THE NoPa CASE

NEW PARTNERSHIPS FOR INNOVATION IN SUSTAINABLE DEVELOPMENT

REFLECTIONS AND ACHIEVEMENTS

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FOREWORD

Dear reader,

The *Novas Parcerias Program* – New Partnerships or, for short, NoPa – is proud to present our second publication.

In July 2014, we published The NoPa Toolbox, a practical manual for our Program and methodology. The toolbox takes a close look into NoPa and its pieces: what they do, how they work and why they work. Now, one year later, we bring you The NoPa Case. This second volume shows that the joint efforts of implementing partners, political partners, eminent scientists and end users of research results have in fact yielded concrete results and – equally important – been largely successful at promoting partnerships solid enough to go over the borders of NoPa itself and promote actual innovation for sustainable development.

We start our journey into The NoPa Case with a brief recapitulation of what the NoPa Program is and how it works; and move on to reflections of our own (the implementing partners), our research projects, and partners. The intention is to take a closer look at what has made NoPa successful and at our contribution to sustainable development.

Next, we present some of our success stories. Six research projects funded by NoPa between 2010 and 2015 showcase their work and findings.

Finally, we have asked some relevant people in the field of international cooperation how NoPa has contributed to an innovative cooperation. You will find their answers in Section Four.

We hope The NoPa Case is as useful to you as it makes us proud. Together with The NoPa Toolbox, this is a document of our experience over the last five years – one you can make your own, adapt and use to continue promoting your partnerships for sustainable development on your own field of work.

Enjoy!

CAPES | DAAD | GIZ

NoPa: an innovative model of producing and disseminating knowledge

Questions related to science, technology and innovation with Germany feature prominently in Brazilian cooperation. They can become even more prominent if barriers such as distance, financing, language and culture are removed for researchers and institutions in both countries. Another considerable challenge is involving the private sector in cooperation projects so that innovation gains more importance both on the German and the Brazilian side.

In this context, NoPa (Novas Parcerias) – a joint action of CAPES, DAAD and GIZ supported by the Ministry of Science, Technology and Innovation (*Ministério da Ciência, Tecnologia e Inovação* - MCTI) – is a modern instrument that optimizes cooperation efforts with solid methodology and large operational flexibility.

NoPa uses a set of tools that address the crucial points of bilateral international cooperation: identifying partners, structuring projects, defining eligibility criteria, obtaining seed money and disseminating results to society.

Offering a website in which researchers, companies and financing institutions publish their plans and contact details, NoPa has created an online environment in which converging interests can be identified and consolidated. In some cases, this leads to a first project draft.

It is also crucial to note that NoPa agrees its criteria with partners, focusing on the desired objective and the topics in question. Furthermore, events and technical visits organized by NoPa contribute to an exceptional matchmaking environment and result in many project proposals as well as partnerships that go far beyond the Program's own goals, mainly due to the diversity of interest groups present.

The DAAD-CAPES call for projects shows close cooperation among partners, as do the aforementioned selection criteria that are defined in collaboration with an expert group. Last, but certainly not least, NoPa also ensures the dissemination and transfer of results to the private sector. Thus, the well-to-wheel cycle of innovation is complete.

All this makes NoPa an innovative model of producing and disseminating knowledge, a model that should be followed.

Eduardo Soriano Lousada
General Coordinator for Sectoral Technologies – Ministry of Science, Technology and Innovation (*Ministério da Ciência, Tecnologia e Inovação* - MCTI)

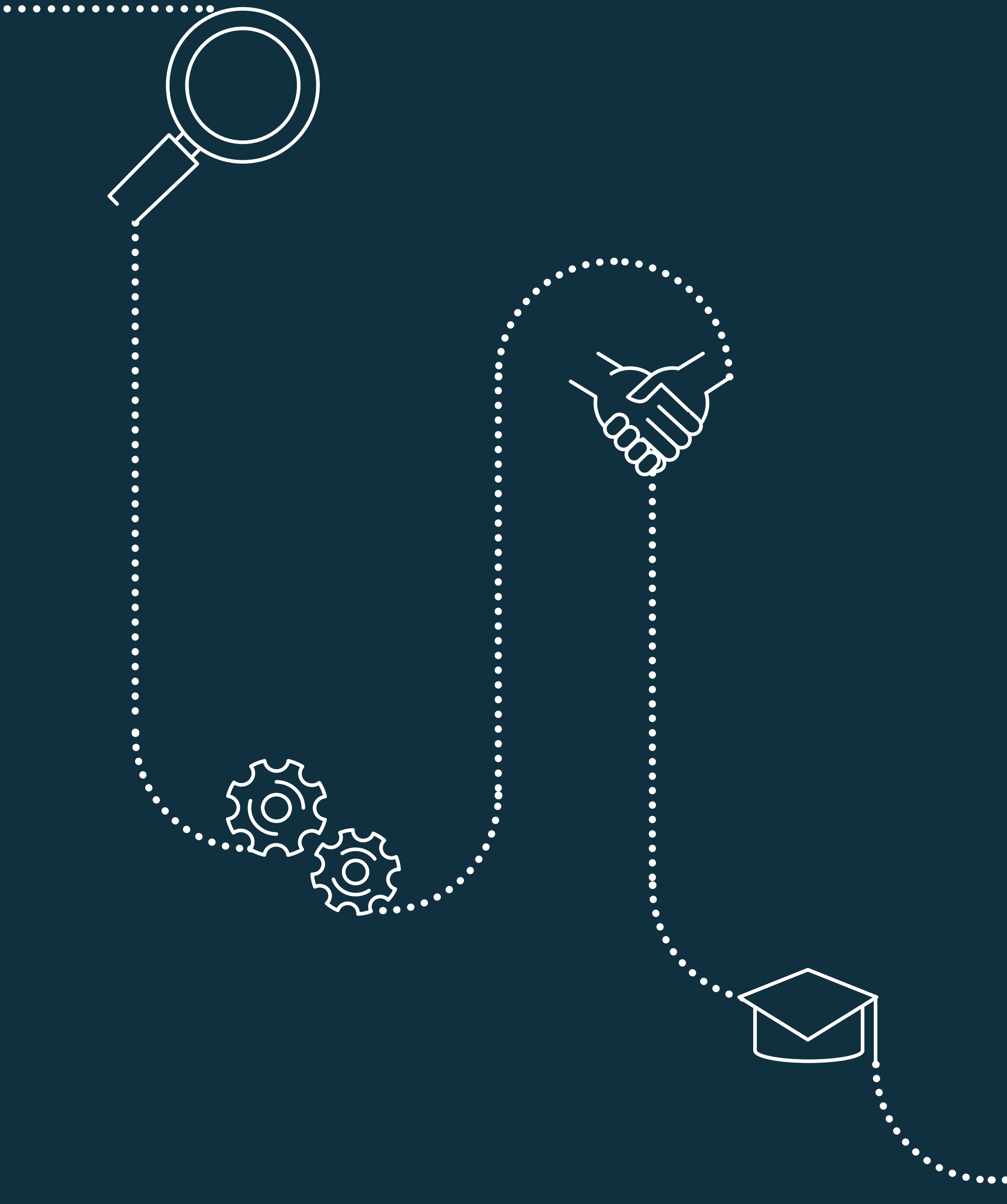
NoPa: building on the success of the Brazil—Germany Cooperation

The quest for innovation has been an important feature of the Brazil-Germany Cooperation for decades. For more than fifty years now, we have been promoting scientific exchange and technical cooperation with Germany, with excellent results for both parties. In 2010, NoPa amalgamated the achievements of these two modalities of cooperation in one – and even more innovative-Program.

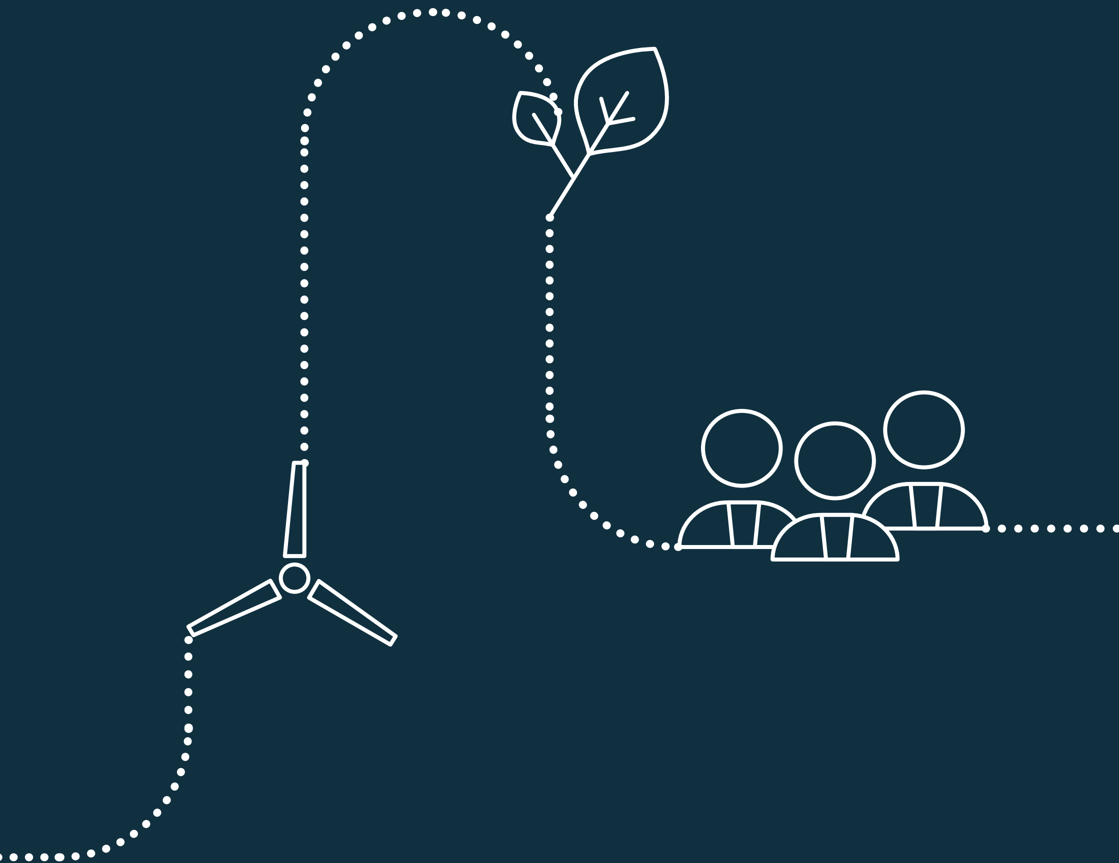
The Novas Parcerias (NoPa) Program has provided support to the Ministry of Cities and the PROBIOGAS Program (this one another initiative of the Brazil-Germany cooperation) by funding state-of-the-art research in biogas technology. This is a particularly relevant technology to Brazil since it responds to our needs in both sanitation management and renewable energies. As I write this, NoPa is selecting project proposals in the field of energy efficiency in buildings, sanitation and urban mobility – three areas of great interest to Brazil of which the last two are the responsibility of the Ministry of Cities.

In addition to an innovative approach that builds on the previous success of the cooperation between Brazil and Germany, NoPa is an important tool that taps into the capacities of the two countries to face challenges that are relevant to the entire planet, like the reduction of greenhouse gas effects. You can see concrete examples of this in this NoPa Case; and we are pleased to support this the Program.

Ernani Ciríaco de Miranda
Department of Institutional Articulation
Environmental Sanitation Secretary National
Ministry of Cities of Brazil

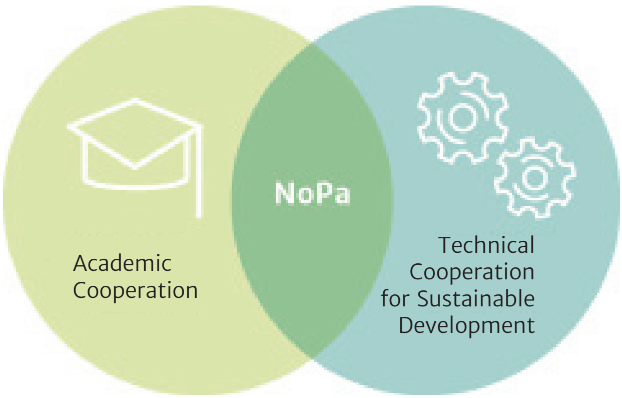


1 WHAT IS NoPa?



1.1 BACKGROUND

The Brazilian-German joint efforts to face global challenges dates back to more than five decades ago. During the 2010 intergovernmental consultations, the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Brazilian Ministry of External Relations (MRE) negotiated a joint program to foster research to meet the demands of both the private and public sectors in Brazil and promote innovation for sustainable development. The initiative was also part of the 2010-2011 Brazil – Germany Year of Science, Technology and Innovation. Baptized ***Novas Parcerias*** (New Partnerships), the new program has joined the competencies and instruments of academic cooperation and technical cooperation in an innovative cooperation modality that focused on the two theme areas of the Brazil-Germany cooperation: *Protection and Sustainable Use of Tropical Forests* and *Renewable Energies and Energy Efficiency.*



1.2 PHILOSOPHY

NoPa's primary objective is to facilitate new partnerships to promote sustainable development. To achieve that, it is essential to bring together the capacities of the players involved in the scientific and technical cooperation modalities: scientists, research funders, development agencies, government bodies, policy makers and the private sector, to name a few.

