

Development Research Projects – Training Projects for the South

General report form

1 FACT SHEET

Project title	RENEWABLE
Country	Vietnam
Year of project launch	2016
Northern coordinator	Prof. Gauthier Eppe
Northern coordinating university	Université de Liège, ULiège
Southern coordinator	Prof Le Hung Anh
Southern coordinating institution	Industrial University of Ho Chi Minh (IUH), Vietnam

2 FOLLOW-UP ON OPERATIONAL STRATEGY

2.1 REMINDER OF THE OVERALL OBJECTIVE, SPECIFIC OBJECTIVE, AND EXPECTED RESULTS

OO	To contribute to the prevention of coastal surface and coastal groundwater pollution from aquaculture farming in Vietnam and to preserve the livelihood of local populations involved in shrimp production.
SO	The feasibility of the reduction of the pollution load of aquaculture wastewater discharged in coastal areas by using microalgae is demonstrated, their biomass valorization techniques are tested and results disseminated to the regional government and aquaculture farmers.
ER0	Resources are used efficiently and effectively.
ER1	A fit to purpose - valorization technology for saline shrimp farming wastewater treatment is tested at pilot scale.
ER2	The valorization potential of products/biomass produced through saline shrimp farming wastewater treatment is tested and documented (biofuel, animal feedstuff).

ER3	Aquaculture wastewater treatment and valorization knowledge and know-how are increased by academic and applied researches and disseminated to the regional government and aquaculture farmers.
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2.2 INDICATORS

The table of indicators below has been prepared by ARES in order to facilitate the collection of data that may be useful for generation of the final reports that ARES must provide to the DGD for all its projects that have been launched within the same year, once these projects have been completed. Please fill out this form as completely as possible. If certain indicators or variables are not relevant to your project, please write "NA". If, though the project may have been completed, certain activities are ongoing and may lead to later changes in the values of certain indicators, please specify this in the notes.

For example, if a doctoral student has yet to present his/her thesis, but this presentation will take place in the coming months, please specify this, providing, if possible, the expected thesis presentation date.

INDICATORS	VARIABLES		FINAL VALUE	NOTES
F.1 Number of long training courses created/improved upon	Number of bachelors/masters/doctoral programs improved upon		0/23*/2	20 masters in Vietnam and 3 in Belgium
	Number of bachelors/masters/doctoral programs created		0	The objective was not to created new one but strengthening existing programs like EMES (Executive Master in Environmental Sciences)
	TOTAL F.1		25	
F.2 Number of occasional training courses held	Number of workshops and seminars held		9	4 in Belgium in person (from 2016 to 2019, before Covid) and 5 in Vietnam in person (from 2016 to 2019)
	TOTAL F.2		9	
F.3 Number of persons who received grants	Number of persons who received refresher/training course grants (if it is not possible to determine the number of men and women, please provide the total number)	♀	0	
		♂	0	
		Total	0	
	Number of students who received a doctoral grant	♀	1	Mrs Thu Thuy Cao, PhD Student
		♂	1	Mr Nguyen Thao Luu, PhD student
		Total	2	

	Number of students who received a postdoctoral grant	♀	0	
		♂	0	
		Total		
	Number of students who received a scholarship	♀	0	
		♂	0	
		Total		Many Master exchange students but with no budget, no scholarship from RENEWABLE
	TOTAL F.3		2	
F.4 Number of persons trained under group training courses	Total number of participants in seminars/workshops	♀	35	
		♂	25	
		Total	60	
	TOTAL F.4		60	
F.5 Success rate for diploma courses	Number of persons who have received diploma grants (master's or doctorates)	♀	1	
		♂	1	
		Total	2	
	Number of persons who have received diploma grants and have obtained their diploma	♀	0	Mrs Thu Thuy Cao, not yet defended, planning end of 2023, first trimester 2024
		♂	1	Mr Nguyen Thao Luu, PhD defended in September 2020
		Total	1	
	Success rate	♀	0	
		♂	100	
		Total	50	
R.1 Number of research projects carried out	Number of research projects carried out as part of a doctoral course		2	
	Number of research projects carried out as part of a master's course		23	
	Number of student projects completed (TFEs)		23	
	TOTAL R.1		25	
R.2 Number of research centers supported and/or created	Number of research centers supported		2	
	Number of research centers created		0	
	TOTAL R.2		2	
	Number of reports written (published)		1	

