

TBSC Specific Project Description for Education¹

1. Title: Educational development phase 2

Theme: Education

Number(s): C4E8b

2. Responsible cluster team member/principle investigator

Specific for project C4E8b:

Name: 5.1.2e

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In collaboration with: 5.1.2e

Primary workplace (institute and building where the project will be performed):
Leiden Institute of Chemistry, Leiden University

3. Summary (1/2 A4)

General summary for project C4E8: In this project, which is a follow-up from the earlier project C4E5, we aim to develop a further series of educational modules to develop strong and transferable intellectual and practical skills, such as mathematical, analytical and problem-solving skills, at the boundaries of physics, chemistry, thermodynamics, nanotechnology, plant biology and microbiology that are necessary for pushing out the frontiers of these disciplines and for thriving the research and development covered by the BioSolar Cells program. This project will be a success if the following educational modules are developed:

- a. New inquiry-based approaches to learning ("profielwerkstukken").
- b. Development of a MOOC (massive online open course) on BioSolar Cells and energy sustainability for high school students.
- c. Development of a MOOC on BioSolar Cells and energy sustainability for Bachelor and Master students.
- d. Education and dissemination on the design of a marketplace for BioSolar Cells: science-based business, management of sustainable innovation.
- e. Education and dissemination on BioSolar Cells for future policy makers: development of a sustainability major.
- f. Further development of a 6-ec introductory course on BioSolar Cells in which all key elements of the BioSolar Cells program are covered (artificial systems, algae, plants and societal debate).

¹ To be submitted for approval to the TBSC SAB; upon approval basis for the SPA.

Initially, all educational modules will primarily be developed at the VU Amsterdam and Leiden University, with input from other BioSolar Cells partners where appropriate. However, the output of this project is intended for use by the entire consortium and will be disseminated to all partners by means of the team site.

4. Keywords

General keywords for project C4E8: Education, innovation, dissemination, digital learning media, outreach, classes, practicals

5. Project description (1-2 A4)

5.1 Project direction

General project description for project C4E8: In the BioSolar Cells consortium we apply the principles of photosynthesis in the development of (semi-)artificial devices, microorganisms for direct conversion of solar energy into fuel, and plants with enhanced photosynthetic conversion of solar energy into food, feed, fuel and feedstock. Research within the program is at the cutting edge of physics, chemistry, thermodynamics, nanotechnology, plant biology and microbiology. Education can form a vital partnership with research to accumulate knowledge and develop additional vision and to equip and inspire a new generation of researchers, policy makers and industrialists. The development of educational modules is already underway in the BioSolar Cells program, and progress has been made with educational material for high schools, vocational education, and universities (both undergraduate and postgraduate). In particular, we wish to follow up the work begun in the C4E5 project. The exciting work that has already begun needs to be cultivated and extended. Also, new educational projects will be embarked upon. This is the goal of this project.

In the educational program and in this project, the existing knowledge on the principles of photosynthesis and the newly developed knowledge on BioSolar Cells will be accumulated and converted into a coherent educational program for high school and university students. A range of students is targeted in this C4E8 project. These include (but not limited to): high school students, Bachelors and Masters students studying the physical, chemical or biological sciences, students of business and innovation, and students of public governance. Having a wide range of students provides us with a unique opportunity: students from within the sciences will be equipped and inspired for future research or employment in the field of BioSolar Cells; students from business and governance will be taught the basics of the science behind BioSolar Cells and will therefore be able to provide rational and quantitative input into the sustainability debate.

To reach these goals, the co-workers employed within the educational program will develop a number of modules and courses:

- a. Inquiry-based approaches to learning (“profielwerkstukken”). A number of “profielwerkstukken” have already been developed within project C4E5. These include projects on characterisation of solar cells and fuel cells, fluorescence spectroscopy of plant leaves, algae and chlorophyll, the catalysis of water oxidation, and microalgae

cultivation for fuel production. There are all very successful. There is a need to continue support for these existing projects, and develop new ones. Some of the “Profielwerkstuk” projects have the potential to be simplified for use in regular high school classroom education.