In this context, NoPa taps into the networks of both the academia and technical cooperation programs, acting as a facilitating agent between research on the one side and decision makers in policy and the industry on the other. More specifically, NoPa plans and implements concrete activities in three major areas: facilitation of contacts; communication and dissemination of project work and results; and monitoring the use of research results. DAAD and CAPES advise and support universities during the application process and throughout the duration of research projects.

1.3 PARTNERS AND THEIR ROLES

NoPa partners establish solid partnerships from the very beginning of the process as they engage their complementary competencies and capacities to promote research for innovation under clearly defined tasks and responsibilities.

Partners tap into their established procedures and complement them with innovative elements so that the results research generated under NoPa are more likely to be applicable in the industry and used by decision-makers in both policy and practice.

The program is jointly implemented by two agencies of renowned relevance in academic cooperation: the German Academic Exchange Service (DAAD) and the Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES); and the Deutsche *Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* by commission of the German Federal Ministry for Economic Cooperation and Development (BMZ). While DAAD-CAPES and DAAD-GIZ have already worked together in a variety of other programs, NoPa is the first cooperation program to bring the three institutions together.

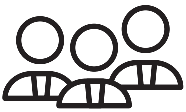
You can find more information on the NoPa partners and the cooperation structure on the **NoPa Toolbox**, Chapter I.

1.4 METHODOLOGY

NoPa's approach and methodology is, in addition to the concrete innovation generated by the research projects themselves, another important legacy of the Program. Our innovative approach relies on close interaction among the academia, the industry, policy makers, research funders and technical cooperation programs not only throughout the length of research, but also beyond it.

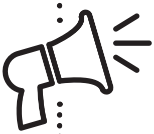
Our methodology has been tested and improved in the last five years and consists of the following instruments:

Thematic Advisory Groups (GAT)



The Thematic Advisory Groups (*Grupos Assessores Temáticos – GAT*) are a key element to guarantee the scientific research carried out under NoPa is oriented to concrete demands. The GATs gather knowledgeable representatives of the private and public sectors, the civil society, the academia and technical cooperation programs to define the specific research themes and selection criteria pertinent to NoPa's call for projects. Each field contemplated by NoPa's call for projects has its specific GAT.

Call for Projects



The NoPa Call for projects is jointly prepared by academic and technical partners according to the themes and criteria defined by the GATs. DAAD and CAPES publish the Call in Germany and Brazil, respectively, using their own information platforms and procedures.

Project proposals can be submitted 45 to 60 days from the date the Call is published.

While the Call for Projects is open, CAPES, DAAD and GIZ are available to assist candidates with information on funding, procedures and the general objectives of the NoPa Program.

Matchmaking

NoPa holds a matchmaking event soon after the Call for Projects is published. The objective is to provide potential candidates with a platform on which they can establish partnerships and draft joint project proposals.

During NoPa's matchmaking events, representatives of the private and public sectors, the civil society and the academia, from both Brazil and Germany, also have the chance to broaden their contact networks, consult the funding agencies (CAPES and DAAD) on practical matters and participate in relevant field trips and seminars.

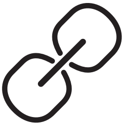
Project Selection

A joint scientific committee organized by CAPES and DAAD with the assistance of GIZ selects the research projects that will be funded by NoPa. Before the final selection by the scientific committee, GAT members are invited to make a technical assessment of the project proposals in their respective fields. The selection committee takes this technical assessment in consideration when making their final decision.

Kickoff Meeting

The selected research projects participate in a Kickoff meeting with the NoPa team, the funding agencies (CAPES and DAAD) and relevant technical cooperation partners. The objectives of the Kickoff meeting are the following:

- Introduce practical aspects of the NoPa Program;
- Clarify doubts about funding;
- Identify potential synergies among the selected research projects;
- Provide research projects with an additional opportunity to work on their planning and establish initial progress milestones; and
- Start the *de facto* interface between research projects and the Brazil-Germany technical cooperation projects by introducing the GIZ focal points.



Implementation of Research Projects and GIZ Focal Points

The implementation of the research projects continues after the Kickoff meeting. During this phase, the NoPa team, the funding agencies and the GIZ focal points provide the necessary support to the research projects.

A GIZ focal point is designated to each research project. They are key people in technical cooperation projects with solid technical knowledge and a vast network of project partners in the industry, the government and the civil society.

The GIZ focal point is responsible for the interface between the research and the relevant technical cooperation project with the objective of facilitating the translation of project results into concrete innovation for sustainable development.

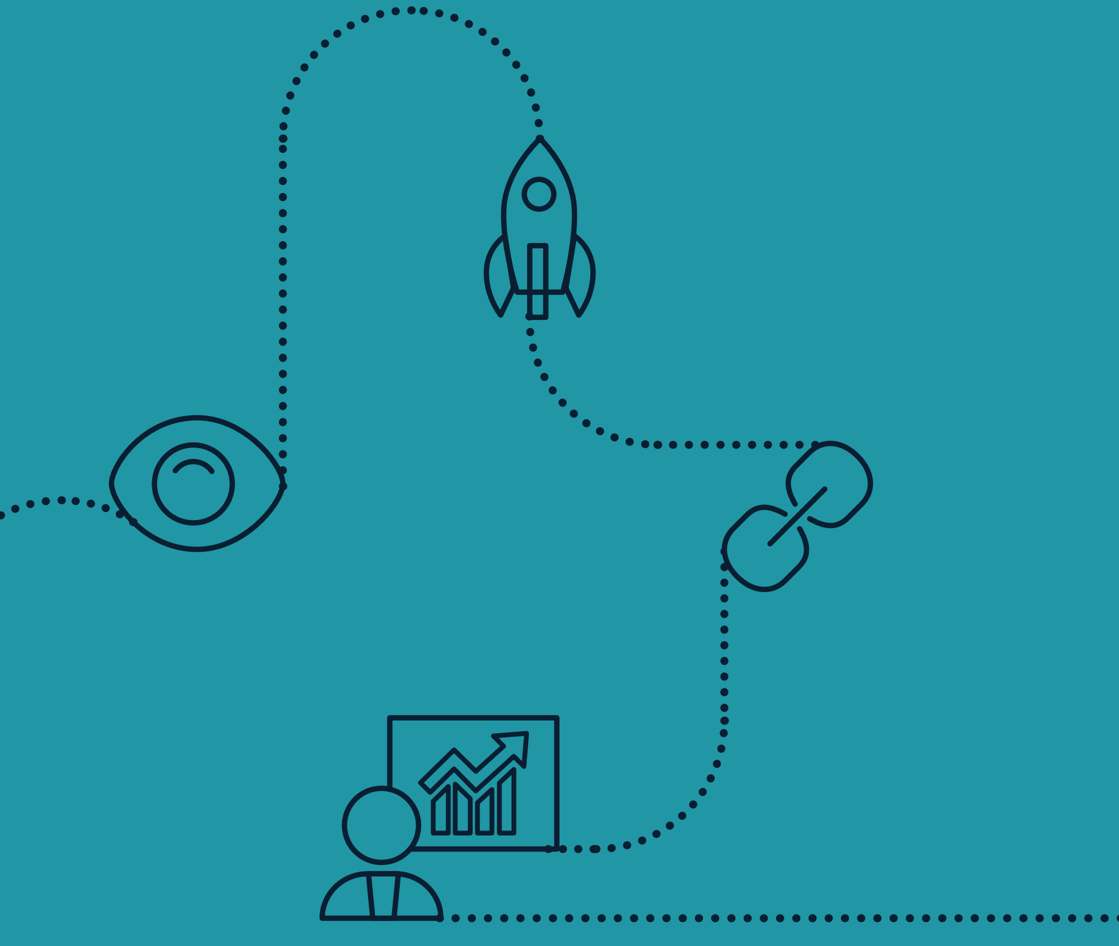
In that sense, the GIZ focal points guarantee the communication between the research project and potential users for their results. They also connect research projects and the NoPa team.

Research-into-Use (RIU) Workshop

As the research projects are closer to completion, they hold Research-into-Use workshops to present their findings to potential users, consolidate partnerships to promote the concrete application of research results and pave the way for continued cooperation. The research teams themselves carry out Research-into-Use workshops with the support of the NoPa team and the GIZ focal points.

A more detailed description of all NoPa instruments and their roles in promoting sustainable innovation can be found on **NoPa Toolbox**, Chapter II.

2 REFLECTIONS ON THE NoPa EXPERIENCE



2.1 REFLECTIONS ON THE NOPA EXPERIENCE

The importance of science and research is even greater in a globalized world that requires societies to produce more knowledge to face the challenge of sustainable growth. In this context, science and development are deciding factors for a favorable development dynamics in emerging countries. Conversely, it has become more important for developed countries to be present in the markets of the future in order to secure their own competitiveness. Thus, the relevance of cooperation among developing and developed nations is now a key factor for global development, with benefits to all the parties engaged.

While the cooperation between developed and developing countries is not a new concept, much has changed with the ascension of countries like Brazil to the position of players of greater global relevance. Rather than a mere recipient of foreign aid, Brazil has become a demanding partner that is able to choose from the range of the available international cooperation offers those that it considers more suitable to its own agenda. At the same time, the country is capable of contributing significantly with its own expertise and resources. That shifts the relation between cooperating parties from one of "donor" and "beneficiary" – or those "who know how it's done" and those who "must learn how to do it" – to one of cooperation at eye level and on equal terms.

Given the existence of a high thematic and methodical overlap between technical cooperation and scientific cooperation in Brazil and Germany, the two countries decided to promote sustainable development more efficiently and effectively through more intense cooperation.

With that in mind, during the 2010 intergovernmental consultations, the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Brazilian Ministry of External Relations (MRE) negotiated a joint program to foster research to meet the demands of both the private and public sectors in Brazil and promote innovation for sustainable development. The initiative was part of the 2010-2011 Brazil – Germany Year of Science, Technology and Innovation. Baptized ***Novas Parcerias*** (New Partnerships), the new program has joined the competencies and instruments of academic cooperation and technical cooperation in an innovative cooperation modality that focuses on the two theme areas of the Brazil-Germany cooperation: *Protection and Sustainable Use of Tropical Forests* and *Renewable Energies and Energy Efficiency*.

The NoPa Program entails rather innovative concepts as it works in the interface of technical and scientific cooperation to face global challenges and promote sustainable development:

- **Linking the instruments and competences of technical and scientific cooperation**, supporting demand-oriented research by excellent expert and research institutions;

- **A thematic focus** that supports innovation in certain areas, rather than professional education or university education in itself; and

- **A suitable alternative for future cooperation with developing countries** that considers their capacities as active partners rather than mere recipients of aid.

If the challenges inherent to such an innovative approach were great, so were the benefits to be reaped. Now, five years down the road, we have proof that it has been worthwhile: we have been able to collect a number of success stories and are ready to share them with you.

2.2 NOPA I, i-NOPA, NOPA II

NoPa's first call for projects **(NoPa I)** was published in 2010 and contemplated eight projects in the two theme areas of the Brazil-Germany cooperation for sustainable development:

RENEWABLE ENERGIES AND ENERGY EFFICIENCY	
Trustworthy and Energy-Efficient Smart Grids (TruEGrid)	TU Dresden/ Federal University of Itajubá
Energy efficiency of public buildings in Brazil	TU München/ Federal University of Paraná

Political & legal framework conditions for increasing the contribution of renewable energies and energy efficiency	Ruhr-University of Bochum/ Campinas State University
German-Brazilian Research Network on Energy Meteorology Group-Supporting the Energy Future (Energy Meteorology)	University Oldenburg/ National Institute for Space Research
Production of biodegradable lubricant oils from renewable raw materials by sustainable process	University of Tübingen/ Federal University of Ceará
PROTECTION AND SUSTAINABLE USE OF TROPICAL FORESTS	
Nanocellulose from harvesting residues: Innovative strategies to advance the sustainable use of the Amazon forests	University of Freiburg/ Federal University of Rio de Janeiro
Building partnerships and networks for the implementation of the National Plan for Promotion of Socio-Biodiversity Product Chains in the Brazilian Amazon region: Local sustainable economies and value chains of extractivist products-the case of the Brazil nut (sociobio.net)	FU Berlin/ Federal University of Para
Health enhancing local foods in Brazil-The contribution of food and nutritional sciences to Amazon rainforest sustainability: A follow-up study within an eco-nutrition approach	University of Hohenheim/ Federal University Tocantins

The projects were implemented between 2010 and 2013. In November 2013, a Final Conference gathered all projects and prospective end users in Brasilia for the presentation of research results. Potential end users for the results of all projects were engaged, with one noteworthy case: the Brazilian Energy Planning Company (*Empresa de Pesquisa Energética* – EPE), which used the first results of the energy meteorology project to forecast current energy supply and demand.

While the results of the research had only just been presented and the use might still increase in the future, we had the opportunity to learn a few lessons from the final conference of NoPa I. For instance, the alignment of research projects with technical cooperation programs could be improved, increasing the potential for future application.