R.3 Number of publications accepted/scientific reports generated	Number of publications accepted (reports to be published)		1	The first paper of Mrs Thu Thuy Cao is under redaction
	Number of scientific reports presented (at symposia, conferences, etc.)		4	National and international symposia (Belgium, France, USA)
	TOTAL R.3		6	
SS.1 Number of initiatives undertaken for non-university actors	Number of initiatives undertaken for non-university actors (publication, restoration, outreach)		1	Large workshop 40 participants in Ninh Thuan province for farmers and stakeholders in waste water treatment (July 2019)
SS.2 Number of services provided for by third parties	Number of services provided for third parties		2	Two in field surveys organized in Ninh Thuan province for farmers (one in 2019, the second still on going)

3 PERFORMANCE SCORES

For each question, please mark an “x” next to the chosen ranking and provide an explanation for this choice (required).

3.1 EFFICIENCY

Please evaluate to what extent project resources (funds, expertise, time, etc.) were converted into results...

3.1.1 ...in an economical fashion

A	Highly satisfactory	X
B	Satisfactory	
C	Not very satisfactory	
D	Mediocre/Poor	

Explanation for this ranking	1. All the investments were completed and installed in Vietnam within the specified timeframe. <u>An efficient analytical laboratory for microalgae characterization was set up</u> in less than two years at the IUH (before the end of 2018). This efficient laboratory benefits not only for <u>our two PhD students</u>, but also the Vietnamese master students. Every year, several IUH master students do their master thesis in close relation to the theme of renewable energy (see table above), <u>more than twenty master students according to IUH information</u> 2. The inauguration of the pilot in Ninh Thuan (100 m³) in April 2018 allowed for large-scale testing. This pilot is also a <u>didactic tool for student training in Ninh Thuan, for IUH students from Ho Chi Minh city, and Student from Tra Vinh University in South Vietnam (WBI project)</u>. It has also been used to raise awareness among the local population and field actors about the treatment of wastewater from aquaculture. 3. <u>Isolate NL3 was identified as Desmodesmus sp. NL3, which is proposed to be a new species with two group I introns (S516 and S1046)</u> while isolate nl6 was 100% identical to Nannochloropsis salina (D12, accession number JX185299.1) from Shandong in China, so named Nannochloropsis salina NL6. 4. <u>Nannochloropsis salina NL6</u> was characterized by a high percentage of fatty acids (40% DW at the end of exponential phase) and a fatty acid profile <u>suitable for biodiesel production (tested and documented)</u> 5. <u>Desmodesmus sp. NL3</u> was characterized by high protein (40% DW), biomass (1.54 g/L), and lutein (7 mg/g DW) contents at the end of the exponential phase, suitable <u>for animal feedingstuff (tested and documented)</u> 6. Among the key achievements for ER3, the timely completion of <u>Mr Nguyen Luu's thesis</u> after acceptance for first author publication in the international journal Energies 2020, 13(4), 898 (https://doi.org/10.3390/en13040898). The writing of his doctoral thesis completed in May 2020, the defence took place on <u>11 September 2020</u> by video conference. 7. The organization of workshops in 2019 was very successful: a scientific symposium on the topic was organized at the Ho Chi Minh Industrial University on 15 July 2019. This symposium was attended by about 50 participants, mainly from HCMC but also from other provinces in Vietnam. Professors C. Remacle, J-L Vassel, S Agathos and G. Eppe actively participated in this day by presenting keynotes in their respective fields of expertise. This was followed <u>by a field workshop in Ninh Thuan at the Marine Breeding Center</u> (a non-academic partner of the RENEWABLE project) in order to offer 4 workshops during a day organized by the province and in collaboration with the DOST (Department of Science and Technology, also a non-academic partner of the project). The four workshops, all led by a pair of North-South partners, consisted of 1) a workshop
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	on the HRAP pilot project (Prof. J-LVasel, Cao Thu Thuy), 2) a workshop on microalgae collection systems (Prof. S. Agathos, Dr. Trinh Ngoc nam); 3) a workshop on microalgae characterization (Prof. C. Remacle, Luu Thao Nguyen), 4) a workshop on physico-chemical wastewater analysis (Prof. G. Eppe, Dr. Tai). This workshop was attended by about 50 people. 8. To conclude, the socio-economic component was initiated by Prof. Lebailly's team in 2019 in order to study different socio-economic models of valorization of the integrated approach proposed in RENEWABLE. A Gembloux Master 2 student, Bruno Craeye, under the supervision of Prof. Lebailly, conducted a first feasibility field survey in Ninh Thuan with Ms. Thuy (March to May 2019). 9. A second survey is on-going (Mai 2023) and carried out by Mrs Thu Thuy Cao to complete the previous one and finalize the specific chapter related to the socio-economic part of her work.
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3.1.2 ...in compliance with the expected timetable