- b. Development of MOOC (massive online open course) on the subject of BioSolar Cells and energy sustainability for high school students. A start has been made with this project within C4E5a, but an extension is needed. The MOOC will be designed as a combination of video lectures, interactive assignments (including modelling and applets) and peer review questioning. It will be based on EdX, developed in collaboration with Preceptum, and is meant for NLT modules at high schools. The idea is to include general aspects related to sustainability and the energy transition, and aspects more directly related to Biosolar Cells. The development of the material for this MOOC will be performed in close collaboration with the co-workers involved in part c of this C4E8 project (see below).
- c. Development of a MOOC on the subject of BioSolar Cells and energy sustainability for (international) Bachelor and Master Students. This MOOC will be based on the book ‘Energy survival guide’ by Jo Hermans, and the booklet ‘Solar fuels and artificial photosynthesis’ produced by the BioSolar Cells program, and will be offered in English. ‘Energy survival guide’ covers many aspects of energy sustainability: how energy is used, sustainable energy resources, energy storage, etc. ‘Solar fuels and artificial photosynthesis’ covers all aspects of the BioSolar Cells program: (semi-) artificial devices, microorganisms, and plants. We aim to make a course that is a concatenation of these two publications; thereby providing an overview of energy sustainability with a strong emphasis on BioSolar Cells. The most important concepts developed within the modules d (science-based business) and e (energy policy) will be included as well. The development of the material for this MOOC will be done in close collaboration with the co-workers involved in part b of this C4E8 project (see above) and in collaboration with the co-workers involved in the C4E5d program.
- d. Education and dissemination on the design of a marketplace for BioSolar Cells: Science based business (through links with the Science, Business and Innovation Bachelor and Master programmes at the VU). Within this module, we will develop a number of concepts that are relevant for the management of sustainable innovation and valorisation, like stakeholder analyses, market analyses, methods to assess the status of technological development, economic analyses to determine the dominant drivers for development, opportunity recognition, theory about niche formation and market development, SWOT analyses, IPR, Life Cycle Assessments and environmental impacts, methods to assess value and supply chains, and scenario studies. Also innovation theories, transition theories, key characteristics of entrepreneurship and intrapreneurship and corporate social responsibility will be covered.
- e. Education and dissemination on BioSolar Cells for future policy makers: development of a sustainability major. The deployment of BioSolar Cells technology is dependent upon there being an appropriate policy framework. Future policy makers are therefore an important target group for education within the BioSolar Cells program. One way to reach this target group is by incorporating BioSolar Cells education into Liberal Education programs. Liberal Education is an approach to learning that empowers

individuals and prepares them to deal with complexity, diversity, and change. It provides students with broad knowledge of the wider world (e.g. science, culture, and society) as well as in-depth study in a specific area of interest. A liberal education helps students develop a sense of social responsibility, as well as strong and transferable intellectual and practical skills such as communication, analytical and problem-solving skills, and a demonstrated ability to apply knowledge and skills in real-world settings.² It is thus our aim to introduce a major on sustainability into a Liberal Education program to teach the basics of quantitative literacy as applied to BioSolar Cells and the bio-based economy to future policy makers.

- f. A 6-ec introductory course on BioSolar Cells in which all key elements of the BioSolar Cells program are covered (artificial systems, algae, plants and societal debate). A course was offered in Amsterdam in 2013 based on interactive lectures on the three scientific themes of BioSolar Cells and literature studies on a theme covered by BioSolar Cells. This course will be continued and further expanded. Also, a second 6 ec module will be developed based on the book "Fundamentals of Materials for Energy and Environmental Sustainability" (D.S. Ginley & D. Cahen, eds). The latter course will cover most areas of the BioSolar Cells program, but will be somewhat more materials oriented.

The educational material described in points a to f above will primarily be developed at the VU Amsterdam and Leiden University. However, if it is perceived that it is advantageous to perform educational activities at other knowledge institutions (either because of a greater need for the modules at that university, or because that university is better equipped to execute the modules) then this can be arranged on an ad-hoc basis. The output of this project is intended for use by the entire consortium and will be disseminated to all partners by means of the team site.

Specific project description for C4E8b: The co-worker involved in this part of the project is

5.1.2e

(Leiden University).

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and co-workers from the VU in Amsterdam will collaboratively implement the educational modules described above. Being based in Leiden, Dr Purchase will primarily carry out her work at Leiden University and Delft University; however, she will also take on a co-ordinating role and seek to expand educational activities to other universities. The goals that will be focused upon in this part of the project are goals a, c, e, and f.

Goal a: 5.1.2e will take on a co-ordinating role and act as a contact person for profielwerkstukken. In this position, she will both continue to provide support for existing "profielwerkstukken" and develop new "profielwerkstukken". New projects will be made by plugging into the research of BioSolar Cells and taking a small step from a research project that can be reproduced by a high school student. Furthermore, at Leiden University, there is the Pre-University College. This college attracts excellent (average grade > 8) high school students from the region, who come for extra tuition and do their "profielwerkstuk" at the university. These students are an excellent target group for the BioSolar Cells program.