In general, considering its pilot character and short period, NoPa I produced impressive outputs. On an evaluation mission performed right after the final conference, all interviewed stakeholders perceived that NoPa enriched the collaboration between technical and scientific cooperation. The value added through cooperation with GIZ was unanimously confirmed; especially the facilitation of networking, technical advice and the development of new instruments like matchmaking or installing interdisciplinary technical advisory groups (GATs) for the selection of research topics and projects.

In addition to the successful implementation of the results, this first call for projects was also a test run of the NoPa methodology. During these first five years, we have observed the methodology very closely and made the necessary adjustments and improvements. Equally important, the implementing partners CAPES, DAAD and GIZ could improve their cooperation strategy and incorporate the lessons learned to future NoPa calls.

NoPa's second call for projects built on the success of NoPa I and was integrated with two GIZ projects under the German Initiative for Climate and Technology (*Deutsche Klima- und Technologieinitiative – DKTI*) in the areas of Concentrating Solar Power (CSP) and Biogas. The second call, baptized **i-NoPa** (with the "i" standing for integrated), was published in 2013 and contemplated seven projects that were implemented between 2013 and early 2015:

CONCENTRATING SOLAR POWER (CSP)	
Thermodynamic and economic evaluation of a solar aided sugarcane bagasse cogeneration power plant	University of Duisburg-Essen, Federal University of Santa Catarina (UFSC), Federal Institute of Santa Catarina (IFSC), Federal University of São Paulo (UNIFESP), *Laboratório de Combustão e Engenharias de Sistemas Térmicos* (LabCET)
CSP TOOLS - System/grid integration of CSP, comparison and application of planning tools	University of Stuttgart, German Aerospace Center (DLR), Federal University of Rio de Janeiro (UFRJ-COPPE)
Heliothermic Energy Studies (CSP): Educational Consortium for the Integration and Sustainability in the Agro-industries	BTU Cottbus, Federal University of São Paulo (USP), São Paulo State University (UNESP), FH Aachen - Solar Institute Jülich, Industrial Solar, German Aerospace Center (DLR)

BIOGAS	
Capacity-building and fundamental research in order to develop and thus bring into service a mechanical biological treatment facility (MBT) with an integrated fermentation stage for the community of Jundiaí, SP (Brazil)	TU Braunschweig, DBFZ, Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio), Center for Research, Education and Demonstration in Waste Management e.V., Eggersmann Anlagenbau, Município de Jundiaí (SP), Universidade Anchieta Jundiaí
Desulphurization of Biogas by Adsorption and Chemical Oxidation Technologies - Development of New Materials	University of Leipzig, Federal University of Ceará (UFC)
Biogas for small Scale Power Generation (Bio-Concept)	TU Berlin, Instituto Tecnológico da Aeronáutica (ITA)
Sustainable bioeconomy in Brazil: Bioenergy from biogas using various types of waste substrates from the Brazilian bioethanol industry	University of Rostock, Deutsches Biomasseforschungszentrum (DBFZ), Helmholtz-Zentrum f. Umweltforschung (UFZ), Federal University of Goiás (UFG)

In general, i-NoPa benefitted from a methodology and a cooperation arrangement that had not only proven successful, but also been improved to better achieve the Program's general objective.

i-NoPa incorporated a number of improvements that resulted from the lessons learned from NoPa I. For instance, individual project Research-into-Use (RIU) workshops were introduced to facilitate the presentation of research results and arrangements for continued cooperation; and a kickoff meeting was created to gather all projects in one event so important information could be clarified before actual implementation began.

The implementation of i-NoPa was a success among the stakeholders, and the likelihood that project findings resulted in innovation for sustainable development was greatly improved. That gave way to the publication of **NoPa's third call for projects (NoPa II)** in early 2015. At the time of writing, 35 project proposals have been submitted and are being assessed by DAAD, CAPES and GIZ. The proposals are under the two theme areas (*Renewable Energies* and *Energy Efficiency and Protection and Sustainable Use of Tropical Forests*) and focus on the following specific fields:

- Energy efficiency in public buildings;
- Energy efficiency in urban mobility;
- Energy efficiency in sanitation;
- Land and environmental regularization; and
- Vulnerability and adaptation to climate change.

2.3 A NEW FORM OF COOPERATION

The idea of joining the consolidated expertise of both the Brazilian and German sides to facilitate new partnerships to promote sustainable development made perfect sense. DAAD and CAPES were not only recognized for their successful contribution in promoting academic research, but also boasted a history of joint achievement. GIZ, in its turn, had successfully implemented a large number of technical cooperation projects and, over decades, established a relevant network with the private and public sectors in the two countries. The cooperation between GIZ, DAAD and CAPES, however, was something new: it needed to be established from the beginning – as was the cooperation between NoPa and the existing programs of Cooperation for Sustainable Development (CSD). From the beginning, we knew there would be challenges to face.

> ***"NoPa allowed COPPE´s research team to establish fruitful and long-lasting partnerships with German research groups. It also favored capacity building between the teams."***
>
> *Alexandre Szklo, Federal University of Rio de Janeiro*

In order to guarantee the success of NoPa, it was necessary to come up with an steering framework that would allow CAPES, GIZ and DAAD to work towards a common goal while adhering to their own mandates and procedures and, most importantly, generating additional opportunities and value for the partners.

After five years of NoPa, we feel we have succeeded. Both CAPES and DAAD have managed to synchronize their funding and respond flexibly to needs within their established administrative procedures and regulations. Additionally, the three implementing partners have managed to contribute with their individual strengths in a complementary fashion.

CAPES and DAAD were responsible for supporting the researchers and for taking care of administrative issues, while GIZ was particularly responsible for providing technical advice to the researchers, developing instruments, and translating the products and findings of the projects into concrete application. The longstanding cooperation between DAAD and CAPES especially facilitated the set up and implementation of research cooperation projects in a fairly short time frame.

In cooperation with CAPES and DAAD, GIZ also organized events like dialogue meetings with stakeholders, project kickoff meetings, final project conferences and research-into-use workshops. These events were key to enable researchers to receive orientation for their work and to offer in return new results and insights, which were useful for practitioners when implementing policies and developing sustainable business solutions.

GIZ has also provided research projects with advice to develop communication strategies to convey their message to the non-academic audience – who were, after all, the bulk of the end users of their research results.

As a result, NoPa boasts good reputation and great visibility among Brazilian and German partners, who recognize its achievements and benefits. Partners particularly appreciate the cooperation on equal terms, the joint definition of research needs, and the facilitation of international exchange. NoPa is acknowledged as a pioneering initiative that established new structures at the interface of scientific cooperation and technical cooperation. Together, we have successfully built on the competences, expertise and mechanisms provided by relevant Brazilian and German organizations.

NoPa's primary objective is to facilitate new partnerships that promote sustainable development. To achieve that goal, it was necessary to tap into a complex network of partners and stakeholders that consisted of scientists, research funders, development agencies, government bodies, policy makers and the private sector.

> ***"DAAD provided for consistent, hassle-free preparation and implementation of the project."***
>
> *Jörg Hoffmann, University of Leipzig*

Such a complex pool of stakeholders was a challenge in itself. Each had their own interests, worked according to their own internal procedures, existed within their own cultural framework and spoke their own language. To make the challenge even more interesting, they were in countries as diverse and complex as Brazil and Germany. To focus on a common goal, we have tapped into the networks of both the academia and technical cooperation programs, acting as a facilitating agent between research on the one side and decision makers in policy and the industry on the other.

> *"NoPa did not only help us to link with a partner, but was a stepping stone for future collaboration, as we made valuable contact with local companies willing to support and develop research activities in our field of interest."*
>
> *Jan Mihalyovics, TU Berlin*

More specifically, NoPa has planned and implemented concrete activities in three major areas: facilitation of contacts; communication and dissemination of project work and results; and monitoring the use of research results. In that context, DAAD and CAPES have advised and supported universities during the application process and throughout the duration of research projects.

2.4 INTEGRATION WITH PROJECTS OF COOPERATION FOR SUSTAINABLE DEVELOPMENT

Another significant challenge for NoPa had to do with connecting scientific research with the existing projects of the Cooperation for Sustainable Development implemented under the Brazil-Germany partnership in two major theme areas: *Protection and Sustainable Use of Tropical Forests* and *Renewable Energies and Energy Efficiency.*

Having implemented technical cooperation projects with Brazilian partners for five decades, GIZ has become part of a vast network of experts and decision makers from both the public and the private sectors in the country. GIZ then played a key role in facilitating contacts between these partners and the researchers, as well as in bringing on board relevant actors of its Technical Cooperation Programs in Brazil.

To guarantee the best connection among the research projects, the technical cooperation programs and their relevant networks, GIZ appointed **focal points** to each research project. The focal points were GIZ personnel in technical cooperation projects with solid technical knowledge and a vast network of project partners in the industry, the government and the civil society. They were responsible for the interface between the research and the relevant technical cooperation project with the objective of facilitating the translation of project results into concrete innovation for sustainable development.

While designating focal points to each individual research project was a very successful initiative, it was not one without challenge. It was necessary that the focal points themselves and the research projects worked as an effective interface with technical cooperation programs, and that their different perspectives of what "research", "application" were could be translated into a common language. This was improved along the implementation of NoPa I and i-NoPa; and has resulted in a practical manual to the focal points for NoPa II.

Another important point of connection between NoPa and the technical cooperation programs were the **thematic advisory groups** (GATs). The GATs gathered knowledgeable representatives of the stakeholders in the broader research areas contemplated by NoPa to define the specific research themes and selection criteria pertinent to the call for projects. Each field contemplated by NoPa's call for projects had its specific GAT.

In addition to the private sector, policy makers, the academia and the civil society, the technical cooperation programs also appointed representatives to the GATs of their respective areas of interest. In that sense, the GATs played an important role

"The focal point provided the network with valuable support along the project including facilitating us further contacts, enriching even more the partnership created."

Cynthia Guerrero, BTU Cottbus

in not only guaranteeing that NoPa research projects were oriented to actual demands, but also in assuring the integration of scientific cooperation and technical cooperation from the very beginning of the NoPa process.

2.5 INTEGRATION AMONG PROJECTS AND WITH USERS

After the successful implementation of the first NoPa research projects, we set out to further improve the synergies not only between research and technical cooperation, but also among the research projects themselves. The **NoPa Kickoff Meeting** was then introduced with i-NoPa.

The kickoff meeting took place at the beginning of the implementation of the research projects and gathered researchers, the NoPa team, the funding agencies (CAPES and DAAD) and relevant partners from the GIZ technical cooperation, with the purpose of aligning the research projects towards the achievement of the NoPa objective at the earliest stages of the research work.

The kickoff meeting proved itself an excellent opportunity to introduce the GIZ focal points to their projects (and vice-versa) and to shed light on their roles and responsibility along the development of the research. The most important objective of the kickoff meeting was to have projects come up with research-into-use indicators against which they could measure their success in achieving NoPa's general objective.

> ***"She [the focal point] was an efficient mediator between our team and the other stakeholders of the Program. She was also available to support the project."***
>
> *Alexandre Szklo, Federal University of Rio de Janeiro*

Additionally, as all selected research projects were for the first time together in one specific event, the kickoff meeting was the perfect time to bring them all up to speed regarding the NoPa methodology and general goals. Research projects and their respective focal points could then start planning their activities in alignment with what was expected from them at the end of the process. Equally important, the kickoff meeting gave projects an opportunity to identify potential synergies among themselves, pave the roads for new partnerships and increase the potential of their contribution to sustainable development.

The kickoff meeting has been perceived as a very positive instrument by the vast majority of both researchers and technical cooperation partners, but improvements are already in store for NoPa II. One of them consists of having more representatives from the industry, government and the civil society – potential users of research results – participate in the kickoff meeting to guarantee their engagement with the projects from the earliest phases of implementation.

"The methodology suggested by i-Nopa was well understood. In this occasion the milestones of the project were agreed and also some of the technical details of the project. The exercise realized by the GIZ staff had a positive impact on the project planning and schedule."

Edson Bazzo, Federal University of Santa Catarina

2.6 STREAMLINING RESULTS INTO CONCRETE INNOVATION

In spite of NoPa's successful approach, making sure the results achieved by the research projects were converted into concrete applications and actual innovation has been the greatest challenge we've faced – and the reason for our tireless quest. Part of the question has to do with the nature of science itself: it is about the questions rather than about the answers, and as such, it will rarely provide a *prêt-à-porter* solution as a result. As a matter of fact, it is not uncommon for scientific investigations to produce further questions as opposed to answers. Another challenging factor is that the road from research to application is a long, winding one that can hardly be covered in the few months of a NoPa research project's life span.

The question remained: how could we increase the likelihood that the findings of NoPa's research projects were actually put to practical use and eventually contributed to sustainable development?

One of the answers to that question was an instrument introduced by i-NoPa: **the Research-into-Use Workshop**. As the research projects neared to completion, they held Research-into-Use workshops to present their findings to potential users, consolidate partnerships to promote the concrete application of research results and pave the way for continued cooperation. The GIZ focal points, who played a key role in connecting the research projects with those potential users in the public and private sectors throughout the entire implementation phase, were once again an essential piece of the RIU workshop. They provided technical advice, offered their networks and followed up on the developments of the cooperation between researchers and end users even beyond the completion of the projects.