A	Highly satisfactory	
B	Satisfactory	X
C	Not very satisfactory	X
D	Mediocre/Poor	
Explanation for this ranking	I would classify between satisfactory and not very satisfactory because the project was strongly impacted since March 2020 by the Covid 19 crisis in Belgium but even more drastically in Vietnam. Thus, we have a part of responsibility but not totally. Before that date, during the first 3 years, no major deviations from intentions, deliveries and milestones were observed. We were on time for all the tasks and all the tasks were on schedule. We were able to finalize Mr. Nguyen Luu's thesis remotely with a PhD defense held via video conferencing, but all results were obtained and processed by March 2020. Covid 19 has highly impacted the end of the project, especially for the second thesis of Mrs Thu Thuy Cao. Her PhD has not been completed yet. The main reason is that her thesis is more focused on practical aspects and measurements to be done in the field in Vietnam. For almost two years, she was not able to travel from Ho Chi Minh to Ninh Thuan to conduct tests. We have not been able to finalize it within the time frame of the	

	project. However, it is planned to finalize and defend her thesis by the end of 2023, beginning of 2024 if the paper under redaction will be accepted in an international peer reviewed journal.
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3.2 EFFECTIVENESS

Please evaluate to what extent the specific objective of the project has been achieved as per expectations

A	Highly satisfactory	
B	Satisfactory	X
C	Not very satisfactory	
D	Mediocre/Poor	
Explanation for this ranking	<u>Effectiveness specific objective (SO): The feasibility of the reduction of the pollution load of aquaculture wastewater discharged in coastal areas by using microalgae is demonstrated, their biomass valorization techniques are tested and results disseminated to the regional government and aquaculture farmers.</u> - Demonstration of the feasibility of the reduction of pollution load by using microalgae in the context of Vietnam. - One PhD thesis defended, and one article published. - Strong involvement in project's activities of both master degree's student from the North (3) and South. In particular, the students from the North contributed to the set-up of the pilot. 6 Master Students from the South completed their master thesis in 2017-2018. 6 Master Students from the South completed their master thesis in 2018-2019. 5 Master Students from the South completed their master thesis in 2019-2020. 19 master students in total during the first 3 years. 3 master student (2 chemical engineers from ULiège and 1 bio engineer from Gembloux AgroBioTech) went 3 months in Vietnam during the academic year 2017-2018, 2018-2019 and 2019-2020. - Commitment of the scientific community within the IUH and the University of Liege.	

	- Mitigate : The second PhD is still ongoing but is likely to be achieved by the end of 2023-beginning of 2024. The first series of results were not of the requested quality to pave the way to a publication. New measure campaigns were performed during summer 2022 and are under treatments. Effectiveness for ER1 on valorization technology for saline shrimp farming wastewater - New knowledge developed on endemic strains: selection of microalgae strains with high exploitation potential of two stains NL3, NL6 . - Lab pilot has been developed within IUH. Effectiveness for ER2 The valorization potential of products/biomass produced through saline shrimp farming wastewater treatment is tested and documented (biofuel, animal feedstuff). - Installation of a large-scale HRAP in Ninh Thuan, which allows to perform large-scale tests with a patented airlift system and demonstrate the feasibility of the process. - Ownership of the field pilot by the Ninh-Thuan Region. - Use of the pilot for trainings and researches. Effectiveness for ER3 Aquaculture wastewater treatment and valorization knowledge and know-how are increased by academic and applied researches and disseminated to the regional government and aquaculture farmers. - Organisation of a successful workshop in 2019 (more than 50 participants in IUH in Ho Chi Minh and in Ninh Thuan for the technical in field workshop).
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3.3 RELEVANCE

