ: 2021-2022), Abiram Gnanasampanthan (UoJ: 2022), Thuraisamykurukkal Thivakarasarma (UoJ: 2022) and Velu Aeneas Jerron (UoJ: 2022) having their research stay at HVL.



Student mobility: Four final year electrical engineering undergraduates from HVL participating and presenting their project on 'Smart Energy: Solar Energy Based Grid System' at the UoJ in 2017.



Student mobility: PhD students from HVL visiting UoJ, participating in seminars, conferences and collecting data for their study in 2017 & 2020.



Research stay - 2019 & 2021: Students of UoJ, CIT, Alahappa University and HVL participating and demonstrating their research activities to school students and the public during the Research Days in 2019 and 2021 organized by Bergen city's research and educational institutions to promote research and innovation.



Research stay: Håkon Eidsvåg, PhD Research Fellow from HVL assisting and demonstrating to staff and students on simulation studies on nanomaterials for clean energy technologies, participating in clean energy seminars and outreach activities in Sri Lanka in 2020 during his research stay at UoJ. A new research group on computational study on nanomaterials for PV and Health applications was established in 2020 and a new MPhil student, Ms. Chapa was recruited under the project. Dr. A. Thevakaran has been serving as the principal supervisor of the student. This is the first such research group in Sri Lanka. The PhD research fellow Håkon Eidsvåg from HVL, during his research stay in Sri Lanka provided his support in establishing this group in early 2020. The project envisions the expansion of this group through national collaborations with similar competent institutions benefitting Sri Lanka in the long run.



Visits by academics and industrial partners: The students from UoP, UoJ, CIT, Alahappa University and HVL presenting and demonstrating their research activities and experiments to different external collaborators attached to the academic and industrial network in Norway during their visits to the research laboratories in 2018, 2019, 2021 & 2022.

Summary of Students mobility programmes

PG students and (period)	From	To	Research equipment handled at HVL/UIB	No of workshops attended	No. of course credits followed
Mr. S. Uthayaraj (12 Months)	Oct 2018	Sept 2019	Solar simulator, GC, Bio-Logic Potentiostat, FT-IR, SEM, EDX, XRD, Raman Spectroscopy, UV-VIS Spectroscopy	10	5
Mr. A.U. Malikaramge (12 Months)	Oct 2018	Sept 2019	Solar simulator, GC, Bio-Logic Potentiostat, FT-IR, SEM, EDX, XRD, Raman Spectroscopy, UV-VIS Spectroscopy	10	5
Mr. T. Rajaramanan (3 Months)	Oct 2018	Jan 2019	Solar simulator, GC, Bio-Logic Potentiostat, FT-IR, SEM, EDX, XRD, Raman Spectroscopy, UV-VIS Spectroscopy	5	1
Mr. A. Pirashanthan (11 months)	Feb. 2021	Dec. 2021	Solar simulator, GC, Bio-Logic Potentiostat, FT-IR, SEM, EDX, XRD, Raman Spectroscopy, UV-VIS Spectroscopy	8	5
Ms. S. Sivagowri (17 months)	Nov. 2020	Feb. 2022	GC, UV- VIS, FT-IR, SEM, EDX, XRD	8	5
Ms. T. Kajana (14 months)	Nov. 2020	Dec. 2021	Bio-Logic Potentiostat, CH-Analyzer, Raman Spectroscopy, UV-VIS Spectroscopy, SEM, EDX, XRD, FT-IR	8	5
Ms. C. P. Wanniarachchi (7 months)	Sept. 021	To date	Supercomputer	5	5
Mr. G. Abiram (2 months)	Feb. 2022	To date	Thermal Evaporator, Biologic, UV-Visible Spectroscopy, FT-IR, SEM, TEM	1	-
Mr. T. Thivakararasma (2 months)	Feb. 2022	To date	Thermal Evaporator, Biologic, UV-Visible Spectroscopy, FT-IR, SEM, TEM	1	-
Mr. V. Aeneas Jerron (2 months)	Feb. 2022	To date	Supercomputer	1	-

4.0 Establishment of Clean Energy Research Lab (CERL) & Procurement of Research equipment

The Clean Energy Research Laboratory (CERL) of 1,200 square feet floor area is constructed adjacent to the Nanoscience Research Laboratory on the first floor of the Department of Physics, University of Jaffna under the Higher Education and Research collaboration on Nanomaterials for clean energy

technologies (HRNCET) project. With assistance from the Ministry of Higher Education, Sri Lanka and Royal Norwegian Embassy in Colombo a well-equipped Clean Energy Research Laboratory (CERL) was established within 100 days.