² Definition from the website of the Association of American Colleges and Universities, see http://www.aacu.org/leap/what_is_liberal_education.cfm, accessed 18 September 2013.

Goal c: 5.1.2e is well positioned to contribute to the content of the MOOC. She

5.1.2e
5.1.2e Furthermore, Leiden University already has already produced two MOOCs, so there is expertise already present in Leiden for doing this.

Goal e: At Leiden University, there is the Leiden University College (LUC) The Hague. This is an excellence education liberal arts and sciences college with the themes of peace, justice and sustainability. We have already developed a first-year course on sustainability and the bio-based economy and a few later-year courses. Along with colleagues at the LUC, we are continuously developing a sustainability major. This is proving to be an excellent testing ground for developing science-based courses for students from a non-science background. The course material and teaching methods that we develop here can be applied in other liberal education environments.

Goal f: A 6-ec introductory course on all aspects of the BioSolar Cells program will be developed. The textbook "Fundamentals of materials for energy and environmental sustainability" (D.S. Ginley & D. Cahen, eds) will be used to base the course on. We hope to deploy the course both in the regular education in Leiden as well as in the excellence education at Leiden University College. On the longer term, course material could be used at other universities.

5.2 Context

General context for project C4E8

BioSolar Cells vs. existing educational infrastructure: The goal of this project is to produce educational modules based upon the research being performed within the BioSolar cells program. This places the context within the BioSolar Cells community. However, many of the educational modules will need to fit within existing educational structures (particularly high school and undergraduate material). This means that any modules that are developed within the project will need to be done so with an awareness of the demands of any pre-existing educational infrastructure.

National vs. International: The BioSolar Cells program is primarily a Dutch national program. This makes any educational material primarily fall into a national context. (Any educational material will initially be deployed at Dutch educational institutions.) However, some of the educational institutions mentioned above have a strongly international character. The Leiden University College, for instance, has a large portion (>30 %) of its students coming from other countries and all teaching is done in English. Likewise, many Masters programs at participating universities are in English to cater to international students. Finally, the development of MOOCs (in English, goals b and c) puts this project on a firmly international footing, as this material will be available to anyone anywhere in the world.

5.3 Potential impact

General potential impact for project C4E8: A wide range of students is targeted with these educational modules. The potential impact is therefore myriad. By means of the educational modules described here, students can acquire intellectual and practical skills on

BioSolar Cells for participating in future bio-based economies either in R&D, business or governance.

6. Project and valorisation aims (1-2 A4)

6.1 Challenges

General challenges for project C4E8: The goal of this project is to implement educational modules within existing programs of the participating universities to reach as many students as possible. We aim to produce educational material of the highest possible scientific and educational quality. This goal presents two main challenges: a) Any new BioSolar Cells educational material needs to be introduced with sensitivity for the existing educational infrastructure, without compromising the quality of the new educational module; b) In cases where modules are developed for students from a non-science background, these students need to be taught the basics of quantitative literacy in a fashion that is accessible to these students and yet maintains a high scientific level.

6.2 Valorisation plan

General valorisation plan for project C4E8: This project affords a mechanism by which knowledge gained in BioSolar Cells can be accumulated and disseminated. It provides a unique environment for young people to interact with that information and study it from various perspectives. Critical evaluation of the knowledge by our students may lead to new fundamental research questions that will form the basis for new grant applications

Material from the educational modules will be available to BioSolar Cells partners via the team site, at BioSolar Cells meetings, or on request. Newly generated modules and insights will be communicated to the outside world by e-learning and (chapters in) textbooks.

Collaboration with industrial partners will be encouraged where appropriate. Such partners may be asked to give guest lectures or allow students to visit their facilities.

Economic development:

General economic development for project C4E8: Industrial partners will be asked if they would like to participate in one or more of the to-be-developed courses, by means of guest lectures. New ideas arising from the educational modules may be translated into grant applications and the industrial partners from BioSolar Cells may benefit from new ideas that can be turned into new projects. Where appropriate, entrepreneurial students will be encouraged to explore the feasibility of a spin-off company based on BioSolar Cells research activities.