Please re-evaluate the relevance of the operation, considering any possible changes that might have taken place during its implementation, in the external situation, or within the project's partner institutions

A	High	
B	Reasonable	X
C	Limited	
D	Relevance in jeopardy	
Explanation for this ranking	At the internal level of institutions partners (Academic, research institutions, partners and teams involved), no change in particular. All the teams were stable and motivated for the project: - Strengths of the team: good relationship within the team and strong involvement from both sides, i.e. the characterization of new algae strains has been an important source of motivation for the team - The team was composed by scientific pairs. It has been particularly optimal and pave the way to conducive scientific exchanges. - Overall support and participation of the University team. - Strong motivation of the Vietnamese students to commit themselves, to understand and to appropriate their research topics. - Long stay of PhDs in Belgium was really an asset for PhD students for such technical and scientific project. - Good communication skills in English within the core team (North and South coordinators). However, communication much more complicated with South partners without any previous foreign experience outside Vietnam, despite intensive English courses to improve their level. External situation: - Strong interest from the local public stakeholders in wastewater management and willingness from the shrimp producers and companies to commit to some projects' activities. - Covid crisis highly impacted the end of the project, even if RENEWABLE project has been extended until 2022. He had a critical brake for the smooth implementation of the project.	

	- Hierarchical decision-making process in Vietnam is complex and difficult to understand or anticipate.
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3.4 POTENTIAL VIABILITY

Please evaluate...

3.4.1 ...to what extent the operation promises to survive from a financial and economic point of view (financial viability)

A	Very promising prospects	
B	Good prospects	
C	Uncertain prospects	X
D	Negative prospects	
Explanation for this ranking	We can highlight some potential viability based on the following argues: - Conducive relationship between HUI and Liège University - Ownership of equipments at IUH (new lab installed with good équipement facilities) and uses of this equipment for pedagogical purposes (all grades) - A new module in the EMES programme with microalga application, taught by Professor Remacle and Dr Nguyen Thao Luu (PhD1) - Permanent position at the IUH for one of the PhD, Dr Nguyen Thao Luu - Staff from IUH participated in project's implementation and strengthened their skills in academic project management. However, the prospect and financial viability are uncertain because: - Financial resources are now lacking to maintain the RENEWABLE laboratory at IUH - Maintenance and further development of the pilot in Ninh Thuan plan remain an issue. Human, technical and financial resources are still lacking.	

	- The Marin Center in Ninh-Thuan is now focusing on fish farming rather than on shrimp aquaculture. - We didn't see any willingness of south partners to seek other financial resources or to raise funds via ensuring complementarity with bigger funding (for instance World Bank, EU etc.), in particular when projects are at a pilot or demonstration phase for future scale-up.
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3.4.2 ...whether conditions for local adoption of the project have been fulfilled and will remain so (social viability)

A	Very promising prospects for adoption	X
B	Good prospects for adoption	
C	Uncertain prospects for adoption	
D	Negative prospects for adoption	
Explanation for this ranking	I think we can be optimistic about this point with very promising prospects and that for several reasons: - The training of numerous Master students and our PhDs has given them a solid background in the field. - Raising awareness of the problem of wastewater discharge from aquaculture. - Field studies have also highlighted farmers' awareness of the issue. - The dissemination of knowledge through various workshops organized in the field with local players, farmers and stakeholders - The sharing of the Ninh Thuan large pilote scale as a teaching tool and demonstrating tool for other universities, such as Tra Vinh, via a complementary WBI-funded project, has widened the circle of players in the field. - A <u>new teaching module</u> for EMES has been proposed and validated between ULiège and IUH. This teaching module will be effective for the next academic year 2023-2024: Micro-Algae and high value bioproduction based on RENEWABLE project results and skilled developed during the project. Prof C. Remacle partner of the RENEWABLE project will be in charge of this module accompanied by Dr Luu Thao Nguyen, former PhD student of the RENEWABLE project <u>who has now a tenured scientific lecturer position at IUH, thanks to the RENEWABLE project.</u>	

3.4.3 ...whether partners possess the necessary capabilities to verify the operation themselves and to continue it (knowledge transfer/capacity building/technical viability)