The Clean Energy Research Laboratory (CERL) was officially opened by the Hon. Ambassador Thorbjørn Gaustadsæter and Rector Berit Rokne on the 11th of May 2018. The establishment of CERL at the Department of Physics has become a cornerstone for advanced modern research on clean energy technologies,

and it has already helped in producing quality research, conference papers and journal papers. Currently, there are nine postgraduates and a few undergraduate research students working at CERL.



Equipment and Research facilities at the Clean Energy Research Laboratory

The Royal Norwegian Embassy in Colombo funded to purchase research equipment such as X-ray diffractometer, Solar Simulator with power supply, gas purification system for Glove box and other safety facilities such as Fume hood, Solvent storage cabinets, work bench etc., worth LKR 35 million. A separate seminar hall of 300 square feet floor area was also established to have regular group meetings and online discussions with collaborators from Norway, India and UK.



Fume hood



Work bench



Gas purification system



X-Ray Diffractometer (XRD)

5.0 Dissemination of Knowledge: Training workshop, Seminar, Symposium and Conferences

5.1 Training workshop on 'AFM and XRD : Effective research tools for material research' - 2020

Clean Energy Research Laboratory, Department of Physics received an atomic force microscope (AFM) and an x-ray diffractometer (XRD), worth of LKR 12 million each, from the State Ministry of Skills Development, Vocational Education, Research & Innovations, and Royal Norwegian Embassy in Sri Lanka, respectively. On the request made by our collaborators from National Institute of Fundamental Studies and Universities

of Peradeniya, Ruhuna and Kelaniya, a Training workshop on "Atomic Force Microscope (AFM) and X-Ray Diffractometer (XRD) as effective research tools" was held at the Clean Energy Research Laboratory (CERL), Department of Physics for training the research students on September 12 & 13, 2020.



5.2 Clean Energy Seminar - 2018

Norway and Sri Lanka have partnered and are laying greater emphasis on collaborating on clean energy technologies as a sustainable way of tackling future energy demands while also reducing emissions. This partnership in research, development and investments in clean energy between Norway and Sri Lanka resulted in the establishment of a clean energy research consortium in 2017 bringing together private enterprises, academics and researchers from both countries. This was made possible with the financial assistance from the Royal Norwegian Embassy in Colombo. The consortium builds linkages between research and industry between both countries and encourages advancement, investments, partnerships and joint ventures towards low carbon solutions. As part of this initiative, a clean energy seminar was conducted in Colombo on 9 May 2018, in collaboration with the Sri Lanka Energy Managers Association (SLEMA).

The main objectives of this clean energy seminar were four-fold:

- To establish an arena to present the Norwegian and Sri Lankan private sectors working on clean energy technologies such as solar, wind and hydrogen
- To facilitate a meeting place for the academia and private sector in the field of clean energy technologies from both countries that would lead to the establishment of a sustainable research consortium
- To obtain in-depth knowledge on the energy regulatory measures and policies in Sri Lanka
- To facilitate and motivate the private sector and universities from Norway and Sri Lanka to initiate future partnerships including joint-ventures



5.3 Clean Energy Seminar – 2020

Theme: Clean Energy Expert Panel Discussion: Investing in Clean Energy in Sri Lanka – Drivers and Barriers

The Royal Norwegian Embassy in Colombo together with the University of Jaffna and the Western Norway University of Applied Sciences hosted an expert panel discussion on 21 January 2020 under the title 'A New Decade: Investing in Clean Energy in Sri Lanka – Drivers and Barriers'. The conference was

held at the Galle Face Hotel, Colombo. This conference brought together several key actors, stakeholders, and experts from the Sri Lankan clean energy sector as well as a delegation from Norway for the panel discussion.



