Mondialogo Engineering Award 2008/2009

EFFECTIVE LOCAL SOLUTIONS FOR EXTRACTION AND ENERGY-EXPLOTATION OF PALM-OIL

PARTNERS: Santo Toribio de Mogrovejo Catholic University, Peru:
Max Jorge A. Romero Rivas;
Pedro Carlos Castillo Rodríguez;
University of Genoa, Italy:
Michela Mazzoccoli;
Giovanni Pongiglione;
Centro di Istruzione e Formazione Artigianale e Professionale, Bula, Guinea Bissau (CIFAP):
Sunhana 'Ndemi;
Jackson Gomes;
Domingos Alfonso Nhaga;
Julho Albino Indequi.

Structure of project proposal

I. Cover sheet
   a. Title of the project proposal
      Effective local solutions for extraction and energy-exploitation of palm-oil
   b. Name, e-mail of main contact person
      Michela Mazzoccoli, michela.mazzoccoli@gmail.com
   c. Names and countries of participating institutions
      i. Department of Civil, Environmental and Architectural Engineering (DICAT), University of Genoa;
      ii. Centro di Istruzione e Formazione Artigianale e Professionale, Bula, Guinea Bissau (CIFAP);
      iii. Santo Toribio de Mogrovejo Catholic University, Peru (STMCU).
   d. Proposed country of implementation
      Guinea Bissau
      Peru
   e. Names of all International Project Team members and their nationality
      Michela Mazzoccoli, Italy;
      Giovanni Pongiglione, Italy;
      Max Jorge A. Romero Rivas, Peru;
      Pedro Carlos Castillo Rodríguez, Peru;
      Sunhana 'Ndemi, Guinea Bissau;
      Jackson Gomes, Guinea Bissau;
      Domingos Alfonso Nhaga, Guinea Bissau;
      Julho Albino Indequi, Guinea Bissau.

II. Management summary (maximum 2 pages)
   a. Purpose and description of the project proposal.
      Guinea Bissau, like all Western and Central Africa, is reach of spontaneous oil palm forests which are strongly under-exploited because of the current poor efficiency of the extraction systems in use in the villages (extraction yield in the order of less than 0.5 ton of oil/hectare and extraction efficiency lower than 50 %). A similar situation occurs in Peru. In San Martin, Ucayali, Loreto and Huanuco regions, even if palm oil is partially used for biodiesel and glycerin production, a large number of rural communities is not able to exploit oil palm forests for energy self-production due to a lack of appropriate technology and technical assistance.
      The aim of the project is:
      1. to design, test and divulgate a Village Scale palm oil extraction plant based on the optimized traditional process, but with double extraction efficiency;
      2. to evaluate and demonstrate the possibility to use a little part of the oil produced in the village as fuel in a diesel-generator set. Demonstration will take place in two inner villages selected by the students of the local team by a long run testing where village people will operate the plants under the supervision of the students.
      Expected follow up of the project is the diffusion of technologies (both: oil extraction and bio-fuel use in Diesel engine) in the Country with a better and larger exploitation of the resources available by the oil palm forests and distributed power generation in the inner villages.
   b. Description of organization of the International Project Team and progress of work
      University of Genoa will operate as technical partner, with the aim to design the oil extraction system, to select the most appropriate Diesel GenSet and to

design the system modification to enable the Diesel engine to work with the oil from the oil extraction system. Included is the selection of the most suitable Diesel engine and the design of simple methods to purify (as far as possible in the villages) the crude oil toward the standards of vegetable oil for use in little diesel engine. The first long term trial of the selected Diesel engine with said crude palm oil will be also performed in Italy under the supervision of Genoa University. Finally, the scope of Genoa University will be to transfer the results to the partners by arranging Design Guides, Instruction Manuals and teaching the partners as far as necessary.

CIFAP-Bula in Guinea Bissau and Santo Toribio de Mogrovejo Catholic University in Peru will be responsible for all the local activities, from the revision of the design documents to match the local conditions (to harmonize with local experience, to maximize local materials and construction, etc), to the construction, erection and testing of the plants, to the selection of the villages where to perform long run testing, to the assistance in the long run testing and finally to develop the technology thanks to the experience gained in the long run tests. Specially in this last activity, significant help is expected by the exchange of information and the dialogue among all three partners. This development activity, to be carried on by sharing the knowledge and the experience with the partners, is expected not to end with the project, but to continue by the creation in CIFAP-Bula and in Santo Toribio de Mogrovejo Catholic University of two "Palm Oil Development Center" (PODC) with the potential to become the reference point in the respective Countries for palm oil extraction and distributed bio-fuel production.