A	Absolutely	X
B	To a satisfactory extent	
C	To a partial extent	
D	Not at all	
Explanation for this ranking	This is the contribution of the RENEWABLE project for which we are particularly proud. <u>It is a strong achievement with great impact.</u> The RENEWABLE project has strengthened the collaboration between ULiège and IUH involved for master programs already existing. ULiège and IUH collaborate since 2010 in an executive master program entitled Executive Master in Environmental Sciences (EMES). Prof J-L Vassel and Prof. G. Eppe teach two modules in connection with the RENEWABLE thematic: Treatment and management of liquid pollution and Analysis of environmental contaminants, respectively. The project has definitely reinforced the professional relationship and collaboration between the two institutions. The benefits of this research project have had a direct impact on the curricula of these two modules: • With the treatment and management of liquid pollution module: Students will be taught about theory and practice in the field of wastewater treatment. A specific focus is now given to treatment of aquaculture, food processing by using algae, subject of primary importance for Vietnamese students interested in Environmental Sciences regarding the economic activities of this sector in Vietnam. The Pilot installed in IUH laboratories and developed during the RENEWABLE project, will be directly used by students during practical work sessions in the coming years. • With the environmental contaminant analysis module: Students are able to practice analysis of algal components and biomass composition, including algal oil content, using the laboratory installed by the RENEWABLE project	

	A new module has been proposed and validated between ULiège and IUH. This teaching module will be effective for the next academic year 2023-2024: Micro-Algae and high value bioproduction based on RENEWABLE project results and skilled developed during the project. Prof C. Remacle partner of the RENEWABLE project will be in charge of this module accompanied by Dr Luu Thao Nguyen, former PhD student of the RENEWABLE project <u>who has now a tenured scientific lecturer position at IUH, thanks to the RENEWABLE project.</u>
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3.5 GENDER

Please evaluate to what extent gender issues have been considered within your operation

A	Highly satisfactory	X
B	Satisfactory	
C	Not very satisfactory	
D	Mediocre/Low	
Explanation for this ranking	We have paid attention to gender equality within our consortium, and we have also paid attention especially in the selection of the PhD students and master students where we ensured the gender equality. (see F3 and F4, for example).	

3.6 ENVIRONMENT

Please evaluate to what extent environmental issues have been considered within your operation

A	Highly satisfactory	X
B	Satisfactory	
C	Not very satisfactory	
D	Mediocre/Low	
Explanation for this ranking	Inherently, the RENEWABLE project was oriented towards environmental sustainability. It fitted perfectly with the priority thematic of the ARES-CCD document for Vietnam highlighting management and protection of natural resources related to water issues with a strong emphasis in environmental protection and sustainable development. In this context, the RENEWABLE research project aimed to contribute to the prevention of coastal surface and groundwater pollution from aquaculture farming in Vietnam by reducing its pollution load with the use of microalgae wastewater treatment approach. The biomass produced was a potential source of possible renewable energy for biofuel production and animal feedstuff production. Thus, the project was constructed in way that tackles the environmental issues mentioned above.	

4 LESSONS LEARNED

1. Identify the elements implemented within your project that you think it might be worthwhile to replicate or favor for future ARES operations.
 - Do not hesitate to ask for seeking complementarities with ongoing projects and future projects, funded by ARES, WBI, or other relevant cooperation partners, it is necessary from a sustainable point of view.
 - Continue to disseminate project's results.
 - Even if new projects targets another aspect of wastewater management, how the link can be made with former projects and investments in the country?
 - If the project involves important investments, it is recommended to have a plan on how to use them after the project, how it can be recycle-re-used with new projects, how close collaboration with other institutes/research teams can be set up. It is important to avoid duplicates with public money.
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2. Identify issues encountered during your operation that ARES should know about and/or recommendations that you may have to improve the quality of operations.

I have identified several issues.

- The first is certainly the language barrier when working with non-French-speaking South countries. Selecting partners, students and PhD students who have already had international experience, for example through exchange scholarship programs, is certainly an important asset to take into account to ensure the success of the project.
- Scarce resources for scientific research in Vietnam. It causes some pressure on Vietnamese academics which have to constantly engage with external partners. it also poses problems in terms of financial viability and prospects. There is little vision for maintaining and sustaining the investments financed by ARES such as equipments. If an instrument breaks down, there is little or no money to repair it.
- Since Covid and energetic crisis and traveling costs, less travels from the Vietnamese side due to the limitation of resources at the IUH.
- Link up the ARES project to additional resources to ensure sustainability.