5.4 International Symposium on Nanomaterials for Clean energy and Health Applications (ISNCHA2017)

From 6th -8th December 2017, an international symposium was arranged in India under the NORPART projects. Both students and staff from HVL, UiB, UoA, UoJ and UoP participated in this symposium and meetings along with our partners from CIT. Eight academics from Universities of Jaffna and Peradeniya and Eastern University of Sri Lanka were actively participated by presenting papers at the symposium under this project.



On 27th of January 2020 HRNCET project coordinators Professor Dhayalan Velauthapillai and Professor P. Ravirajan visited the Coimbatore Institute of Technology, India and PSG College of Technology, India who are the longstanding partners of Western Norway University of Applied Sciences (HVL). A new MOU was signed by HVL with Alagappa University, Karaikkudi, Tamilnadu in the field of nanomaterials for clean energy applications in front of Hon. Excellencies Ambassador Hans Jakob Frydenlund and Director General Anne Line Wold in Chennai, India.



5.5 International conference on Advanced Materials for Clean Energy & Health Applications (AMCEHA)

Preconference Discussion Forum on promoting STEMM education in Northern Sri Lanka

A Preconference Discussion Forum was held on February 5, 2019. Scholars from the diaspora community and the Northern Province of Sri Lanka working in the STEMM fields, including representatives from the University of Jaffna, Provincial and Zonal Education Departments, teachers (from science, mathematics and technology streams) of the Northern Province, shared their views and actively participated in the discussion.



The findings revealed during the discussion and the proposed recommendations are listed below:

- ▣ Commencing the GCE(A/L) classes in April every year by redistributing the course units and completing the syllabus by the end of 5th term so that revision classes and practice examinations could be organized in the 6th term. A similar redistribution of course units for other subjects needs to be done.
- ▣ Conducting career guidance programmes to all secondary level students
- ▣ Creating interest in STEMM fields among elementary level students through exhibitions and innovative initiatives
- ▣ Organizing Seminars and Training Programmes to raise the competence of Science and Mathematics Teachers of Grades 8 - 10 in schools as it is vital to promote interest in STEMM fields among the students during the middle stages of their secondary education.
- ▣ Ensuring laboratory facilities at required levels in all schools and encouraging regular practical activities including practical exercises/examinations. Laboratory based training for a student is essential to improve his/her soft skills and to enhance interest in the subject and class attendance.
- ▣ Ensuring the availability of a full-time Laboratory Assistant with appropriate skills in each laboratory
- ▣ Providing the required training to Laboratory Assistants on laboratory organization and management, operation and maintenance of laboratory equipment, maintenance of consumables, disposal of expired chemicals and health & safety in the laboratory
- ▣ Establishment of central / mobile laboratories (Physics, Chemistry and Biology) with advanced facilities in each Educational Zone as a complementary arrangement; however, additional fund allocation may be enquired for maintenance of the laboratory and remuneration for a Laboratory Assistant.
- ▣ Restricting the late evening private tuition classes
- ▣ Establishing a Centre in each educational zone to facilitate self-learning from 6 - 10 pm daily and to provide the necessary guidance, training and assistance to the private candidates
- ▣ Encouraging the use of modern teaching aids as well as e-resources by providing the necessary know-how
- ▣ Enabling engaged learning (through observing, hypothesis making, critical thinking, creating, experimenting, analysing, communicating and collaborating) as an overarching approach
- ▣ Encouraging team based, multi-disciplinary projects for school-based assessments
- ▣ Involving the diaspora in building laboratory facilities at schools and providing educational tools, scholarships, etc.
- ▣ Active campaigning among the parents and general public to create awareness on STEMM education.

An action plan consisting of the above findings and suggestions for enhancement of STEM education were submitted to the Governor of the Northern Province

The international conference on Advanced Materials for Clean Energy & Health Applications (AMCEHA 2019) was jointly organized by the University of Jaffna (UoJ) and the Western Norway University of Applied Sciences (HVL) from 6-8 February 2019. The conference was funded by NFR, DIKU, the Royal Norwegian Embassy in Colombo, the Sri Lanka Sustainable Energy Authority and the Ministry of Science, Technology and Research in Sri Lanka. The Norwegian Ambassador to Sri Lanka, His Excellency Thorbjørn Gaustadsæter was the Chief Guest and Prof. P.S.M. Gunaratne, Head, Research and International Cooperation and Vice-Chairman, University Grants Commission, Sri Lanka was the Guest of Honour.