The project is presently in the design phase of a "village scale" palm oil extraction plant, after that in Bula, a small town nearby Bissau, tests were carried out in the CIFAP Institute on a family scale prototype based on a local traditional process reviewed and optimized with the help of the University of Genoa (Italy). They have shown the possibility to double the oil production yield at the same time reducing the energy (wood) requirement. In the meantime, the most suitable Diesel engine for power generation in the village has been selected and procured, and nowadays the palm oil supply system to the engine is in the design phase.

c. <u>Indication in a short outline of the relevance of the project proposal in addressing the Millennium Development Goals, especially poverty reduction, sustainable development and mitigating negative impacts of climate change</u>.

Expected benefits from the project are:

a. to reduce poverty in the internal villages of Guinea Bissau and Peru (and may be near Countries in the future) giving the village the possibility to sell palm oil produced in an efficient way. The profits is expected to increase not only thanks the higher extraction efficiency, but also because the high extraction efficiency and the reduction in manpower will push the village people to enlarge the harvesting in palm forest presently unexploited ;

b. to introduce in the villages, presently without electrical energy or with energy systems depending on a difficult fuel-transport *(in the rain season villages remain cut off for months)*, a local energy production system, fully independent, for improving the life level (little industrial activities, lighting, schools, health centers, water purification, etc);

c. the use of palm oil for power generation in place of Diesel Oil gives its contribution to reduce the exploitation of fossil fuels and mitigate climate change thanks to zero emission of CO_2 and SO_2, while NO_x remain at the same level.

III. Concept and proof of international cooperation and intercultural dialogue* (maximum 200 words per team)

a. Students group A: Michela Mazzoccoli and Giovanni Pongiglione (Genoa University)

i. We decided to take part in Mondialogo as we are interested in cooperation and we are member of PS76 Association (an Italian Voluntary Association). (Michela) I am chemical engineering and I am currently doing a doctorate at the DICAT who collaborate with the PS76 for several years and (Giovanni) I am attending to the last year of mechanical engineering. The thesis that I'm writing to get my degree is focused on the idea to gain electrical power using a diesel engine burning *palm oil.*

ii. The PS76 Association was working on the palm oil extraction systems in Bula (Guinea Bissau) collaborating with the CIFAP, at the same time the Santo Toribio de Mogrovejo Catholic University (Peru), who has collaborated with the DICAT for long time, was interested in oil palm extraction. As above mentioned, we were interested in cooperation, for this reason the International Team was born.

iii. We believe that the project can be enriched by the ideas and contributions of people with different cultures through dialogue intercultural that Mondialogo enables us to achieve.

iv. A cooperation project has the advantage of putting together the local environmental knowledge which the Guinean and Peruvian students have with some technical improvements that we can bring with the support of DICAT and PS76.

v. We think that we can gain competence, but especially to grow personally making a cooperation project with students of different culture through dialogue and in a spirit of cooperation.

b. Student group B :Max Romero and Pedro Castillo (Catholic University Santo Toribio de Mogrovejo)

i. I, Max Romero, am industrial engineering student and I decided to take part in Mondialogo because it is a form of new capture knowledge that can be applied in my country in a practical way. I, Pedro Castillo, am also studying industrial engineering, and I decided to take part in Mondialogo since is a way of interacting with people from other countries, and to prove our knowledge and values acquired in our universities.

ii. The Santo Toribio de Mogrovejo Catholic University, who has collaborated with the University of Genoa (Italy) for long time, was interested in oil palm extraction, at the same time the PS76 Association, which was collaborating with the University of Genoa as well, was working on the palm oil extraction systems in Bula (Guinea Bissau) collaborating with the CIFAP. For this reason the International Team was born.

iii. When different parts of the world have the same problems, they can be solved them with the contribution of ideas, knowledge and work of people from different cultures who seek a single goal. Moreover the local population can receive benefits.

iv. International cooperation allows to see directly the problem reality in each country, find the solution and to realize it.

ii. We think that Mondialogo allows of professionally and personally growing, making a cooperation project with students of different culture.

c. Students group C: Sunhana 'Ndemi, Jackson Gomes, Domingos Alfonso Nhaga, Julho Albino Indequi, CIFAP Bula, Guinea Bissau.