While the projects themselves had to organize and implement their respective Research-into-Use workshops, they counted on the support of the NoPa Team for the methodology and documentation.

"The RIU workshop was important to have an overview of the total project results and to promote the interaction with other institutions for the future, the guarantee of project continuity."

Christiane Pereira, PUC Rio de Janeiro

Virtually every NoPa research project established contacts with end users from both the private and public sectors during the implementation phase and the Research-into-Use workshops. This is a major success factor as it is an essential element to connect research results and concrete applications. However, in some cases, there is a challenge in promoting a more intensive involvement of the private sector or even an uptake of the results generated by the projects. Considering the complexities inherent to the process of transferring research results into actual innovation for sustainable development, there is always the risk that cooperation remains punctual, or that initially interested companies withdraw from the process altogether. Bearing that in mind, special emphasis was placed on agreements for continued cooperation during the RIU workshops, and the GIZ focal points were called to provide additional support and follow up to make sure the partnerships between researchers and end users remain active beyond the NoPa research projects.

2.7 BEYOND NOPA

After five years and three calls for projects, the NoPa Program boasts not only excellent results by the research projects it funded, but also improved concepts and methodologies that have increasingly called the attention of other players in technical and scientific cooperation.

It is our understanding that the experience we have amassed is, in addition to the NoPa project results, an innovative contribution to sustainable development.

Our best practices include demand-orientation of the research cooperation projects, matchmaking events, calls for proposals and selection of the projects, synergies with technical cooperation programs, and a manual with practical advice for research project management, to name a few.

NoPa's best practices have been documented in fact sheets and presentations explaining the model and the tested instruments, two publications (*The NoPa Toolbox* and this one, *The NoPa Case*), an institutional video and a functional website that has been an important means of communication with our stakeholders. All these are tools we make available to the parties interested in adapting and using the NoPa methodology in their respective contexts.

The following partners and stakeholders have already used the NoPa model for future research or cooperation:

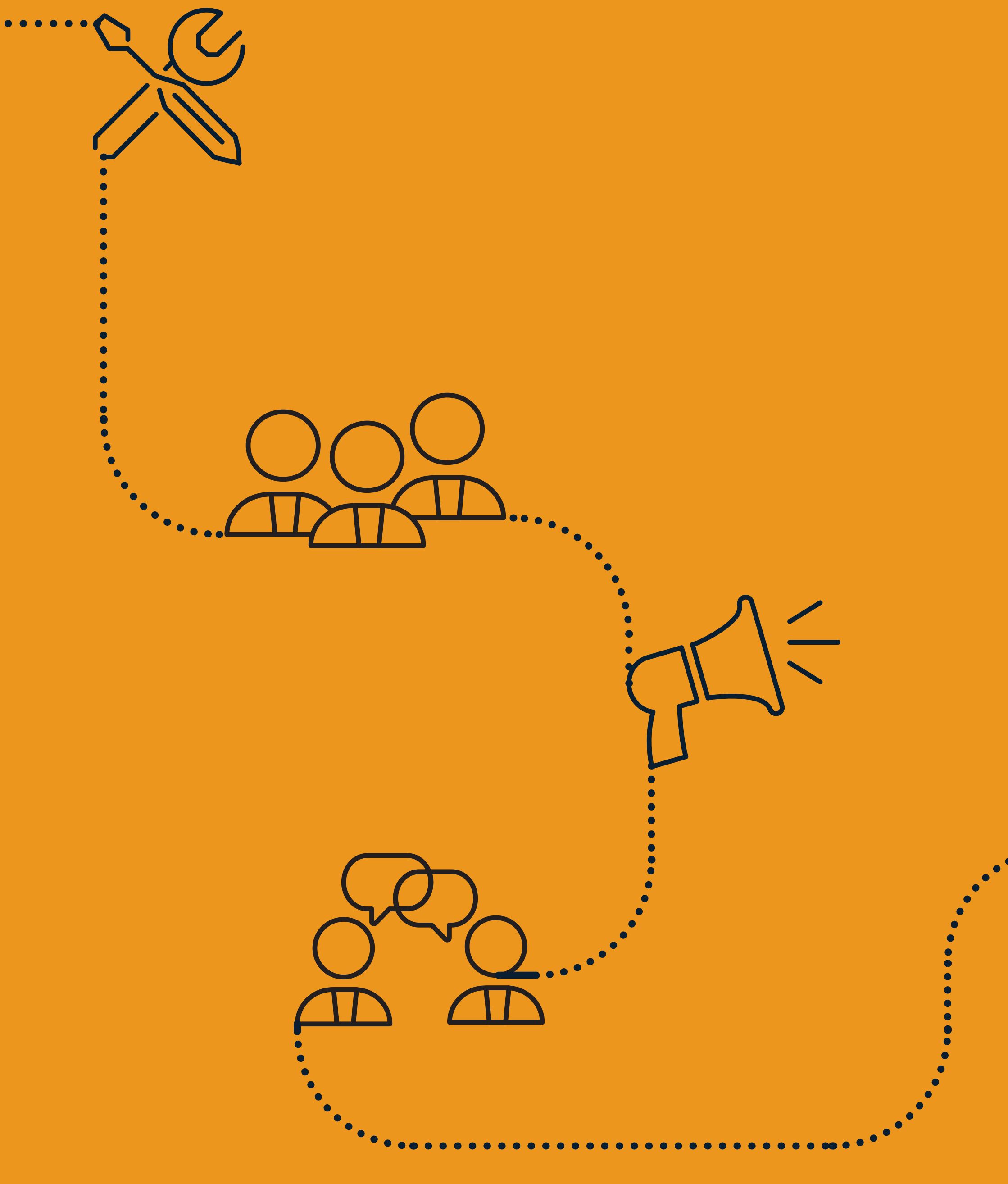
- **The Brazilian ministries MMA (Ministry of the Environment)** and **MDA (Ministry for Rural Development)** have held matchmaking events for researchers, politicians and practitioners in the area of "sustainable value chains for products of Brazilian socio-biodiversity". The objective of these events was to establish public private partnerships, with the participation of science.

- **The Brazilian Ministry for Science, Technology and Innovation (MCTI)** now applies NoPa’s use-oriented selection criteria in current calls for proposals in the area of renewable energy.

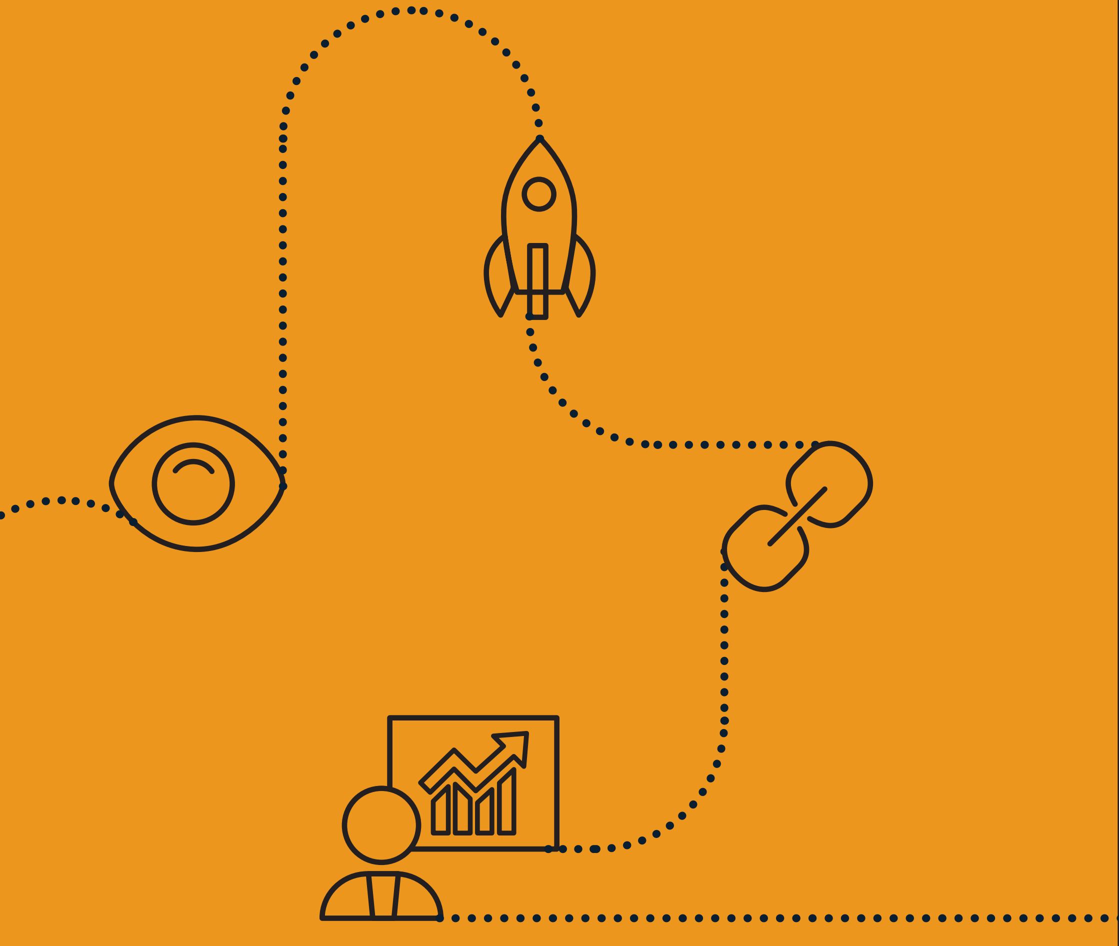
- **FINEP** (*Financiadora de Estudos e Projetos* or Funding Authority for Studies and Projects), an organization of the Brazilian federal government under the Ministry of Science of Technology devoted to funding of science and technology in the country, has been experimenting NoPa’s matchmaking concept.

Generally, NoPa’s model and its instruments are received with great interest among partners of both technical and scientific cooperation in Brazil as well as in other countries.

NoPa’s experiences and achievements have been discussed in various events taking place within the framework of the German Year, such as the regional Ecogerma in Belem, and Brazilian institutions like the energy provider CEMIG, or BNDES, the National Development Bank, have requested further information on NoPa and its instruments. Technical cooperation programs elswhere in the world have also manifested their interest in adapting and adopting some NoPa instruments in their own work.



3 SUCCESS STORIES – PROJECTS



NOPA SUCCESS STORIES

CONCRETE RESULTS OF THE BRAZILIAN-GERMAN NEW PARTNERSHIPS BETWEEN 2010 AND 2015

Brazil needs innovative solutions to face global challenges in climate change and biodiversity protection without endangering economic growth and social progress. One of the most populous countries and the sixth largest economy in the world, Brazil ranked 61 of 142 in the Global Innovation Index 2014. It can improve this position by enhancing international cooperation and intensifying collaboration between research and practice, taking advantage of the excellent research institutions and universities already existing in the country.

In this context, practice-oriented research that builds on collaboration with public and private sector partners offers great potential for innovation. In addition, this innovative form of cooperation can help Brazil meet its own climate protection goals more rapidly. These include reducing harmful greenhouse gas emissions by protecting biodiversity and tropical forests, and using more renewable energy sources and technologies to boost energy efficiency.

Between 2010 and 2015, the NoPa Program funded 15 research projects that combine a results-based focus with practical application: three in the theme area Protection and Sustainable Use of Tropical Forests and twelve in the theme area Renewable Energies and Energy Efficiency. Additionally, a third call for projects in both theme areas was published in early 2015. In the last five years, NoPa has promoted new partnerships between 46 Brazilian and German universities and engaged 55 partners from the public and private sector as well as the civil society.

Practice-oriented research has been the focus of NoPa since the beginning. All projects cooperated with partners from practice and society in order to apply research results and foster concrete innovation on the ground. We are glad to present a selection of four projects and their concrete results in a variety of fields related to the German-Brazilian Cooperation for Sustainable Development. In each of them, there are examples of how results are being applied, translated into practice and developed further.

Puxirum: Value Chain of the Brazil Nut

The Puxirum research project analyzed the value chain and local production of Brazil nuts in Brazilian Amazonia. It was implemented by the Free University of Berlin, the Center of Higher Amazonian Studies (*Núcleo de Altos Estudos Amazônicos* – NAEA), the Federal University of Pará (UFPA), the Federal University of Western Pará (UFOPA), the Federal Rural University of Amazonia (UFRA) and the University of Southern Denmark. As a direct result of the project, a Technological Extension Center (Núcleo de Extensão Tecnológica – NEXT) was established and received five years' funding from the State Secretariat for Science, Technology and Innovation (*Secretaria Estadual da Ciência, Tecnologia e Inovação* - SECTI), a partner from the public sector. Moreover, a governance committee for the value chain of Brazil nuts was put in place in the municipalities of Oriximiná and Óbidos in the Brazilian state of Pará. The hand press developed by the project to produce briquettes from Brazil nut residues is still being used in the village of Oriximiná.