3. If you had to repeat this project, what would you do the same way, and what would you change? Please explain each element of your response.
 - Certainly, for almost all parts (WPs, tasks,...), I would do it the same way. The point I should have stressed more is the recruitment of doctoral candidates. When launching the project, even though we spent a whole day in Vietnam auditioning candidates with several colleagues from North and South, I think it's important to take your time and make the right and best selection. Eventually, close and open the call again if needed, instead of making a choice by default. The success of a project depends largely on the quality of the master and PhD students selected.

4. What advice would you give someone who wishes to establish a cooperative project in this country?
 - First identify, a reliable partner in the South who is essential to setting up a project and ensuring its subsequent success. Reliable means a partner who masters the language of international communication, i.e. English. Ideally, he should have some knowledge of the FWB and ARES institutional systems.
 - For a country like Vietnam, the political power is not to be neglected in the proper implementation on the field of the various plans and work packages of the project.
 - Never underestimate the administrative work involved in coordinating this type of project, at all levels: implementation, transfer, dispatch and receipt of equipments, work packages implementation on sites. It's important to be able to devote a significant percentage of your time to managing this type of project. The administrative workload is much, much greater than any other classical project that you can apply for regional, federal, EU projects. The main reason is that we don't have any possibility to enroll any administrative or scientific personnel attached to the project from the North.
 - 5 to 10% of your time is needed to coordinate this kind of projects, future candidate must be aware.

5 SUMMARY

Introduction

The RENEWABLE project (REmoval of NutriEnts in Wastewater treatment via microAlgae and Biofuel/Biomass production for Environmental sustainability in Vietnam) aims to couple wastewater treatment and the production of microalgae-based biomass valorisation as an effective way to enhance inorganic nutrients removal (N and P) from aquaculture wastewater and to produce biofuel and animal feedstuff from biomass. The wastewater treatment is the first priority of the project. The Ninh Thuan province situated in South-central region of Vietnam has been selected to install a field pilot. The project have the support from the regional government (DOST, Department of Sciences and Technology) of the province. In addition, the province has a marine seed-breeding center with high technology facilities (people, large scale ponds, laboratories) where the field pilot of the RENEWABLE project have been installed.

The intended effect of the RENEWABLE project, formulated as its SO, consisted to ensure that the feasibility of the reduction of the pollution load of aquaculture wastewater discharged in coastal areas by using microalgae and their biomass valorization techniques is tested and results disseminated to regional government and aquaculture farmers. Farmers, local authorities, shrimp producers and shrimp industry in general have been clearly identified as the end beneficiaries of the RENEWABLE project.

To achieve the SO, a consortium of academic professors, scientists, local government and local farmer association, local research center and industrial partners from the North and the South with diverse backgrounds and complementary skills have decided to join the project. In addition, a steering committee made of representatives of Ninh Thuan provincial authorities has been created to ensure the lobbying towards the adoption of the RENEWABLE technology developed. During this project, two Vietnamese PhD students and more than 20 master students will be financially supported and shared between the different research groups in the North and South partners. Investment and operating costs will allow supporting the research and the technical development of the project in Vietnam by installing a lab pilot at IUH and a field pilot in Ninh Thuan.

Notable achievements within your projects (actions completed, results achieved that you wish to highlight)

1. All the investments were completed and installed in Vietnam within the specified timeframe. **An efficient analytical laboratory for microalgae characterization was set up** in less than two years at the IUH (before the end of 2018). This efficient laboratory benefits not only for **our two PhD students**, but also the Vietnamese master students. Every year, several IUH master students do their master thesis in close relation to the theme of renewable energy (see table above), **more than twenty master students according to IUH information**