There are three main reasons because we decided to take part in Mondialogo:

i. Mondialogo can be an important aid for us to be successful in our target that is to take advantage of our important natural resource, the palm oil forests, to reduce poverty in our Country. Palm oil trees are, at the moment, scarcely exploited and an improvement in the technology extraction and in the cultivation technique should strongly increase the oil production yield in rural areas increasing their income.

ii. We are enthusiastic of the possibility to have a technology exchange with students of two different Universities, Genoa and Santo Toribio de Mogrovejo. We expect strong advantages from this technology transfer as we are presently at a lower level of technical stage, and Mondialogo will give us the possibility to receive assistance in the engineering design methods and advanced cultivation techniques.

iii. One important contribution we think to receive in Mondialogo project is the possibility to establish long term collaboration with the students of Santo Toribio de Mogrovejo University. Thank to this teamwork we expect mutual important advantage in our future Palm Oil Development Center by exchanging experience on the palm trees cultivation and palm fruit processing

IV. Evidence of cooperation (maximum 2 pages, not including appendix)

a. Institutions involved

- Department of Civil, Environmental and Architectural Engineering (DICAT) – University of Genoa, Italy;
- Santo Toribio de Mogrovejo Catholic University, Peru;
- Center for education and craft and professional training (CIFAP), Bula, Guinea Bissau.

b. Outline of discussion and development of idea and project proposal

DICAT is since long time paying special attention to the Millennium Development Goals. In 2007, was informed, in the frame of a current collaboration with PS76 (an Italian Voluntary Association), of the possibility to develop a palm oil extraction system based on the traditional methods in use in Guinea Bissau and to verify the possibility to use part of the oil as a fuel in a Diesel GenSet for inner villages electrification. Under the suggestion of “Amigos da Guineè Bissau” (a local Voluntary Association) CIFAP-Bula was selected as the best place where to do the local part of the Project. CIFAP has the best mechanical workshop in all Guinea Bissau, and Padre Jorge (the Director) is continuously looking for working openings for young people trained in the Institute. Then an agreement was reached with CIFAP for construction and testing of the first prototype

Then, in 2007 and 2008, the oil extraction was designed in Genoa, the drawings were sent in Bula for check and comments, the equipment was fabricated and the plant assembled in CIFAP and finally the system was tested. The results were encouraging, giving oil of a very good quality and with double extraction efficiency compared to the traditional process. The pilot plant is in the way of a long test running in three villages in Guinea Bissau. This system has presently the capacity of 100 kg/day of fruits, which can be defined as Family scale plant.

That was the situation around middle 2008, when the idea of a larger, continuous plant, with the size of around 10-20 times the family scale (what we call the “Village Scale”) plant was born. This Village Scale plant will be based on the same operational sequence than the Family scale, but it will be a

continuous process instead that a batch operation. DICAT and CIFAP agreed to entrust main part of the work to two groups of students. The recent installation of Internet connection in CIFAP will facilitate communication and dialogue between the two groups of students.

On the other hand, DICAT was coopering with STMCU in the field of energy generation from renewable sources since about 2001. Different energy sources have been taken into account, for example bagassa and barbojo from sugar cane, rice hulls, urban waste. The studied energy process was biomass gasification coupled with engines or fuel cells. This research activity resulted in several feasibility analyses and student mobility programs. Due to the large presence of palm forests in San Martin, Ucayali, Loreto and Huanuco regions in Peru, DICAT proposed to STMCU the possibility to join the present project proposal: adding the experience and the tradition of Peru villages could give further benefit to the Project. So a third group of students from STMCU was included in the Project.

The team experience in energy generation, joined with the need to find a way for small distributed power generation in the villages (most villages are presently without any form of electricity or with energy systems depending on a difficult fuel-transport), suggested the idea to use part of the oil produced in the village as bio-fuel for Diesel GenSet.

Presently, the Diesel GenSet most appropriate for this function has been selected and procured and the addition of palm oil injection system is under design.

c. Information on the development of any prototypes or associated activity

The Family Scale plant is a prototype where the following ideas have been introduced respecting the traditional sequence of operations:

a) to use the same component [the sterilizer] for the sterilization and the digestion process, eliminating this way manual empting and filling of fruits from/to different equipments (reducing man-hours and saving thermal energy);

b) to have only one source of thermal energy (the steam generator) for two equipments (the sterilizer and the clarifier) this way reducing again man-hours and energy (wood) requirement . The Village Scale plant, presently under the design phase, is a prototype too, continuing to use these concepts and further reducing man-hours requirements by transforming the batch into a continuous process. In addition, the use of horizontal screw press instead of a vertical screw press will further increase extraction efficiency

d. Estimate statement of the likely costs of implementing the proposed project

Cost of the project (total) is estimated around 90.000 € (including past activities)

e. Estimated time frame for implementing the proposed project

The following is an estimated time frame for the project:

i. Design and assembly of a Palm Oil Diesel injection system: May 2009;
ii. Design of the "Village Scale" prototype: June 2009;
iii. Construction and erection of the "Village Scale" prototype: December 2009;
iv. Long run testing of Diesel GenSet with palm Oil in Italy: December 2009;
v. Long run testing of Diesel GenSet with palm Oil in The villages: December 2009;
vi. Long run testing in the village: June 2010;
vii. Design revue on the basis of test experience: September 2010.

f. Appendix (including outline of project cooperation, technical correspondence, development of idea and any prototypes, photographs of team and team-work): See Appendices.