CSP Tools

Thanks to high levels of solar irradiation and favorable geographic conditions, Brazil has great potential for harnessing solar thermal energy through Concentrating Solar Power technology (CSP). In this project, partners from the University of Stuttgart and the Federal University of Rio de Janeiro (UFRJ) developed a model for integrating CSP into Brazil's energy matrix and formulated concrete recommendations for policymakers and industry. These recommendations are already causing measurable impact on the ground: the Brazilian Energy Research Institute (*Empresa de Pesquisa Energética* – EPE) has recently adopted the soft-linked model approach developed by the project partners in their work. Furthermore, the German Aerospace Center (*Deutsches Zentrum für Luft- und Raumfahrt* - DLR) also continues to cooperate with the project partners to apply and develop the new model. In addition, the Brazilian National Electric Power Agency (*Agência Nacional de Energia Elétrica* - ANEEL) and the energy company *Companhia Hidro Elétrica do São Francisco* (CHESF) are working together to further develop the project's model for CSP plants.

Energy Efficiency in Public Buildings in Brazil

The harmonization of energy efficiency and the preservation of architectural heritage is a challenge that, in Brazil, takes on characteristic features as the country has public architecture built mainly in the 1960s and. In this context the Federal University of Paraná (UFPR), the Federal University of Rio de Janeiro (UFRJ) and the Technical University of Munich realized a joint research project on efficient energy use. Therefore two buildings were adopted as case studies of architectural heritage and energy efficiency: the Polytechnic Center in Curitiba (Paraná), and Block C of the *Esplanada dos Ministérios*, in Brasília (Federal District). The project comes to the conclusion that there is a real possibility of making these buildings efficient by recovering the original design. Other efficiency gains are expected from new conditioning and lighting technology. These results and their future implementation were discussed with the project partners.

A German-Brazilian Research Network on Energy Meteorology

In order support the Brazilian and German aims to develop renewable energies, the National Institute for Space Research (INPE) and the University of Oldenburg established a research partnership in Energy meteorology which is strongly directed towards a sustainable research and development (R&D) infrastructure. The German-Brazilian network currently carries out studies for Brazilian and German institutions and companies. Through the research stays of two PhD students from INPE at Oldenburg University a significant transfer of methodologies could be achieved while simultaneously valuable feedback of research requirements from Brazilian applications was given. The Brazilian Energy Research Institute (EPE) added the developed projection methods for energy demand and offer to their own projection mechanism and is currently applying them. Another major aim was working towards joint German-Brazilian cooperation in a larger R&D project which led to a workshop in December 2013 in Recife in collaboration with Brazilian power company *Companhia Hidro Elétrica do São Francisco* (CHESF).

Solid Waste Management in Jundiaí

This project focused on sorting and managing solid waste for the generation of biogas. It was conducted in partnership between Brazilian and German universities (Technical University of Braunschweig, Pontifical Catholic University of Rio de Janeiro, and Anchieta University of Jundiaí) and the municipality of Jundiaí in the state of São Paulo. An evidence-based detailed method for solid waste management and electricity generation was developed, the first of its kind in Brazil. Additionally, the Center for Research, Education and Demonstration in Waste Management (CREED Brasil) for technological capacity building was inaugurated during the project and will continue to promote waste management across the country. Moreover, the municipality of Jundiaí formed a working group composed of actors from various key sectors to continue binational cooperation and to put research findings into practice.

Cogeneration Plant Using Sugarcane Bagasse

During the harvest season, Brazil's sugar and alcohol industry generates electricity in cogeneration plants fuelled by sugarcane bagasse, the fibrous residue of sugarcane juice extraction. This research project conducted by the University of Duisburg-Essen, the Federal University of Santa Catarina (UFSC) and the Federal University of São Paulo (UNIFESP) studied the possibility of integrating solar energy into these cogeneration plants. This would extend electricity generation across the entire year – and not only from April to December, the harvest season, when sugarcane bagasse is readily available. The project resulted in concrete technical recommendations and economic assessments of different options available for constructing a solar-aided cogeneration plant. A pilot plant is currently being constructed by the companies TGM Turbinas and Valmont, and by the charitable association of the coal industry of Santa Catarina (*Associação Beneficiente da Indústria Carbonífera da Santa Catarina* - SATC).

Puxirum

Strengthening Brazil Nut Value Chains in the State of Pará, Amazon

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University of Southern Denmark.

ABSTRACT

To support those people who care for the forest and use the forest in a sustainable way by gathering its products without destroying it is considered an effective measure to protect tropical forests. Gathering (or "extracting") products from the forest which are not wood – so called non-timber-forest products (NTFP) – is considered an economic activity which helps to make a living for forest users, often traditional or indigenous groups. Strengthening forest extractivism could thus galvanize the 'valuing', and protection, of biodiversity as well as the survival of and respect for the diversity of social and cultural traditions – so called sociodiversity. Therefore, in 2009 Brazil implemented the National Plan for Promotion Socio-Biodiversity Product Chains (*Plano Nacional de Promoção das Cadeias de Produtos da Sociobiodiversidade* – PNPSB, also called Plano SocioBio) as one measure towards the goal to protect the Brazilian Rainforest.

The *Puxirum* project aimed at providing constructive inputs for strengthening Brazil nut value chains, particularly in the Calha Norte region, while contributing to enhance NTFP management in line with the PNPSB. As a result, we recommend concerted simultaneous action in all sectors along the value chain, strong political commitment to supporting the NTFP sector, and strengthening existing networks and initiatives on NTFP in Brazil, mainly to enhance knowledge management.

In order to put these recommendations into practice, a Center for Technological Extension (*Núcleo de Extensão Tecnológica* – NEXT) was established during the project and received funding for five years' operation from the public sector partner *Secretaria Estadual da Ciência, Teconologia e Inovação* (SECTI). Furthermore, the Amazon municipalities of Oriximiná and Óbidos formed a joint governance commission on the Brazil nut value chain in order to discuss joint actions. Moreover, a manual press to produce briquettes from nut residues, developed within the framework of *Puxirum*, is still being used in the municipality of Oriximiná.

The point of departure of this article is a brief reasoning and description of what the *Puxirum* project was about and where its studies were mostly conducted (1). The main problems of the Brazil nut value chain in the Calha Norte region are then presented (2.1), as they shape the

scope for the design (using a transdisciplinary approach) and operation (employing a multi-sectorial and multi-scalar approach) of the project (2.2). Subsequently, the highlights of Puxirum's outputs and impacts (2.3) provide the groundwork for key policy recommendations (3).

1. THE PROJECT IN A (BRAZIL) NUTSHELL

The project was first formally named "SocioBioNet Project"1. Yet, from the kick-off meeting on, project members collectively called it *Puxirum*, which means joint action in the local colloquial language.

Why is a project for building networks needed in order to foster socio-biodiversity value chains? Because reconciling local development and forest conservation depends mainly upon identifying common challenges and goals, as well as synergy potential between forest user groups (e.g. the *Cooperativa Mista Extrativista dos Quilombolas do Município de Oriximiná* - CEQMO and Brazil nut extractivist associations), firms and service providers – including government entities e.g. *Instituto de Desenvolvimento Florestal* (IDEFLOR) within PNPSB, NGOs like the *Instituto de Manejo e Certificação Florestal e Agrícola* (IMAFLORA) and international cooperation agencies such as *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* – for achieving mutual beneficial outcomes such as sustainable rural development. Reaching this goal depends largely upon people within institutions exchanging knowledge, experience and acting collectively – *Puxirum* – to achieve mutual benefits based on the inclusive development of value chains of socio-biodiversity products, including Brazil nut.

The project focused on linking ongoing initiatives from actors of various sectors of society that are involved in improving the exploration, processing and marketing of NTFP, especially Brazil nut, as well as in researching or 'co-developing' reasonable strategies to strengthen sustainable management initiatives focused on the use of NTFP in the Brazilian Amazon region.

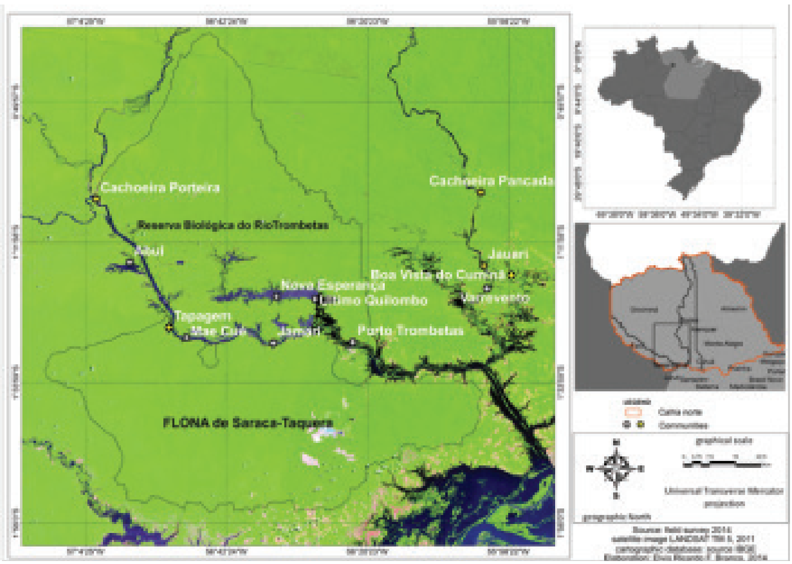
In order to enhance communication, discussions, coordination and

[1] Integral project title: "Building partnerships and networks for the implementation of the National Plan for Promotion of Socio-Biodiversity Product Chains in the Brazilian Amazon region: Local sustainable economies and value chains of extractivist products – the case of the Brazil nut (sociobio.net)"

cooperation, a series of specific workshops at the local, regional and national level were held to stimulate the construction of reliable and sustainable networks and partnerships, intending to bundle existing experiences and information as well as to develop new and innovative mechanisms, which support the implementation of the PNPSB.

The content of the workshops varied from topics related to problems of production, logistics and marketing on local level, e.g. good production methods and certification, as well as new sub-products such as Brazil nut briquettes. Challenges and potentials of the implementation of PNPSB were discussed at regional level in a conference, as were possibilities of developing a given local cluster of Brazil nut production (*Arranjos Produtivos Locais* – APL) in a smaller workshop. Other crucial project activities were networking of scientists via academic conferences and a local workshop with local stakeholder in order to establish a coordination structure for the strengthening of a Brazil nut cluster in the region of Calha Norte in the West of the Brazilian state of Pará.

Several workshops and scientific studies took place in the Calha Norte municipalities of Óbidos and Oriximiná, especially in *Quilombola* communities, which are mainly involved in Brazil nut gathering in this territory (cf. figure 1).



Source: Elvis Ricardo F. Branco 2014

Figure 1: Quilombola Communities in Calha Norte Region, Pará: Focos study area from the Puxirum project with high concentration of Brazil nut stands

2. CHALLENGES OF THE BRAZIL NUT VALUE CHAIN, PROJECT APPROACH, OUTPUTS AND IMPACTS

Chapter 2 starts with problems that affect Brazil nut value chains and NTFP management in the Brazilian Amazon Region, including challenges identified at the local and regional level (2.1). These build up the key pillars for elaborating on *Puxirum*'s approach (2.2), which leads to the main products of the project and its impact (2.3).

2.1 CHALLENGES OF THE BRAZIL NUT VALUE CHAIN IN THE BRAZILIAN AMAZON REGION

Increasing deforestation in the Amazon, especially on the interface of the biomes Cerrado and Amazon region, particularly in the 1990s and 2000s, caused by extensive cattle ranching (1998-2008: 70-80 per cent of deforestation in the Brazilian North region, Nepstad et al. 2008) and monocultures (e.g. large scale soybean and, in recent years, oil palm plantations, cf. Backhouse, 2013), calls for strengthening more environmentally as well as socially sound economic sectors. As the Brazilian Amazon has long been exposed to these challenges, the government has started to face them based on demands from social movements, including social-environmental NGOs as well as development agencies to address alternatives for inclusive sustainable development. Although far from a shift in investment priorities for land use, the government of Brazil started to recognize and promote the potential that lies in the extractivism of NTFP, not only for conserving the Amazon forest, but also for sustainably managing the so called socio-biodiversity – a management practice which has been realized worldwide by traditional communities for centuries (cf. Shanley/ Stockdale, 2008).

Sustainable forest management is a widely-accepted approach for promoting economic and social development of local communities in tropical areas while at the same time helping to conserve tropical forests. Income-generating opportunities and economic incentives for the local population are considered key aspects for making sustainable forest management work as well as for preventing deforestation. Within this debate, several studies emphasize the significance of the inclusion of NTFP as a central component of a profitable and sustainable forest management strategy (Escobal/Aldana 2003; GTZ 2008; Guariguata 2009; Laird et al. 2010). Thereby, politicians as well as development agencies have adopted this idea and increasingly promote the sustainable exploitation of NTFP in their programmes. The extraction of NTFP represents only a fraction of Brazil's primary sector, with 0,48 per cent (MDA et al. 2009, 2; Clement/Fonseca 2008). However, the economic potential of NTFP and its positive impacts on sustainable forest management have not sufficiently been explored yet. Meanwhile, studies on the commercialisation of NTFP at the local level have shown a number of obstacles that hamper the effective marketing of the products (Marin/Emmi 2000; Escobal/Aldana 2003; Hecht 2007, Diniz 2008; Burke 2010; Le Tourneau/Greissing 2010; Duchelle et al. 2011; also related to this issue: Homma 1993; Pinheiro Klüppel et al. 2010; Shackleton et al., 2011). This demonstrates the need for further research and knowledge exchange on the integration of NTFP in sustainable forest management. Moving forward, this could open the door for a range of options to further promote the economic and sustainable use of forest products, and could pave the way out of the current conflict that exists between economic development efforts and environmental issues.