The conference comprised over 400 participants including experts, scientists, scholars, academics, students, and local and foreign industrial representatives. The participants included 120 foreign delegates from countries such as Norway, India, Canada, Australia, UK, Bangladesh, Sudan, Sweden, Finland, Egypt, China, Japan and USA. The conference received 180 research articles of which 140 articles were selected and presented after the peer-review process. The conference included oral presentations, poster presentations, one-minute spotlight presentations of the posters and plenary talks by eminent scientists in the fields of nanomaterials for solar cells, health applications and energy storage systems.

The Norwegian Ambassador to Sri Lanka, His Excellency Thorbjørn Gaustadsæter and Prof. P.S.M. Gunaratne, Head, Research and International Cooperation and Vice-Chairman, University Grants Commission, Sri Lanka addressing the gathering at the AMCEHA-2019 conference. The Vice Chancellor, University of Jaffna on behalf of the University Council presenting a memento to Prof. Dhayalan Velauthapillai as an appreciation for the collaborative initiatives between the universities



The second day of the conference was organized under different symposiums with themes on solar energy applications, advanced materials for health applications, advanced functional materials, and wind/hydrogen/bioenergy and storage applications. Each symposium had four plenary and invited lectures with more than 30 contributed papers.

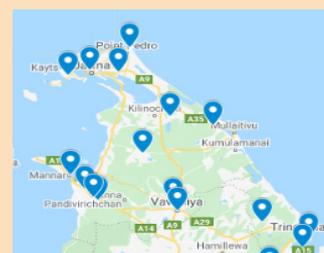
The Sri Lanka-Norway workshop on clean energy applications was held on the third day of the conference at the Faculty of Engineering at Kilinochchi. The workshop was attended by the participants of the conference, policymakers, industrialists, investors and representatives from the clean energy sector in Sri Lanka. The theme of the session was on the challenges and possibilities of implementing clean energy solutions in Sri Lanka and strengthening collaborations in higher education and research in the field of clean energy technologies between the universities in Norway, Sri Lanka and India. The AMCEHA 2019 international conference has helped establish new networks between the national and international research groups to and as a result, three different collaborative research proposals were submitted in Sri Lanka, India and Norway.



6.0 Outreach Activities:

6.1 Educational training on utilization of clean energy technologies

In collaboration with the Jaffna Science Association and Provincial Department of Education, Northern Province, more than 3000 GCE (A/L) students in the Science and Technology streams from 55 schools in the Jaffna district were educated on the significance of clean energy technologies through interactive discussions and hands-on experiments in 2017. Further, the trained students actively participated in the subsequent activities on the theme such as poster preparation, documentary film making and invention of appropriate and innovative formulations organised under the project.



More than 500 school students from 17 Educational Zones of 3 districts in the Eastern Province of Sri Lanka benefitted from the Clean Energy Workshops organized under the project at the Eastern and South Eastern Universities in collaboration with the State Ministry of Skills Development, Vocational Training, Research and Innovation.

During this workshop, innovation exhibits and posters were demonstrated.



Demonstration on the Fabrication of low-cost nanostructured solar cells to school students with the assistance of demonstration kits, posters and video clips received the attention of many students.

Further, findings of research studies on clean energy technologies were disseminated at the SHILPASENA EXPOSITION-2019 events, held in Colombo and Polannaruwa, Sri Lanka.

A number of outreach activities were also arranged in Bergen, Norway to inspire the school children in Bergen on emerging clean energy technologies. All these activities, especially the Forskningsdagene 2019, received wide public attention through media coverage.

The researchers based at HVL, Bergen visited two schools in Bergen, Rå Skole and Apeltun Skole, in 2021 and demonstrated emerging solutions on energy production and energy storage based on their research findings.