V. Conclusion (maximum 2 pages)

a. Reflections on the development of the project proposal and associated team-work

The project will allow developments in technology and training. In fact the local people in Peru and Guinea Bissau will have electricity produced from palm oil and the realization of two "Palm Oil Development Center", in Peru and in Guinea Bissau, that will continue to work together in future, will allow to local students to obtain a technical training.

b. Importance of international cooperation in the development of the project proposal.

International cooperation is expected get the following targets:

i. The application of a well developed experience and capacity in process design (DICAT) to old traditional sequence of operation (like present methods for palm oil extraction in use in villages of Guinea Bissau and Peru) is expected to optimize efficiency of the process in strong way without losing the experience gained in years and years of the traditional method. In effect, the "Family Scale" prototype has shown the possibility to double the extraction efficiency with, at the same time, reducing the wood (for heating) consumption. The "Village Scale" prototype (that is one of the object of this Project) is expected to give the same benefits with the further advantage to strongly reduce both capital cost of the plant and manpower for oil extraction, this way reducing the production cost. It is, as far as we know, the only continuous plant for this size plants

ii. Dialog between the Guinea Bissau and Peru will allow to use the experience of two different situations by sharing the teachings from the tests of the two plants. This benefit will continue after the end of the Project thanks to the enduring collaboration between the two PODC (see point c. below)

iii. Transfer of the process design capacity and technology from DICAT to CIFAP and STMCU. Included in the Project is the preparation by DICAT of Design Guides and Manuals containing the criteria that constitute the basis for the Equipment and Plant design. The understanding of said criteria will allow the establishment of a technical patrimony on which draw for future developments of the plants

c. Possible plans to develop and implement the project proposal and future collaboration.

As anticipated in the management summary, the Project is planned to end at the time when the oil extraction plant and the Diesel GenSet fuelled with palm oil, located in the selected villages, have overcome their long test run with the satisfaction of the village people. At this time, the students of local team will have gained a significant capacity and experience in the design and operation of the palm oil extraction systems and bio-fuel use. This potential has to be exploited and it is intention of CIFAP and Universidad Católica Santo Toribio de Mogrovejo to constitute a "Palm Oil Development Center" (PODC) with the perspectives to promote the exploitation of palm oil forests, to continue to improve the technology of the oil extraction and bio-fuel preparation, to teach villages to properly operate the plants, to improve