In 2009, the Brazilian government started to address this complex situation with the PNPSB. It is a joint programme by the Brazilian Ministry of Agrarian Development (MDA), the Ministry of the Environment (MMA), the Ministry of Social Development and Fight against Hunger (MDS) and National Supply Company (*Companhia Nacional de Abastecimento*, Conab). The plan was elaborated based on a participatory approach including workshops at the national and regional levels with stakeholders such as public authorities, civil society, private sector, financial institutions and development agencies. Along six ambitious strands of action, the plan's goal is "to develop integrated actions for promoting and strengthening the role of socio-biodiversity product chains in building sustainable markets," with a further focus on the inclusion of local communities (MDA et al. 2009, 2).

A remarkably innovative asset of the PNPSB is the fact that it fosters synergies which stem from integrating different existing policies of the Brazilian government: mainly, the policy that guarantees a minimum price for certain commodities from extractivists and small scale farmers (*Política de Garantia de Preços Mínimos*, PGPM), the program for buying a certain amount of their local production (*Programa de Aquisição de Alimentos*, PAA), especially for school food (*Programa Nacional de Alimentação Escolar*, PNAE).

This notwithstanding, in early stages of the project in 2011, it appeared that the ambitious and innovative plan had not been implemented satisfactorily at the local level. An analysis of the implementation of the plan in the federal state of Pará in 2012-2013 indicated a key reason to be related to governance issues. Specific implementation constraints range from restrictions to the access to land, property rights and credits – due to the lack of the so called *Declaração de Aptidão da Agricultura Familiar* (DAP) (relevant for accessing PGPM, PNAE, PAA) – to markets, information and education at the local level. In addition, the lack of economic incentives precludes the effective inclusion of private (and public) investment in potential sustainable forest activities, e.g. NTFP extraction. The marginalization of NTFPs over decades in the rural development agenda of the Brazilian government and the lack of specific know-how, including for extractivism specific technical advisory and extension services, calls for concrete research and development as well as plans and actions that are both formal and extraction-specific.

Further, Brazil nut and Babaçu were chosen as key products of the national socio-biodiversity strategy. Therefore, our project focused on one of these selected products: the Brazil nut. In the Brazilian Amazon and especially in our project region, Calha Norte, the Brazil nut value chain faces several challenges.

The supply side, e.g. Brazil nut extractivists, face difficulties in meeting hygienic and legal standards such as from the European Union in 2003 for the production, transport, post-harvest, processing as well as commercialisation, for example from nut contamination by aflatoxin (Álvares/Wadt 2011). This is not only related to the lack of local or regional adaptation of these mandatory requirements, but is also aggravated by poor local infrastructure, including for stocking and drying Brazil nuts.

Extractivists have insufficient market access, particularly to niche markets that can add value to the extractivist product at the local level. Brazil nut gatherer groups in Oriximiná do neither participate in organic nor fair trade certification, mainly due to the lack of reasonable price premiums from regional processing mills for covering additional (labour) costs to follow international standards (cf. Dittrich 2013). Given locally unfavourable benefit-cost ratios, they rarely take part in quality assurance systems, e.g. by following post-harvest requirements for "good practice Brazil nut" (*castanha-do-brasil de boas práticas*). Challenging is also the underutilised potential of organisation of extractivists in forest user groups and cooperatives, which, if further explored, could not only enable the access to new market opportunities but also increase their bargaining power and benefit share within the value chain (cf. Cunha, forthcoming). Most extractivists still sell their Brazil nut individually to local intermediaries, from whose advance payments they depend upon to cover their extraction costs (Cunha 2014). This dependency stems from an unbalanced historical trade relationship in the rural Amazon, which is directly related to *aviamento* structures, and indirectly to policy support to local *elite-seringalistas, donos de castanhais* and processing mills over decades. Gathering nuts in remote Brazil nut stands, despite their possible high productivity, can turn out to be unfeasible, given low benefit-cost ratios. Further, ecological limitations of the Brazil nut tree comprise insufficient natural regeneration and high variation in productivity of Brazil nut stands (Scoles/Gribel, 2012).

Overall, the value chain in the Calha Norte region is, to a large extent, unstructured, characterized by inefficient logistics for marketing products of extractivist communities, given difficult accessibility conditions in relation to urban centers and markets.

2.2 PROJECT APPROACH

The *Puxirum* project builds up on the aforementioned problems and research needs, ranging from demands identified by local value chain actors and Brazil nut post-harvest management as well as ecological shortfalls to common interests in scoping production and market opportunities for mutual benefits. The project focused on connecting ongoing initiatives from various sectors of society that are involved in improving the extraction, processing and marketing of NTFP, especially Brazil nut, as well as in researching and providing inputs for policy strategies to strengthen sustainable management initiatives focused on the use of NTFP in the Brazilian Amazon region.

Based on the common interest of working on Brazil nut as a NTFP and socio-biodiversity product, and on shared principles of horizontal knowledge exchange and mutual learning, inter-institutional networks were built to bundle existing experiences and information to support the implementation of the PNPSB. Due to the complexity of the challenges related to the value chain, the *Puxirum* project was designed to comprise smaller sub-topics that correspond to work packages. The work packages were designed along the value chain and represent the interdisciplinary approach of the project (cf. Figure 2).

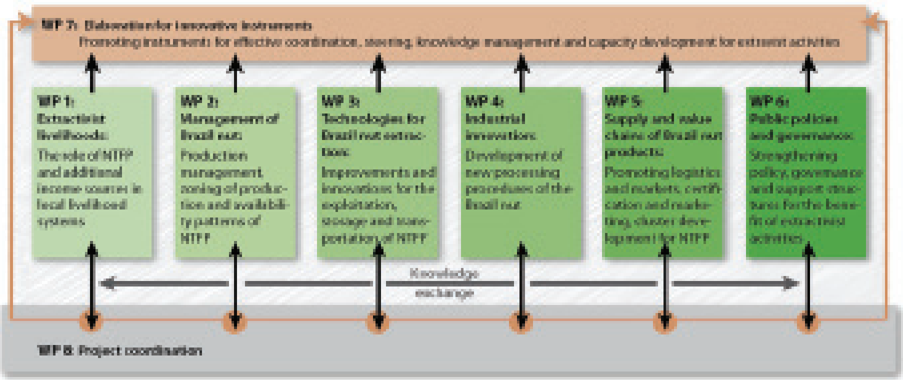


Figure 2: Work packages within the Puxirum project

All work packages operated at the local, regional and national level as well as with the cooperation partners from all five sectors of involved agents: science, politics, private sector, civil society, international cooperation (cf. Figure 3).

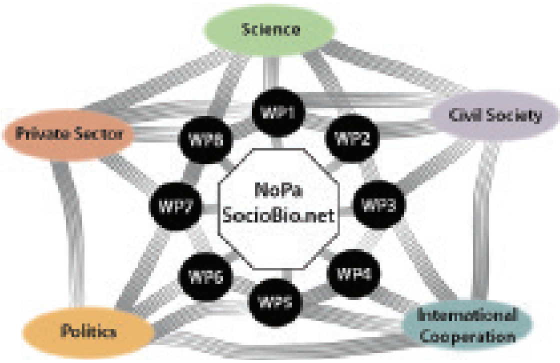


Figure 3: Transdisciplinary approach

Given this modus operandi, the project searched for strategic partnerships while creating mutually beneficent networks, with the purpose of not only enhancing *Puxirum*'s impact but also to influence and give impulses on longer lasting structures, institutions and initiatives. Collaboration among partners from different sectors was galvanized by numerous workshops and studies (cf. 2.3), which laid the groundwork for vivid networks from the municipal to the national level and beyond.

2.3 OUTPUTS AND IMPACTS

The achievements of the *Puxirum* project can be disentangled into not only capacity building and primary research activities but also multiple scientific and academic outputs over the period 2012-2013. The former comprise seven activities including a good practice in post harvest management course for Brazil nut extractivists (supported by the Project and one of its partners Mundial Exportadora Ltda.), household and group interviews as well as SWOT analyses (strengths, weaknesses, opportunities, threats) of the Brazil nut value chain at the community level. Overall, the latter built upon various studies about the Brazil nut conducted by project team members who were supported by CAPES and DAAD, including for Germany-based students to do fieldwork in the Calha Norte region and Brazil-based PhD students studying and writing up their theses at German partner universities in the frame of a bilateral academic exchange.

Scientific outputs comprise the fields of ecology and biology (Regeneration of Brazil nut trees; Native occurrence of Brazil nut trees/ stands; Growth and survival monitoring of Brazil nut in different environmental conditions – cf. Ferreira 2013, Ferreira et al. 2012; Scoles 2012; Scoles/Gribel 2012; Scoles et al. 2014), geography, sociology and economy (baseline survey on livelihood strategies and socioeconomic conditions of Brazil nut extractivists in Óbidos and Oriximiná; livelihoods of extractivists; Brazil nut value chains in the Lower Amazon Basin, Pará; International Brazil nut market; Aspects of the Brazil Nut Value chain in Germany; Challenges and potentialities of organic certification and social organisation of extractivists; Access to natural resources; Extractivism and gender aspects – cf. Cunha, 2014; Dittrich, 2013; Huth, 2015; Krag, 2014; Möckel, 2014; Paul, 2015, Schmidt, 2015; Strehle, 2014), as well as the evaluation of public policy and technological innovation (feasibility study for making use of Brazil nut shells – cf. Schulz Blank, 2012 as well as website and blog contributions and a press release[2]). In addition, a book on the Brazil nut containing articles encompassing various disciplines and new debates from different sectors represents a key output cutting across and beyond all these fields (Segebart et al., 2015).

Further, five dialogue events were organized by the project team and attended by extractivists, scientists, private sector and policy-makers: three were regional seminars (Belém), a national (Brasília) and an international conference (Berlin).

Beyond academia, the following four events organized by the project team, in two cases together with strategic partners, need to be highlighted among outreach achievements and impact. as they contributed to building partnerships for promoting cross-sectoral debates on the Brazil nut value chain while providing input for supporting the implementation of the PNPSB, particularly in Pará:

Conference "Fostering the implementation of the National Plan for the Promotion of Socio-Biodiversity Product Chains (PNPSB)", Belém 2012

In 2012, the project organized a two-day conference in Belém in cooperation with IDEFLOR, aiming at providing research and development ingredients for promoting the implementation of the PNPSB in Brazil. In 2012 the PNPSB was coordinated by the MMA, which was represented at the conference as were more than ten other related institutions ranging from the private sector and universities to NGOs and local Brazil nut cooperatives.

This diversity helped shape constructive debates amongst the participants on strategies based on drivers (e.g. funding opportunities) and constraints (e.g. lack of business enabling environment) for developing the value chains of products of the socio-biodiversity. Local demands and claims from the participating institutions were mapped out. This included simple structures for drying Brazil nut in communities at the forest margins in order to comply to quality requirements for export markets as well as access to services and national policies to contribute to mutual beneficial value chain development. In line with the objective of the *Puxirum* project of strengthening the Brazil nut value chain and developing Brazil nut clusters was identified as one of the pivotal instruments to address these demands.

2 http://stadtinnenarchitektur.de/?p=696; http://brazilianbriquettes.blogspot.de/; http://www.agenciapara.com.br/noticia.asp?id_ver=95588

The conference effectively contributed to initiating lively debates on challenges and potentialities of the implementation of the PNPSB in the Brazilian Amazon, especially in Pará, while scoping for bilateral cooperation opportunities.

New partnerships emerging from the participation of Brazil nut value chain actors at the BioFach America Latina, São Paulo 2013

Participation of representatives from the AMOCREQ association of extractivists (Óbidos) and the Brazil nut processing mill Mundial Exportadora Ltda., accompanied by a researcher of the *Puxirum* team, in the BioFach America Latina[3] in São Paulo from 27th to 30th June 2013. Beyond scoping for new business opportunities – with AmazonOil, Ecocert and Bio EcoBrazil for including a mix of Brazil nut and açaí in school food through the PNAE –, the participation of both ends of the Brazil nut value chain within the Lower Amazon basin resulted in the agreement and initial planning of the good practice course in post-harvest management of Brazil nut, which took place in the community of Cachoeira Porteira, Pará, from 19th to 21st September 2013. On top of these win-win initiatives, the participation of various stakeholders improved the marketing relations as well as trust among these upstream and downstream value chain actors.

Conference "Dialogue between science and politics: Strengthening value chains of Socio-Biodiversity products – the case of Brazil nut", Brasília 2013

With the aim of identifying and building synergies among the Brazil nut value chain actors in Pará and in Brazil, actors from various societal sectors gathered in Brasilia in 2013. Agents involved directly and indirectly in the Brazil nut value chain participated in this event, including the private sector, extractivists, NGOs and academic institutions as well representatives of the MMA and MDA.