Social development:

General social development for project C4E8: The training of high school, Bachelor and Master students in our universities will facilitate the dissemination of knowledge into society. Many BioSolar Cells students will be given an opportunity to become exposed to BioSolar Cells topics.

Providing access to infrastructure

General access to infrastructure for project C4E8: For some of the to-be-developed advanced practical courses, access to the facilities and equipment used for research in BioSolar Cells projects at the participating universities will be possible.

6.3 Timescale: List of milestones, go/no-go decisions and key deliverables

General timescale for project C4E8:

Month	Milestones and Deliverables
6	Inquiry-based approaches to learning (goal a)
6	New version of 6 ec introductory Masters course "BioSolar Cells" First version of 6 ec introductory Bachelor/Masters course on fundamentals of materials for energy and sustainability (goal f)
6	Improved version of a MOOC for high school students (goal b)
12	Integration of BioSolar Cells courses in Liberal Arts & Science (goal e)
12	First version of a MOOC for Bachelors and Masters students (goal c)
12	Course(s) on science based business, management of sustainable innovation, and governance for the biobased scalable economy (goal d)
18	Revised inquiry-based approaches to learning (goal a)
18	Further improved version of a MOOC for high school students (goal b)
18	Update of 6 ec introductory Masters course "BioSolar Cells" Revised version of 6 ec introductory Bachelor/Master course on fundamentals of materials for energy and sustainability (goal f)
24	Revised version of MOOC for Bachelor and Master students (goal c)
24	Course(s) on science based business, management of sustainable innovation, and governance for the biobased scalable economy (goal d)
24	Further integration of BioSolar Cells courses in Liberal Arts & Science (goal e)
General deliverables after 31 months	(including final report) C4E8: all deliverables completed

The team leaders will monitor progress twice per year and will report to the steering committee at the theme level. The mid-term review after 36 months and the final report will be at the project level.

7. Project management

7.1 Project team

Name	Age	Responsibility	Partner	Hrs/week
5.1.2e		Implementation and teaching	LU	27-30
5.1.2e		teaching	LU	4
5.1.2e 5.1.2e		teaching	LU	3
5.1.2e		teaching	LU	3

7.2 Budget: TBSC resources and “eerste geldstroom” matching

Personnel / Name	FTE	2011 (fte)	2012 (fte)	2013 (fte)	2014 (fte)	2015 (fte)	2016 (fte)	Total (fte)
5.1.2e 5.1.2e	5.1.2b							
		2011 (€)	2012 (€)	2013 (€)	2014 (€)	2015 (€)	2016 (€)	Total cost (€)
Personnel / Name	Level ¹⁾							
5.1.2e 5.1.2e	docent				5.1.2b			
	professor							
	UD							
	UD							
Consumables								
General								
Specific								
								Subtotal
Equipment								
								Subtotal
Facilities								
								Subtotal
Travel					5.1.2b			
Outsourcing								

1) PhD, Postdoc, Assistant, Scientist, Senior Scientist, UD, UHD, Professor

7.3 Budget: Matching resources from “tweede en derde geldstroom”

Personnel / Name	FTE	2011 (fte)	2012 (fte)	2013 (fte)	2014 (fte)	2015 (fte)	2016 (fte)	Total (fte)
		2011 (€)	2012 (€)	2013 (€)	2014 (€)	2015 (€)	2015(€)	Total cost (€)
Personnel / Name	Level ¹⁾							Subtotal
Consumables								Subtotal
Equipment								Subtotal
Facilities								Subtotal
Travel								Subtotal
Outsourcing								Subtotal
						Total		

¹⁾ PhD, Postdoc, Assistant, Scientist, Senior Scientist, UD, UHD, Professor

7.4 Project Summary, TBSC funding + Matching sources

[illegible]

7.5 Justification of resources (max 1 A4)

g. Personnel

Personnel are requested to carry out the projects as described in section 5.

b. Consumables

A small budget for consumables is necessary to cover consumables of practicals, the daily costs of the work, and travel, including an occasional trip abroad.

c. Facilities

d. Equipment

This budget is meant to cover small equipment, including computing equipment and analysis software for practicals and the other modules of the educational program.

e. Outsourcing

f. Travel

A small travel budget is requested to cover travel costs for regular meetings with co-workers.

8. Signatures

a. *Legal/statutory/authorized representative of the principle investigators organization:*
Leiden University

Name:

Place: Leiden

Date:

29/01/2014

b. *General Director BioSolar Cells*

Name:

5.1.2e

Place: Wageningen

Date:

4/2/14