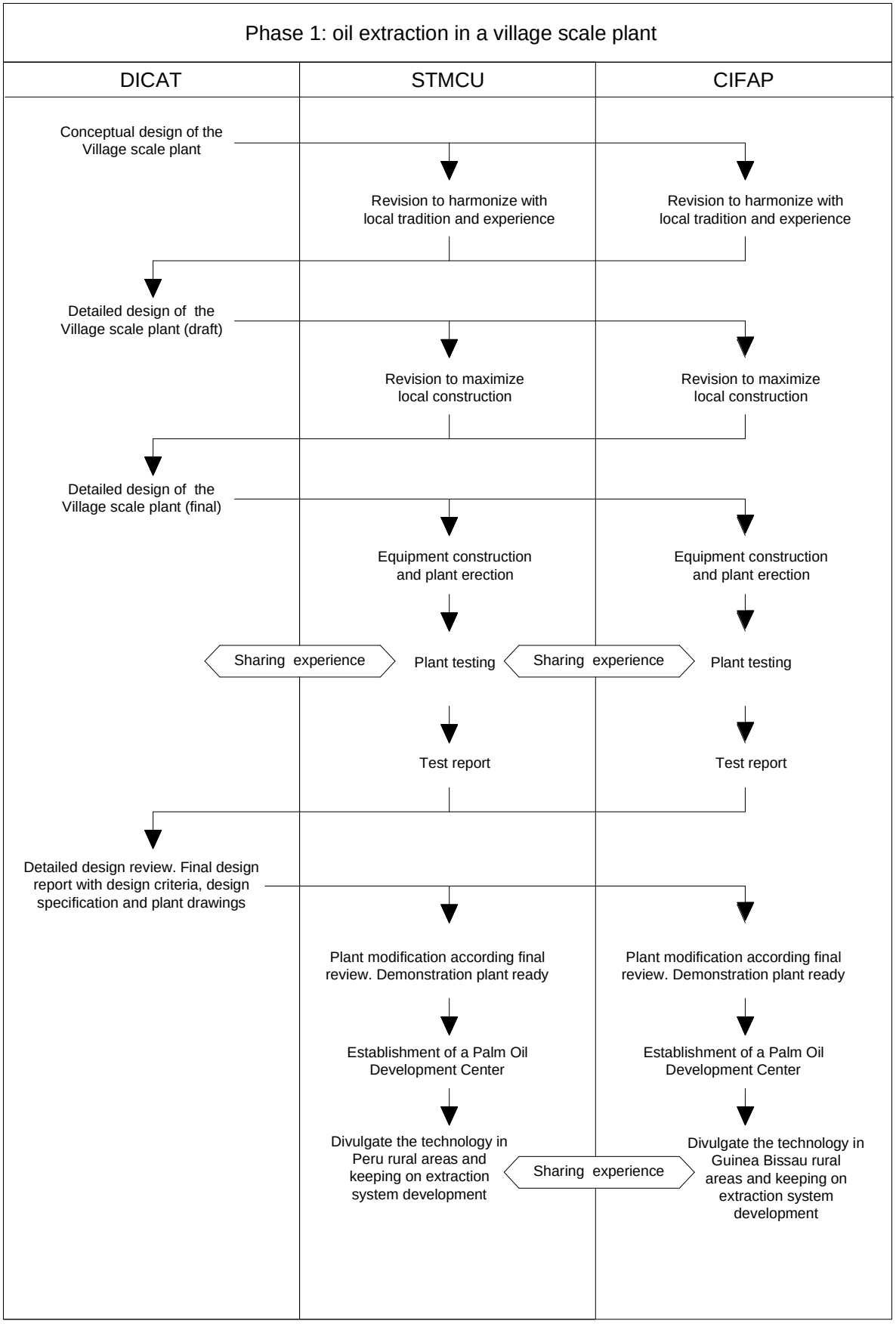
palm trees cultivation to increase the oil yield; in one word this Center is expected to become the reference point for all the villages in the Country (and may be not limited to the Country itself) in the field of the palm oil extraction and use, particularly in the use as bio-fuel. In this development, the two “Palm Oil Development Center” are planned to share their capacity, experience and innovation for mutual benefit, continuing this way the dialogue started with the Project. DICAT will continue to assist both PODC, putting on the table its analysis and design capability and experience.

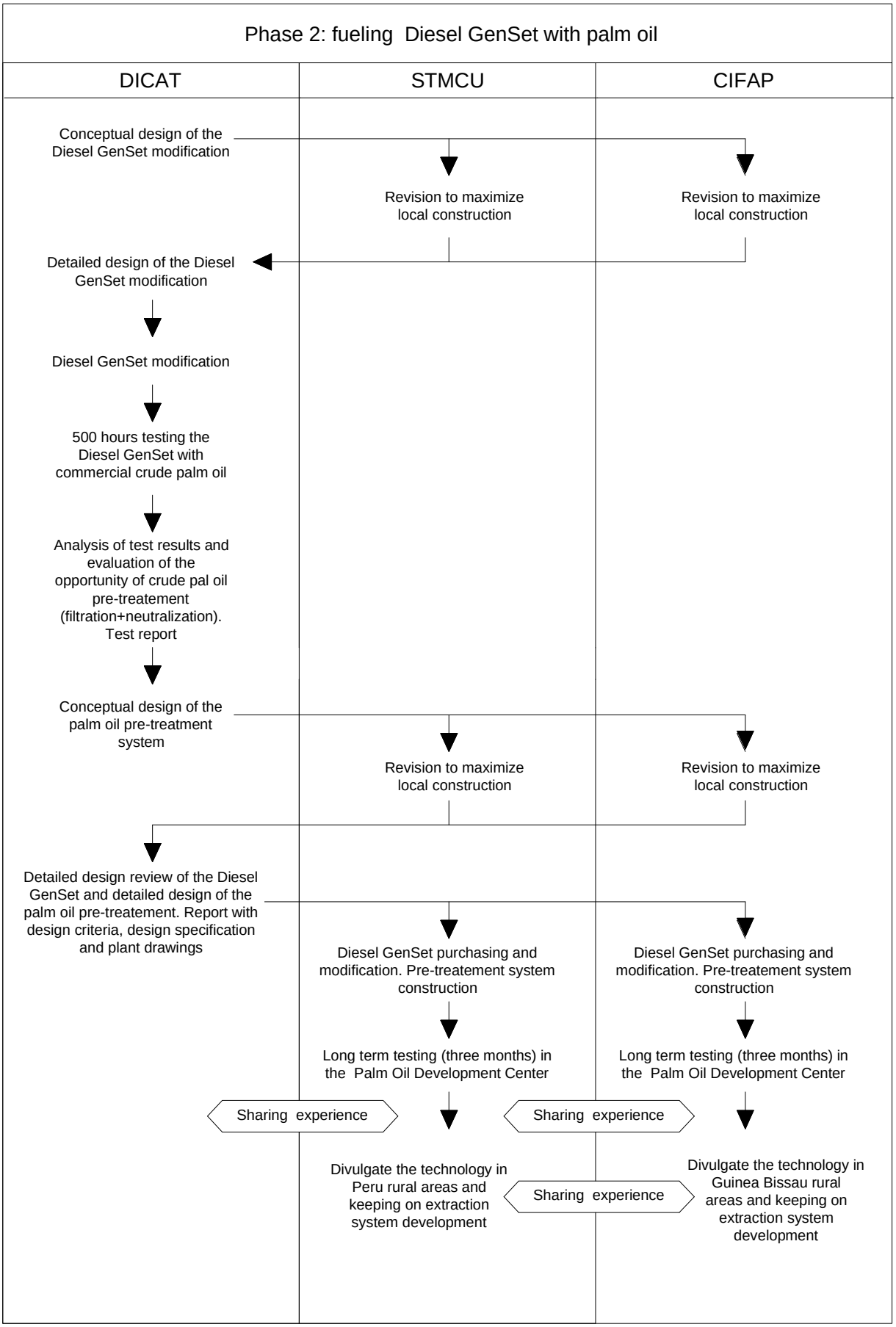
IV. Signatures of the faculty members associated with each student group