It was a fruitful and open exchange that helped the *Puxirum* team and particularly participating partners identify research and implementation gaps related to the PNPSB. Participants learned about new initiatives at the MMA as well as MDA and the *Empresa Brasileira de Pesquisa Agropecuária*

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3 BioFach is an international fair mostly for organic products, for more information, consult: http://www.biofach-americalatina.com.br/

(Embrapa) – Techcast, an umbrella program for all Embrapa projects on Brazil nut nationwide. Public policies, specifically the PNPSB, were presented by their coordinating institution, MMA, while GIZ discussed its value chain development methodology used for the implementation of this program. The stimulating debate raised awareness of key weaknesses, including the urgent necessity to allocate more resources into the PNPSB. Not only did it lack financial and human capital, but also specific extension services to cope with local demands of extractivists in the frame of a long lasting and effective implementation of the PNPSB.

Results from research conducted in collaboration with the *Freie Universität Berlin*, the *Universidade Federal do Oeste do Pará* (UFOPA), the World Agroforestry Centre (ICRAF) and Embrapa, ranging from insufficient natural regeneration of *Bertholletia excelsa* indicating the potential for planting, especially in association with fruit trees and crops – that is, agroforestry systems - to the link between social capital and its potential to reduce the vulnerability of extractivists in the Lower Amazon Basin were presented. At this event in Brasilia, policy makers met the academia as well as private sector and representatives from the geographically distant Lower Amazon Basin. This stimulated knowledge exchange and helped map out research and policy needs for mutual beneficial cooperation among actors at the local and national level involved with the Brazil nut value chain.

Creating vivid networks for mutual benefits of Brazil nut value chain actors and sustainable development: Launching the "Governance Commission for Strengthening the Brazil Nut Vale Chain in the Lower Amazon Basin, Pará", Óbidos 2014

The Governance Commission for Strengthening the Brazil Nut Vale Chain in the Lower Amazon Basin, Pará was launched at a multi-sectorial seminar in Óbidos. The Commission invlves CEQMO and the *Associação das Comunidades Remanescentes de Quilombos do Município de Oriximiná* (ARQMO), the *Sindicato dos Trabalhadores e Trabalhadoras Rurais* (STTR), the *Secretaria Estadual do Pará de Ciência, Teconologia e Innovação* (SECTI), the processing mills Mundial Exportadora Ltda. and Caiba Indústria e Comércio S/A, the *Secretaria do Estado do Meio Ambiente* (SEMA-Belém) and environment and agriculture secretaries from Óbidos and Oriximiná, the *Freie Universität Berlin*, UFOPA, *Universidade Federal Rural da Amazônia* (UFRA), as well as Imaflora, among other actors. It has a high potential of not only serving as a democratic multi-stakeholder platform – headed by Imaflora, having a representative of Mundial Exportadora Ltda. as its vice-president and CEQMO and SEMA as board members – in order to identify demands for designing mutual beneficial value chain development actions. But it also has the potential of being institutionalized through the National Policy for APLs (local cluster development) led by *Ministério do Desenvolvimento, Indústria e Comércio Exterior* (MDIC) for strengthening the value chain on a sustainable basis.

After this event, SECTI initiated planning activities to implement a Center for Technological Extension (*Núcleo de Extensão Tecnológica* - NEXT) in the region of Oriximiná/Santarém to strengthen locally based cluster development focused on the Brazil nut.

Impacts were further reached by the project through local workshops in extractivist communities and interviews on extractivists' livelihoods, access to natural resources, value chains of Brazil nut and social organisation. Those activities contributed to galvanize organizing processes among extractivists and enriched academic research.

Based on a *Puxirum* research output on the use of Brazil nut shells as pellets (Schulz Blank 2012), a workshop was organised in Oriximiná in 2013 in order to disseminate the knowledge of how to produce manual grinders and pellet makers, especially for extractivists as well as for institutions who function as multipliers.

3. EVALUATION AND POLICY RECOMMENDATIONS

Over the last decade, Brazil lost its position as first global Brazil nut producer to Bolivia. That might not be considered a problem, but it is a symptom. Some scientists (e.g. Coslovsky, 2014) see its reason in the lack of investment for modernization of the sector all along the value chain (cf. Donovan et al., 2013). This includes all factors mentioned in 2.1, from the situation in the harvesting process, transport and commercialization in the factories, especially aflatoxin control and marketing, to insufficiently adapted legislation and the lack of public incentives, including financial support and specific financing schemes (e.g. extractivism specific credit lines). The project results could lead to some general reflections and recommendations for the Brazilian Amazon region: while they are valid principally for the Calha Norte region in Pará, they might be scaled out. The development of local clusters is not emerging by itself as the value chain actors are still acting in asymmetrical and dependent relations, whereas a situation of direct competition between the mills provides little to no incentives for cooperation. Strong economic incentives, mediation and moderation from outside, possibly state-driven, are considered essential. As other economic sectors such as cattle ranching and agricultural production in large scale are much more attractive economically than the sector of NTFP, concerted state action is needed to strengthen this sector and revert the dominating rural production scheme towards a more sustainable one in the Brazilian Amazon.

Still, some success stories such as Cooperacre (cf. Almeida et al. 2012) or Ouro Verde Amazônia/Grupo ORSA[4] are expanding the potential of NTFP as an attractive economic sector with all the aforementioned sustainable development benefits. Both examples counted and count with essential support of other institutions. This corroborates the assessment that without external support it is hard to get the sector going. How high these economic incentives would have to be, what economic returns could be expected, remain open questions for ongoing research.

It is very likely that in the long run this proposed investment would lead to a reduction of costs for deforestation control, adaptation to climate change and poverty relief programs – beside its sustainable development benefits for the maintenance of environmental services of this valuable and sensitive ecosystem. This fact should be sustained by quantitative estimations in future research.

In our evaluation three essential steps are needed:

1. A **concerted action** in all sectors along the value chain simultaneously. A strategic and detailed planning as well as **strong governance** and steering concept are essential for this.

2. A **strong political commitment** to the support of the NTFP sector in the Amazon expressed through corresponding and **relevant financial investments** by the state.

3. The **strengthening of existing networks** and initiatives (science,

4 http://ouroverdeamazonia.com.br/quem-somos.php

NGOs, associations, initiatives of private and public sector) which are working on NTFP in Brazil and the enhancement of **knowledge management** in this sector.

As follows, these steps are complemented with detailed recommendations to specific factors relevant for the strengthening of the value chains of Brazil nut, which also apply to other NTFPs, in the Brazilian Amazon region.

Good governance, information sharing and knowledge management structures

- Allocation of specific financial resources for governance and steering mechanisms for the strengthening of the NTFP sector in Brazil.

- Creation of a platform/database of the NTFP sector in Brazil/ Amazon region for knowledge management and better coordination

Decentralized capacity building along the value chain and creating extractivism specific education programs

- Creation of a decentralized Center for NTFPs to function as a center for capacity building for different audiences, access to information, networking, knowledge management, marketing and public relation.

- Capacity building such as good practice courses in quality assurance techniques such as locally adapted certification systems for all actors involved in the value chain in Brazil while co-designing mutual beneficial value adding strategies for NTFP value chains.

- Integration of disciplines on NTFP extractivism and management in curricula of decentralized extension training courses (e.g. *casa familiar rual*), in standard curricula of graduate and/or post-graduate courses in agronomy, (agro)forestry and forest engineering and creation of specific courses (specialization/master) on extractivism/ NTFP, particularly in universities in the Amazon region.

Building up social capital and contribute to even out power asymmetries and access to (natural) resources

- Building up social capital through increasing social ties and access to resources for further equitable integration of marginalized extractivists who are willing to enter new markets while ensuring food security.

- Guaranteeing of secure and continuous access to the relevant natural resources for sustainable NTFP use by redefining or bargaining specific usage rights, fighting deforestation, rural violence from households and fraudulent and speculative land occupation (*grilagem*).

Restoration of degraded landscapes with Brazil nut based (agro) forestry systems

- Reforestation with Brazil nut trees: integration of Brazil nut trees in public and/or communal tree nurseries and promotion of plantation events/programs.

- Enrichment planting of Brazil nut tree in secondary forest using seedlings.

- Deployment of agroforestry systems with Brazil nut trees in degraded areas, especially near rural communities and urban centers.

Overall enabling institutional environment for NTFP aimed at strengthening multiple value chains

- Provide locally adapted infrastructure and legislation with regards to processing, handling and trading of Brazil nut and other products of the socio-biodiversity. The strengthening of NTFP value chains should be seen in its total complexity, not only reduced to the economic dimension, and understood as a participatory regional development strategy that also helps reduce poverty – including, among other aspects, education, political participation, health, social security, income generation and benefit sharing, environmental conservation and maintenance of environmental services, food sovereignty as well as agriculture and (agro)forestry.

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CSP Tools:

Comparison and application of planning tools for grid integration of CSP in Brazil

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ABSTRACT

This chapter explains the need for additional flexibility in power systems with large penetration of variable renewable energy (VRE) sources due to the impacts caused by both variability and uncertainty of wind and solar energy sources. Since 2009 Brazilian energy stakeholders have been discussing new approaches and methodologies to improve VRE modelling within the official tools used for both operational and expansion planning in the power sector.

This chapter presents an innovative approach based on soft-linked model coupling to improve the representation of VRE and of the alternative flexibility sources to the power system. A detailed SWOT analysis (strengths, weaknesses, opportunities and threats) was developed for each tool. The integrated MESSAGE MSB-300 and TIMES-TiPS-B models, both for expansion purposes, were soft-linked to the REMIX-CEM-BR operational model.

This modelling approach not only allows to improve VRE representation, but it is also the best approach to understand the role CSP technology can play in the Brazilian energy and power sectors. The REMIX-CEM model has special features to model and optimize CSP power plant configurations based on the needs of the entire power sector. Soft-linking REMIX-CEM with an integrated model is shown to be the best approach to face the challenges.

The Brazilian Energy Research Institute (*Empresa de Pesquisa Energética* – EPE) has recently adopted this model in their work. Furthermore, the German Aerospace Center (*Deutsches Zentrum für Luft- und Raumfahrt* - DLR) continues to cooperate with the project partners to apply and develop the new model. The *Agênica Nacional de Energia Elétrica* (ANEEL) and the energy company *Companhia Hidro Elétrica do São Francisco* (CHESF) are also working together to further develop the REMIX model for CSP plants.

Keywords: CSP, energy planning models, model coupling, Brazil

1. CONTEXT

1.1 THE NEED FOR ADDITIONAL FLEXIBILITY IN POWER SYSTEMS

In spite of the significant increase in centralized variable renewable energy (VRE) sources, like wind and photovoltaic (PV) power plants, power systems face several problems due to VRE intermittency and uncertainty. High shares of VRE sources may, indeed, threaten the adequacy and reliability of a power system (Drouineau et al. 2014, 2015; Ma et al. 2013; Silva et al. 2014).

Adequacy is associated with issues of investment and it is used as a measure of long-term ability of the system to match the stochastic fluctuations of demand and supply with an accepted level of risk (Silva et al. 2014). To guarantee that energy demand is safely met in a scenario of high penetration of VRE sources, investments to ensure adequacy (in generation and flexibility) of the energy systems must be made (Ma et al. 2013).

System reliability is associated with energy security issues (Winzer 2012). Reliability of the power system is defined as the ability to return to a steady-state condition after a sudden disturbance, such as an unanticipated loss of system elements (e.g. load or production fluctuations, network contingencies) (Drouineau et al. 2014, 2015). Quality in power supply is usually ensured by controlling voltage and frequency deviations, involving events that occur in time scales ranging from a few milliseconds to a few hours (Drouineau et al. 2014). To operate a power system in a reliable way, a market of ancillary services is necessary to ensure suitable ranges of deviations for frequency and voltage, which depend on the kinetic and spinning reserves of the power system and on the reactive power (Drouineau et al. 2015). High deviations of frequency and voltage can lead to brownouts or power outages (Drouineau et al. 2015).

The impacts of a high penetration of VRE sources in a power system, caused by the increasing variability and uncertainty of VRE generation (including VRE forecast errors) and demand, can be organized according to two criteria: spatial and temporal resolution. Spatial considerations differ between local level (very much related to distribution systems) and system wide level (the entire power system) (Soares et al. 2012). The main local impacts occur on voltage control, fault current, harmonic distortion and flicker (Soares et al. 2012). On the other hand, system-wide impacts on power systems include the imbalance between load and generation (response service), diminished reactive power generation, and reduced frequency control (Soares et al. 2012). From the temporal perspective, there are impacts associated to the short and long term scales. Some of the significant technical impacts at a short-time scale are: diminished inertia (synchronous mass), higher rate of change of frequency (ROCOF), problems with fast frequency control, voltage stability, lack of dynamic reactive power reserve, short-circuit power issues and insufficient ancillary services/reserves (Rather et al. 2013; Rather et al. 2014). Long-term challenges are related to adequacy and flexibility requirements (Rather et al. 2013; Rather et al. 2014). Various countries (e.g. Ireland, Denmark, Sweden, Germany) are already experiencing short-term scale flexibility issues in addition to longer-term scale operational challenges (Böttger et al. 2015; Olsson et al. 2004; Rather et al. 2013; Welsch et al. 2014).