6.2 Science Education for Bright Future - 2020

To strengthen science education at secondary education level and attract more students to the Sciences, Technology, Engineering, Mathematics and Medicine (STEMM) fields, the Faculty of Science, University of Jaffna organized the event 'Science Education for Bright Future' in 2020 with the partial funding by the CBERC project. The event focused on the practical aspects of the Sri Lankan Science curriculum from grades 6 to 11 through exhibition, experimentation, discussions and explanations in the fields of Biology, Botany Zoology, Chemistry, Physics and Computer Science including display of various clean energy demonstration kits. Nearly 30,000 students from different schools in the Northern Province benefitted.

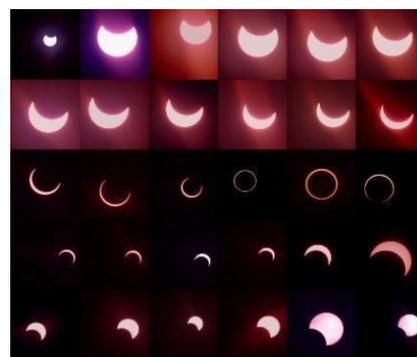


6.3 Annular Solar Eclipse Observation Camps - 2019

In collaboration with Professors Kirthi Tennakone and Adjith de Alwis, Georgia State University, USA, Annular Solar Eclipse Observation camps were established at the premises of the University of Jaffna in Thirunelveli and Kilinochchi with financial support by the then Ministry of Technology and Innovation and Norwegian Embassy in Colombo.

The program aimed at

- ▣ creating interest in science and mathematics, particularly astronomy, among students
- ▣ highlighting the importance of rational thinking and dangers of superstition
- ▣ promoting north-south scientific dialogue and
- ▣ initiating astronomical research in Sri Lanka.



The Table below gives the maximum obscuration and its duration at two key locations during the annular solar eclipse. The maximum obscuration occurred at 9.35 am on December 26, 2019

Location	Maximum Obscuration (%)	Duration
Kilinochchi	93.39	3 min 16.9 s
Jaffna	93.37	3 min 11.8 s

An article titled "Historical Solar Eclipses "written by Prof. Kirthi Tennakone, which appeared in The Island Newspaper (http://www.island.lk/index.php?page_cat=article-details&page=article-details&code_title=215501), received much attention motivating students and general public. Prior to this event, members of Clean Energy Research Laboratory, University of Jaffna and Astronomical Society, University of Colombo jointly conducted nationwide awareness programmes with the assistance of Science and Technology officers attached to Vidatha Resource centres attached to the divisional secretariats (<http://www.mostr.gov.lk/web/index.php?lang=en>). Quiz examinations related to Eclipse and Astronomy, General Science and Mathematics were also conducted in schools nationwide for creating awareness on Annual Solar Eclipse. Top performers in each divisional secretariat of the country were honoured. An informative note on activities in Jaffna during the eclipse was presented at the Proceedings of the Georgia Academy of Sciences, USA and the results of measurements were published in a reputed journal.



7.0 Industrial Collaborations:

Establishment of Research Consortium

CBERC funded by the Norwegian Embassy in Colombo focused on active involvement of the industries in research activities conducted by their HEI partners and realization of collaborative industrial investment projects. As part of this, a number of industrial visits were carried out in Norway by the partner institutions.

A visit to the Christian Michelsen Research (CMR) institute in Bergen was held on 17 October 2017 by the HRCNET project team consisting of Prof. Alfred Christy (University of Agder), Prof. Dhayalan Velauthapillai (HVL), Prof. Gamini Rajapakse (UoP), Prof. Punniamoorthy Ravirajan (UoJ) and research students from HVL, UoJ, UoP and CIT with the team members of CMR consisting of Brent Skeie (CEO), Anders Helland (Head - Parts & Service), Sonia Faaland (Head - R&D) and Nelson Thambijaj (Researcher).

The visit included meetings, discussions, presentations, demonstrations and a factory visit. While different ongoing research activities of HRCNET project and CMR research institute were discussed and demonstrated, the research on low-cost catalysts for oxygen reduction, half-reaction in fuel cells and photocatalytic hydrogen generation using photon upconversion based low-cost catalysts drew the attention of both teams during the discussions.