2. The inauguration of the pilot in Ninh Thuan (100 m³) in April 2018 allowed for large-scale testing. This pilot is also a **didactic tool for student training in Ninh Thuan, for IUH students from Ho Chi Minh city, and Student from Tra Vinh University in South Vietnam (WBI project)**. It has also been used to raise awareness among the local population and field actors about the treatment of wastewater from aquaculture.
3. **Isolate NL3 was identified as Desmodesmus sp. NL3, which is proposed to be a new species with two group I introns (S516 and S1046)** while isolate nl6 was 100% identical to Nannochloropsis salina (D12, accession number JX185299.1) from Shandong in China, so named Nannochloropsis salina NL6.
4. **Nannochloropsis salina NL6** was characterized by a high percentage of fatty acids (40% DW at the end of exponential phase) and a fatty acid profile **suitable for biodiesel production (tested and documented)**
5. **Desmodesmus sp. NL3** was characterized by high protein (40% DW), biomass (1.54 g/L), and lutein (7 mg/g DW) contents at the end of the exponential phase, suitable **for animal feedingstuff (tested and documented)**
6. Among the key achievements for ER3, the timely completion of **Mr Nguyen Luu's thesis** after acceptance for first author publication in the international journal Energies 2020, 13(4), 898 (<https://doi.org/10.3390/en13040898>). The writing of his doctoral thesis completed in May 2020, the defence took place on **11 September 2020** by video conference.
7. The organization of workshops in 2019 was very successful: a scientific symposium on the topic was organized at the Ho Chi Minh Industrial University on 15 July 2019. This symposium was attended by about 50 participants, mainly from HCMC but also from other provinces in Vietnam. Professors C. Remacle, J-L Vassel, S Agathos and G. Eppe actively participated in this day by presenting keynotes in their respective fields of expertise. This was followed **by a field workshop in Ninh Thuan at the Marine Breeding Center** (a non-academic partner of the RENEWABLE project) in order to offer 4 workshops during a day organized by the province and in collaboration with the DOST (Department of Science and Technology, also a non-academic partner of the project). The four workshops, all led by a pair of North-South partners, consisted of 1) a workshop on the HRAP pilot project (Prof. J-LVassel, Cao Thu Thuy), 2) a workshop on microalgae collection systems (Prof. S. Agathos, Dr. Trinh Ngoc nam); 3) a workshop on microalgae characterization (Prof. C. Remacle, Luu Thao Nguyen), 4) a workshop on physico-chemical wastewater analysis (Prof. G. Eppe, Dr. Tai). This workshop was attended by about 50 people.

Feedback from participating stakeholders or observations related to possible changes/impacts that have already been observed due to your operation

The new teaching methods with analytical facilities in the so-called RENEWABLE lab at IUH; the number of students at IUH working in the field, the reinforcement of the department with a new permanent scientist hired after graduating with a PhD from the University of Liège.

Post-project prospects (adoption, viability, etc.)

I would like to highlight:

In terms of research facilities in the laboratory at IUH and in terms of dissemination of knowledge, reinforced the Executive Master in Environmental Sciences (EMES).

The RENEWABLE project has strengthened the collaboration between ULiège and IUH involved for master programs already existing. ULiège and IUH collaborate since 2010 in an executive master program entitled Executive Master in Environmental Sciences (EMES). The project has definitely reinforced the professional relationship and collaboration between the two institutions. The benefits of this research project have had a direct impact on the organization of these two modules:

- With the treatment and management of liquid pollution module: Students will be taught about theory and practice in the field of wastewater treatment. A specific focus is now given to treatment of aquaculture, food processing by using algae, subject of primary importance for Vietnamese students interested in Environmental Sciences regarding the economic activities of this sector in Vietnam. The Pilot installed in IUH laboratories and developed during the RENEWABLE project, will be directly used by students during practical work sessions in the coming years.
- With the environmental contaminant analysis module: Students are able to practice analysis of algal components and biomass composition, including algal oil content, using the laboratory installed by the RENEWABLE project

A **new module** has been proposed and validated between ULiège and IUH. This teaching module will be effective for the next academic year 2023-2024: Micro-Algae and high value bioproduction based on RENEWABLE project results and skilled developed during the project. Prof C. Remacle partner of the RENEWABLE project will be in charge of this module accompanied by Dr Luu Thao Nguyen, former PhD student of the RENEWABLE project **who has now a tenured scientific lecturer position at IUH, thanks to the RENEWABLE project.**

The complete characterization of 2 microalgae strains NL3 and NL6 with high wastewater treatment potential, and potential valorization with high fat content for one and high protein content for the other. These strains are conserved and can be growth in Belgium as well as in Vietnam.