a. See Attachements.

APPENDICES

APPENDIX 1: OUTLINE OF PROJECT COOPERATION




Phase 2: fueling Diesel GenSet with palm oil
DICAT
STMCU
CIFAP
Conceptual design of the Diesel GenSet modification
Revision to maximize local construction
Revision to maximize local construction
Detailed design of the Diesel GenSet modification
Diesel GenSet modification
500 hours testing the Diesel GenSet with commercial crude palm oil
Analysis of test results and evaluation of the opportunity of crude pal oil pre-treatement (filtration+neutralization). Test report
Conceptual design of the palm oil pre-treatment system
Revision to maximize local construction
Revision to maximize local construction
Detailed design review of the Diesel GenSet and detailed design of the palm oil pre-treatement. Report with design criteria, design specification and plant drawings
Diesel GenSet purchasing and modification. Pre-treatement system construction
Diesel GenSet purchasing and modification. Pre-treatement system construction
Long term testing (three months) in the Palm Oil Development Center
Long term testing (three months) in the Palm Oil Development Center
Sharing experience
Sharing experience
Divulgate the technology in Peru rural areas and keeping on extraction system development
Sharing experience
Divulgate the technology in Guinea Bissau rural areas and keeping on extraction system development

APPENDIX 2: TECHNICAL CORRISPONDENCE

We communicated by the Mondialogo Forum sharing files, drawings and other technical correspondence between us.
Sometimes we also communicated by telephone as in Guinea Bissau is difficult to get always electricity.

APPENDIX 3: DEVELOPMENT OF IDEAS AND PROTOTYPES

Appendix 3.1: Family Scale Plant

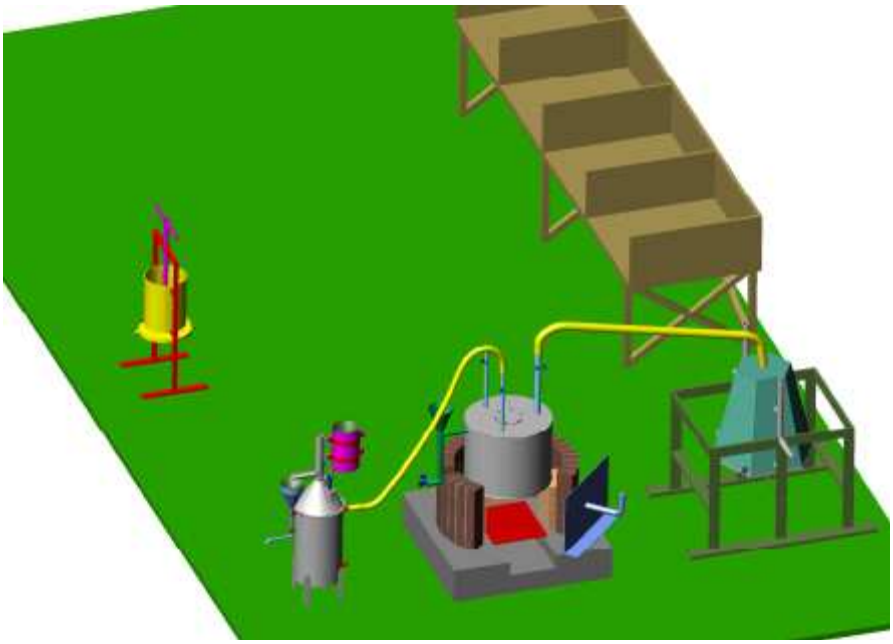
In Guinea Bissau oil extraction from Oil Palms is done according traditional system in use in the Country, sometimes different among themselves. In principle the following steps are commonly performed:

- Heating (sterilization) of fruits with water or steam;
- Digestion of the fruits;
- Reheating of the stuff resulting from the digestion;
- Oil extraction by pressing;
- Oil separation, in hot conditions, from the resulting liquid mixture.