A Norwegian delegation of 32 delegates, including 16 Norwegian clean energy companies and heads at HVL and UiB visited Sri Lanka and held meetings and discussions with authorities, public utilities and institutions in May 2018 in order to work closely on clean energy technologies. (http://project.jfn.ac.lk/hrncet/wp-content/uploads/CleanEnergySeminarPresentationA5_lav.pdf) A seminar was arranged by HVL and UoJ with the support of the Norwegian Embassy in association with Sri Lanka Energy Managers Association (SLEMA) in Colombo on the 9th of May 2018 with more than 100 participants including academics and private sector from Norway and Sri Lanka.

The Norwegian delegation's visit to Sri Lanka in 2018 resulted in a number of initiatives from the private sector for research collaboration between both HVL and UoJ and the industry.

Prof. Dhayalan, Prof. Ravirajan and Prof. Kumara visited and held discussions with UiA and Elkem Solar and Current Solar in Kristiansand in October 2018 to initialize collaborative projects between the institutions and the private sector on solar cell technologies.

Seminars and visits have also resulted in active collaboration between the Universities and private sectors in Norway and Sri Lanka. We have succeeded in several partnerships with the industries by involving them in research and educational projects.

WindSim and GEXCON, two Norwegian companies have agreed to train staff and students involved in our projects in simulation of wind energy and safety management, respectively. GEXCON signed a MoU with University of Jaffna in 2019.

- ▣ Norsk Solar, another solar energy company submitted an application to NORAD to develop floating solar systems in Sri Lanka.
- ▣ Current Solar has installed the first Floating Solar Plant in Sri Lanka in partnership with Innovation Norway and Equinor.
- ▣ GREENSTAT delivered in an application to the Government of Sri Lanka in order to introduce Hydrogen energy in the transport section.

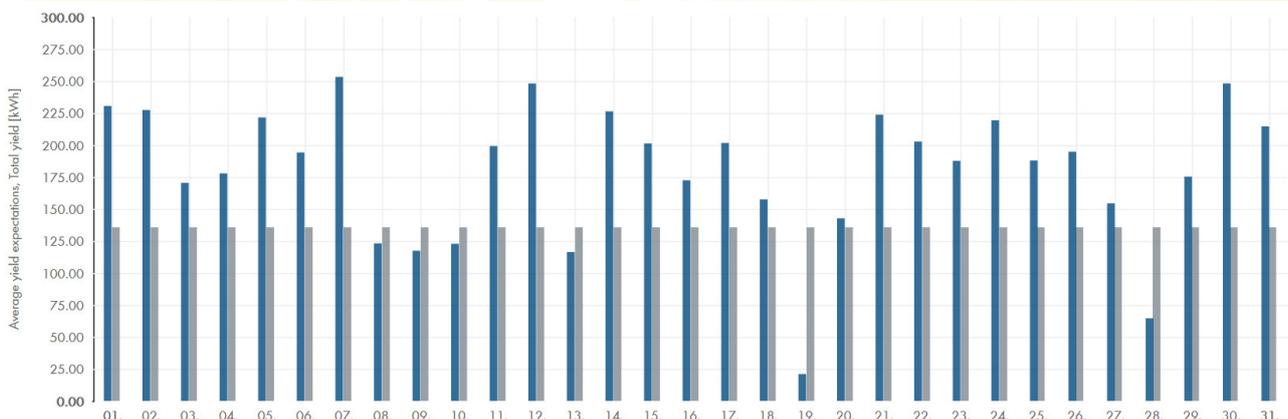
Installation of Sri Lanka's First Floating Solar Plant - January 2020

Sri Lanka's first floating solar plant (46 kW) was declared open on January 24, 2020 by the Norwegian Ambassador to Sri Lanka Trine Jøranli Eskedal, at the Kilinochchi premises of the University of Jaffna (<https://www.youtube.com/watch?v=dIElBngkJ3k>). Current Solar AS, the Norwegian developer of floating PV solutions, designed the system based on the experience from their test site in Singapore. The first floating system is established as an experimental plant in the pond with a depth of about 2 m. Floating pipes used in the design are made of high-density Poly-Ethylene in order to lift the solar panel sets, upon the water surface.

The floating solar plant, installed under the Capacity Building and Establishment of Research Consortium Project, is a result of the research collaboration since 2017 between the University of Jaffna and the Western Norway University of Applied Sciences (HVL) supported by the Royal Norwegian Embassy in Colombo.



Total cost of the floating solar project (component cost) is around LKR 10 million, which includes 157 Solar Panels (295 Wp & 315 Wp), 50kW SMA Inverter Data logger, sensors and a ground mounted PV system. This floating solar system is expected to have 4 - 5% more power yield (kWh/kWp) compared to the land-based system. The average generated power per month is around 5000 kWh. The floating pilot power plant system is connected through a net metering connection to the utility. This is the University supply under the General-purpose tariff system of the Ceylon Electricity Board. The plant generates yearly income of LKR 0.9 million. Therefore, the simple payback period is expected to be around 11 years as it is the first power plant. It is expected to reduce the cost of this plant with technological advancement and when implementing the larger power plant. Accordingly, the payback period will be reduced further. The floating solar power plant is also considered as one of the RE power plant technologies to achieve this Government target. This has been reported in the Ceylon Electricity Board Long Term Generation plan 2022 to 2041. Recently His Excellency President Gotabaya Rajapaksa discussed with the Dean of the Faculty of Engineering University of Jaffna, about the viability of this plant, for large scale implementation in Sri Lanka.



For more detail, please refer http://project.jfn.ac.lk/hrncet/index.php/cool_timeline/sri-lankas-first-floating-solar-plant-opens-in-kilinochchi/.

MOU established under the project



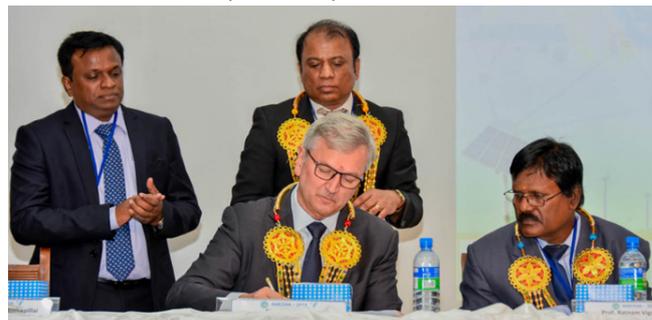
MOU between UoJ and HVL



Technical partnership between UoJ and HVL



MoU between HVL and NIFS



MoU Between UoJ and GEXCON

8.0 Outputs and impacts of the project

8.1 Outputs

- ▣ More than 20 long-term and 15 short-term research student mobilities between Norway and Sri Lanka.
- ▣ More than 20 staff mobilities between Norway and Sri Lanka.
- ▣ A PhD research study at HVL on an in-depth analysis of the drivers and barriers in clean energy transition in Sri Lanka.
- ▣ Successful completion of five MPhil research projects in the area of solar energy, Hydrogen energy, energy storage etc. at HVL and UoJ.
- ▣ Development of two new master curricula in Clean Energy Technologies - first ever in Sri Lanka.
- ▣ Successful intake/implementation of the first group of 16 Master students for the newly established Master program.
- ▣ Publication of more than 70 papers/abstracts including 22 research publications in high impact factor Science Citation Indexed Journals (Q1/Q2).
- ▣ Skills and knowledge development among Bachelor/Master students in clean energy technologies.
- ▣ Hands on' experience for research students in handling high technology characterisation equipment.
- ▣ Facilitation of 4 Norwegian delegation visits to Sri Lanka including a visit of 17 academics and 16 private sector representatives to Sri Lanka to establish a joined research consortium on clean energy technologies.
- ▣ Creation of a sustainable clean energy consortium consisting of educational and research institutions and the private sector from Norway and Sri Lanka.
- ▣ Private enterprise involvement for innovative ideas, collaborative projects which solve technical challenges faced by the relevant industries.
- ▣ Increased involvement of enterprises in Bachelor/Master/PhD innovation and research projects.
- ▣ Development of strategy document for STEMM education in the Northern Province in Sri Lanka
- ▣ Involvement of expatriates from Norway in knowledge transfer from Norway to Sri Lanka through visiting lectures, technical assistance and workshops.
- ▣ Establishment of a well-equipped Laboratory facility for Clean Energy Research at UoJ that can be utilized by the researchers in Sri Lanka for the synthesis and characterization of nanomaterials.
- ▣ Outreach activities to promote clean energy technologies in Norway and Sri Lanka among schools and in the public arena.
- ▣ Three clean energy seminars in Sri Lanka and Norway.
- ▣ First-ever international seminar on Advanced Materials for Clean Energy and Health Applications (AMCEHA 2019) with more than 400 participants including 125 international delegates.
- ▣ Clean energy workshop in 2019 in Kilinochchi to promote Norwegian-Sri Lankan business partnerships in Clean Energy Technologies.
- ▣ Establishment of a new Biomass dryer at the Kilinochchi premises of UoJ for bioenergy research.
- ▣ Installation of first-ever floating solar plant in Sri Lanka based on Norwegian technology.
- ▣ Partnerships with Science Energy Associations and Clean Energy Utility Organizations.
- ▣ High degree of media coverage in four languages (TV, Radio, newspapers and social media in English, Norwegian, Tamil and Sinhala) about the project activities.