In the family scale plant designed under the supervision of DICAT the following original ideas, in the respect of the traditional methods:

1. Using only one steam generator to heat fruits and oil separator instead having two different heat sources;
2. To use the same container to perform fruits sterilization, fruit digestion and reheating of the resulting stuff, eliminating the fruits relocations between different equipment;
3. To heat the fruits with downward steam flow (instead of upward) to facilitate air (oxygen) elimination during the fruits heating (air is heavier than steam) to reduce as far as possible fruits oxidation.

These ideas, realized, resulted in energy saving, time saving and better oil quantity (per unit of fruits) and quality.
The following drawings and pictures show the family scale plant layout and the plant during operation.



Plant Layout

Plant photo

Palm oil at the exit of the Clarifier

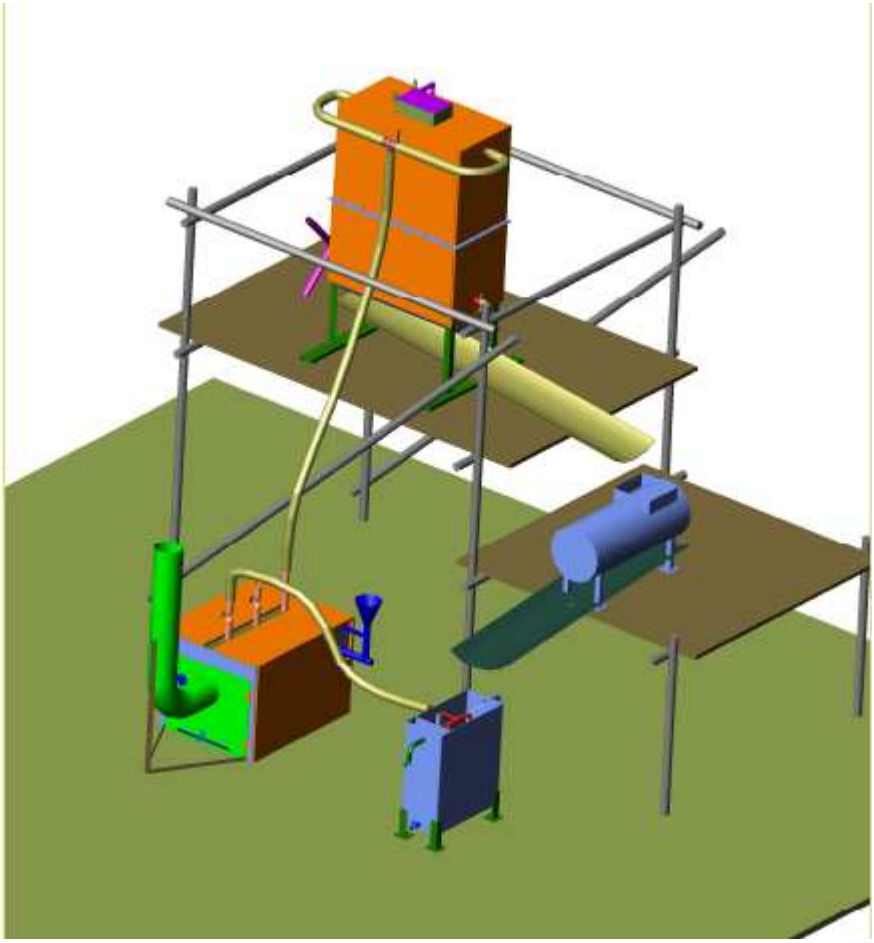
Appendix 3.2: Village scale Plant

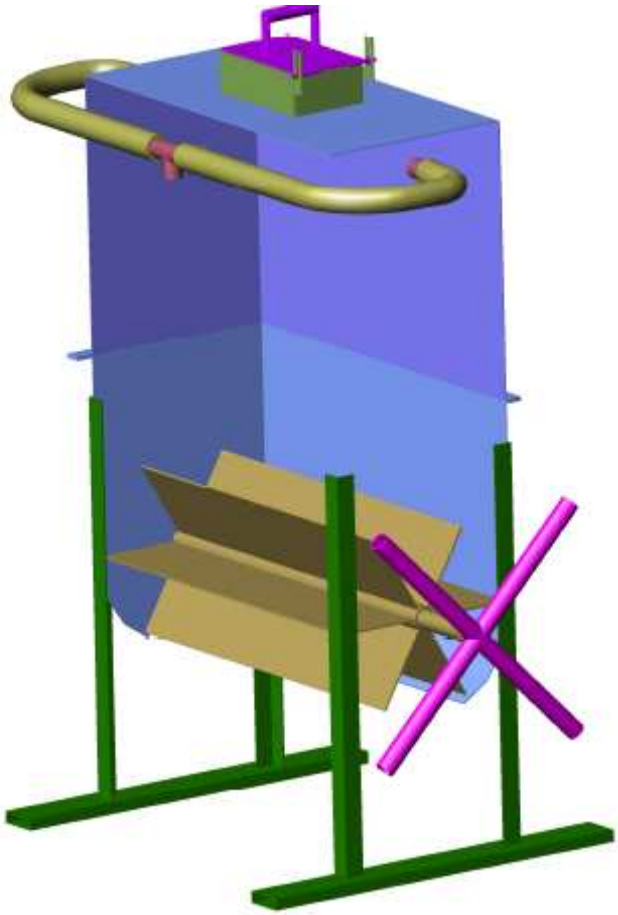
Village scale Plant is using the same concepts and unit operations than the Family Scale Plant, but it will operate continuously. It will use the following equipments:

- Steam Generator (to produce steam for the Sterilizer and the Clarifier)
- Sterilizer (sterilizing the palm fruits in continuous way
- Horizontal screw press (to extract oil from the fruits)
- Clarifier (to seoarate oil from water and solid residues)

As far as we know this is the only continuous palm oil extraction plant of a capacity around 200 kg/h.

The expected plant layout is in figure, while the key element that allows a continuous operation is the rotary valve in the bottom of the sterilizer, as illustrated in the second figure (open view of the sterilizer).
Expected benefits of the Village Scale Plant are the little dimensions of the equipment respect to the plant capacity, the reduced manpower required, the high extraction efficiency and the energy (wood) saving.



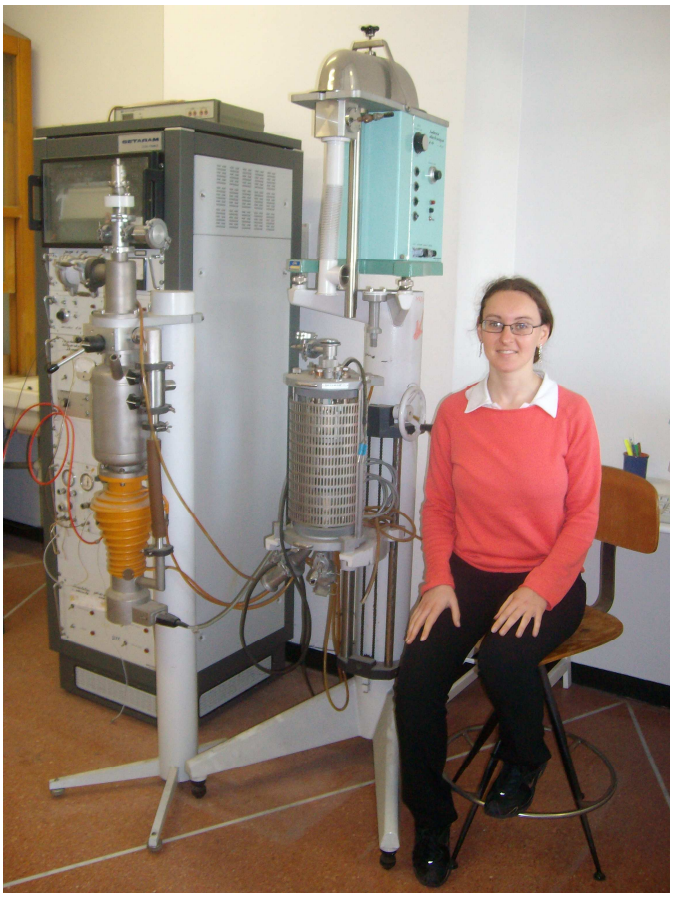


APPENDIX 4: PHOTOGRAPHS OF TEAM

Max Jorge A.Romero Rivas and Pedro Carlos Castillo Rodriguez (Peru)

Sunhana ‘Ndemi, Jackson Gomes, Domingos Alfonso Nhaga,
Julho Albino Indequi and Father Jorge (Guinea Bissau)

Giovanni Pongiglione (Italy)



Michela Mazzoccoli (Italy)