8.2 Impacts

- ▣ Successful development of UGC approved Master degree curricula in Clean Energy Technologies has guaranteed the flow of skilled academics/researchers/entrepreneurs in clean energy technologies.
- ▣ Joint supervision of students at HVL and UoJ has resulted in much needed international research exposure to the students involved.
- ▣ MoU Active between the Norwegian company GEXCON and the University of Jaffna to train the staff and students on fire and explosion safety and to work on Hydrogen technology in the future.
- ▣ MoU Active signed between HVL and the National Institute of Fundamental Studies (NIFS), Sri Lanka to promote research collaboration between the two institutions on nanomaterials.
- ▣ Establishment of a Clean Energy Research Laboratory (CERL) at UoJ with high-tech equipment has resulted in much needed training on a variety of high-tech material synthesis and characterisation equipment.
- ▣ Capacity building at UoJ through lectures, seminars and training.
- ▣ Expatriate (Norway) and partner Universities (India) involvement in capacity building at UoJ has created new international partnerships with other countries.
- ▣ Successful visits of high delegation consisting of private sector and academics from Norway to Sri Lanka and meetings with their counterparts have created opportunities for new business partnerships.
- ▣ The clean energy research seminar in Colombo in 2018, 2020 and 2022 and the clean energy workshop in Kilinochchi in 2019 have set the stage for discussions between Norwegian and Sri Lankan energy stakeholders for joint partnerships.
- ▣ Involvement of the private sector in establishing a Norwegian-Sri Lankan research consortium for clean energy technologies.
- ▣ Involvement of the private sector in mentoring students at UoJ has helped the institutions involved tailor the research to fulfil the needs of the industry.
- ▣ Widespread knowledge sharing through training of 80 teachers in clean energy technologies.
- ▣ Outreach activities in clean energy technologies for over 4000 students from the Northern and the Eastern Provinces in Sri Lanka and continuous dissemination activities at the school level and among the general public (Research days) has helped in creating awareness on clean energy technologies.
- ▣ Handbook on Clean energy technologies - a good reference to understand the basics of technologies.
- ▣ Installation of the first floating solar plant in Sri Lanka by the Norwegian private sector has become a showcase for future projects.
- ▣ High energy output from the floating solar plant at Campus Kilinochchi has resulted in economical benefits for UoJ (nearly one million rupees per year).
- ▣ Mutual understanding and partnership among the research community with multi-ethnic and religious backgrounds through the project.
- ▣ Increased educational/research partnerships between Universities in Norway, Sri Lanka and India through the project - new research funding opportunities have been created.
- ▣ Quality research publications have helped the researchers in their career development.
- ▣ Contribution to promoting STEMM education in the Northern Province in Sri Lanka through dialogues with educational stakeholders, schools and authorities, strategy documents etc have had positive impacts.
- ▣ The reputation of the University of Jaffna has grown positively through this international collaboration.
- ▣ The high degree of gender equality through recruitment of students/researchers in mobility programs.
- ▣ The inclusion of students from an under-privileged background in the mobility program has created new opportunities for these students.
- ▣ Educational and research activities have had positive impacts on clean energy transition and environmental concerns.
- ▣ The high degree of media coverage and partnerships with NGOs like Jaffna Science Association, Sri Lankan Energy Manager Association in Sri Lanka, Forsknings dagene, Klima Festival in Norway have helped in reaching the civil society.

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