To cope with these impacts, power systems will need to have sufficient flexibility to maintain the demand-generation balance at all time (frequency response services), and operational reserve services at a reasonable cost over different time scales (Ma et al. 2013; Silva 2010). Therefore, energy and power system planning will need to address both the problem of capacity adequacy and flexibility.

Traditionally flexibility to meet peak load in short time scales is provided by partially loaded synchronised plants and fast start-up plants, such as open cycle gas turbines (OCGT). Increasing penetration of VRE poses challenges to conventional generators by creating requirements for fast, sudden and large ramping and frequent start-ups (Ma 2013). The ramp rates and the difference between the minimum stable generation and the capacity of a plant[1] are the parameters that define its capability to provide flexibility (Ma 2013). Peaking units are strategically used to meet the needs for backup capacity to handle near term periods with low wind and PV generation.

Besides flexible generation, a modern point of view considers alternative flexibility sources such as flexible demand, flexible energy storage, strengthening of cross border interconnections and grid expansion and

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1 The flexibility index of a whole system is then defined as the weighted sum of the flexibility indices of the individual generators. The weighting factors are taken as equal to the capacity contribution of each unit. (Ma 2013).

flexible district heating and heat pumps. Demand side management (DSM) or demand response, including load shifting and load shedding, is an active topic of research (e.g. Martinsson et al. 2014; Mata et al. 2013; McKenna et al. 2013; Stanojevic et al. 2009). Several energy storage technologies are being largely researched, for example power-to-gas (P2G), pumped hydro storage (PSH), compressed air energy storage (CAES), flywheel energy storage system (FESS) and hydrogen-based energy storage system (HESS) (De Boer et al. 2014; Zhao et al. 2015; Zhao et al. 2015). Scientific and market community have shown large interest in thermal energy storage (TES) technologies for concentrated solar power (CSP) plants due to the high market potential in high direct solar irradiation (DNI) regions of the world (Arvizu et al. 2011; Trieb et al. 2014; Viebahn et al. 2011). The use of electric batteries in plug-in hybrid electric vehicles (PHEV) and pure electric vehicles (EVs) has been studied by Soares et al. (2012). The technical viability of large electric batteries connected to the grid has been studied by Johnston et al. (2015) and Solomon et al. (2014). There are few studies showing a new potential role of large hydroelectric dams in United States to buffer renewables on a large scale, assessing their potential dispatchability and flexibility to accommodate increasing VRE generation (Chang et al. 2013; Kern et al. 2014). Additionally, the use of flexible combined heat and power (CHP), heat pumps and electric boilers in district heating grids have the potential to balance large amounts of VRE electricity (Blarke 2012; Böttger et al. 2015; Capuder and Mancarella 2014; Rinne and Syri 2015). Finally, investment opportunities to build new and refurbished synchronous condensers and systems to add synthetic inertia from wind turbines/HVDC, as well as installation of new infrastructure like FACTS devices (SVC), have been studied by Rather et al. (2013) and Rather et al. (2014).

Although there is a large number of flexibility technologies, TES in CSP plants seems to have a high potential for increasing flexibility in power systems due to its technical characteristics (Arvizu et al. 2011; Lovegrove et al. 2011; Trieb et al. 2014). One of the strengths of CSP is the possibility of TES, which facilitates energy dispatch management during daytime. TES increases the capacity factor of the system and its ability to meet peak loads as well as to operate in the base load with firm energy of solar origin only (Arce et al. 2011; Skumanich 2010; Trieb et al. 2014; Baharoon et al. 2015). In addition, using the same power block to produce firm electricity and then operate in the base load, CSP plants can operate in hybrid systems that employ different configurations (IEA 2012; Montes et al. 2011; Zhang et al. 2010). Hybridisation enables the solar plant to operate partially using a back-up fuel (NREL 2005), that can be fossil (typically natural gas) or non-fossil (biomass or biogas) (Arvizu et al. 2011).

In this context, the use of CSP plants with TES and optimized technology design may be an appropriate solution to provide more flexibility to the power system. Although CSP also depends on solar availability (DNI), it entails the possibility of having both TES and hybridization that allow for reliable delivery of power to the grid at any time of the day –unlike other VRE technologies such as wind and PV.

1.2 WHICH IS THE BEST MODELLING APPROACH TO HANDLE LARGE PENETRATION OF VRE?

Traditionally, electricity generation expansion planning aims at providing, in a cost-effective and reliable way, enough flexibility to handle the variability and uncertainty (forecast error) of demand and to deal with unplanned generation outages.

Until recently, VRE generation has been regarded as a marginal contribution to power systems and, therefore, VRE modelling has been simplified. This conception makes part of a traditional paradigm (methodologies, procedures, standards, planning and tools) for the expansion and operation of thermal- or hydro-thermal-based power systems, under which optimal scheduled traditional power plants (non VRE) aim at supplying electricity to meet the net demand (Silva 2010) (also known as residual load – Bertsch et al. 2014). The net demand is calculated by subtracting the VRE electricity production (and sometimes the energy savings from energy efficiency measures) to the system-wide demand.

The paradigm shift from conventional generator based power system to VRE based system brings various technical challenges at the planning and operation stages. The impacts caused by a large VRE penetration are such that a full re-assessment of power system expansion and operation planning, especially in setting frequency response[2] and operational reserve services, is required (Silva 2010). In this context, the need and cost of providing additional flexibility to integrate large share of VRE generation in the power system has been recognized not only from the system operator

2 Frequency response: regulating capability to maintain balance between supply and demand.

(SO) point of view, but also from a central planning perspective (Silva 2010; Smith et al. 2004).

Hence, there is a challenge related to appropriately modelling the integration of large quantities of VRE electricity to the power systems paying attention to long term impacts to the energy system (Baños et al. 2011; Connolly et al. 2010; Hirth 2015). Despite the fact that VRE impacts are mostly perceived at operational time scales from minutes to day-ahead, additional system flexibility needs to be considered from the energy and power systems long-term planning stage to deliver a system that can handle this large penetration of VRE in a cost-effective manner (Ma et al. 2013; Silva et al. 2014).

Theoretically, any competitive market design that incentivizes long-term investments based on least (total system) cost generation does not need additional incentives for flexibility (Bertsch et al. 2014). Instead, flexibility is a by-product and is not binding in long-term investment models (Bertsch et al. 2014). That explains the importance of adequate energy system modelling.

To face this challenge, an extensive number of long-term energy planning tools considers unit-commitment[3]-derived details (operating reserve requirements, dynamic constraints and maintenance scheduling) that are traditionally ignored in expansion planning models (Hirth 2015; Palmintier and Webster 2011). Nevertheless, experiences reveal that there is no energy tool that completely addresses this challenge, providing at the same time accuracy in results and low computational cost (Connolly et al. 2010; Hidalgo et al. 2015; Silva 2010).

To reduce its computational cost, long-term energy system planning tools usually simplify the problem by considering low temporal resolutions, very stylized techno-economic operational constraints of the power system and of the individual power plants, extensive spatial/geographical resolution and a coarse transmission grid representation. Previous studies show that these simplifications have a significant impact on the model results, that are far to be in line with reality, when analysing systems with high share of VRE generation (example.g Hirth 2015; Palmintier 2014; Palmintier and Webster 2011; Poncelet et al. 2014). For this reason, different efforts have been made to bridge the gap between the outcomes of planning and operational models

3 Unit commitment (UC) models determine the optimal scheduling of a given set of power plants to meet the electricity demand, taking account of the operational constraints of the power system.

taking into consideration real-life restrictions, such as computational cost, excessive complexity and model maintenance and updating cost. For example, efforts have been made to increase the temporal resolution in planning tools (Pina et al. 2011) to increase the level of techno-economic detail within the models (Hirth 2015, Palmintier and Webster 2011; Poncelet et al. 2014), and to improve the spatial resolution and transmission system representation (Fichter et al. 2014a; Fichter et al. 2014b).

Literature distinguishes two methodologies to increase the level of detail (of the features mentioned above) in energy planning tools: "direct integration" and model coupling (Hidalgo et al. 2015). Both approaches allow for modelling power systems with high penetration of VRE technologies, where detailed modelling of flexibility issues is more relevant.

The first method aims at directly integrating additional power unit operational constraints and variables into an energy expansion planning tool (Hirth 2015; Palmintier 2014; Palmintier and Webster 2011; Poncelet et al. 2014). Within the context of systems with high penetration of VRE, it was demonstrated that the more important operational constraints to be considered in a generation expansion planning tool are those of operating reserve requirements and maintenance scheduling (Palmintier 2014; Palmintier and Webster 2011; Poncelet et al. 2014). Furthermore, the impact of dynamic constraints (ramping restrictions, minimum up and down times) seems to be less important (Palmintier 2014). Additionally, some studies found that relaxing integer variables as a way to reduce computational cost seems to have little effect on results (Palmintier 2014). However, it is difficult to generalise these results, which hold for a specific single-country model, and are dependent on the assumptions made and the configuration of each power system.

The second method is coupling operation and expansion models. Model coupling relies on creating soft-links between an energy expansion planning model and a detailed power system operational model (Hidalgo et al. 2015). Soft-linking of two models may decrease computational costs, but implies handling a planning and an operational model, which may lead to correlations between different uncertainties (Hidalgo et al. 2015). This raises the need to address issues such as which outputs from the operational model would be considered in the expansion planning tool as input data and how this information would be fed back from the planning tool to the operational model. This iterative approach has the drawback that convergence might not be reached and optimality cannot be guaranteed (Hidalgo et al. 2015). Nevertheless, so far model coupling seems to be the best approach and the preferred option to address flexibility issues for power systems with high share of VRE generation (Heinrichs et al. 2014; Hidalgo et al. 2015; Fahl et al. 2010; Rosen et al. 2007; Kiviluoma et al. 2014).

Ideally, an integrated energy system model covers all energy subsectors (oil & gas, power, refinery, etc.), and all energy levels (from primary energy to energy services consumed by different activities) of an energy system and, hence, it is well suited as a central assessment tool for a long-term analysis when soft-linked to power dispatch models, electricity market models and tools for investigating social aspects (Fahl et al. 2010; Schaeffer et al. 2015). In this context, coupling (soft linked) large-size integrated energy system models to sector-specific models seems to be the dominant approach for analysing flexibility issues in a long term horizon in energy and power systems with high share of VRE generation.

1.3 THE MODELLING CHALLENGE IN BRAZIL: LARGE PENETRATION OF VRE SOURCES AND ALTERNATIVE FLEXIBILITY SOURCES.

Although renewable energy sources – hydropower in particular – already contribute significantly to the electricity supply in Brazil, a reason for concern is that the remaining hydropower potential is limited (Schaeffer et al. 2013) and fossil fuels, specially coal and some natural gas, are likely to play a larger role in the Brazilian energy system (Lucena et al. 2015; Nogueira et al. 2014), which will result in additional greenhouse gases (GHG) emissions. On the other hand, in the Northeast region of Brazil wind power installed capacity is 5.4 GW and the prospects, considering all wind farms contracted until the end of 2014 by regular auctions, is to install at least 12.6 GW more by 2019 (ANEEL 2014; CCEE 2014; EPE 2014). Although by the end of 2014 the PV installed capacity in the Northeast region of Brazil was negligible (4.6 MWp), this technology shows promising expansion prospects in the country for the long term. Recent auctions[4] held in Brazil contracted a total capacity of 642 MWp of centralized PV in the Northeast subsystem to start

4 Pernambuco state solar auction, held in December 2013, contracted a PV capacity of 122 MWp to start operation until the end of 2016. The sixth reserve energy auction, held in October 2014, contracted for the Northeast subsystem a total of 520 MWp to start operation until the end of 2017.

operation between 2016 and 2017 (ANEEL 2014; CCEE 2014; EPE 2014). A significant deployment of distributed generation (DG) based on PV systems is also expected for the country in the medium to long term. As the share of this VRE generation grows in the power system, the Brazilian power sector could face problems if energy planning tools do not improve their VRE representation, so as to anticipate possible, future negative impacts.

Relevant Brazilian energy sector stakeholders from policy, planning and operational stages show interest in improving the VRE representation within their tools, including the Ministry of Energy (MME), the Energy Planning Company (EPE), Operator of the National System (ONS), Power Sector Regulator Agency (ANEEL), Eletrobras Research Centre (CEPEL), Electric Energy Commercialization Chamber (CCEE), and energy utilities such as Eletrobras, CHESF, CEMIG, etc. (See Figure 1).

Since 2009 energy stakeholders in Brazil have identified a large difference between the verified net demand and the estimated net demand resulting from the DECOMP and NEWAVE models (ANEEL 2011a, 2011b, 2011c, 2012). The reason for that was the uncertainty about the electricity generation from "small power plants" (now called "not individually simulated power units - UNSI") such as wind, biomass and small run-of-river hydro power plants (ANEEL 2011a, 2011b, 2011c, 2012). The generation of the UNSI does not consider an appropriated time and spatial resolution to model VRE. Following the traditional modelling approach in Brazil, estimated blocks of electricity produced by the UNSI are subtracted from the total demand, resulting in the net demand used in modelling (ANEEL 2011a, 2011b, 2011c, 2012). Already in 2011, the average amount of electricity supplied by small power plants was more than 5,000 MWyear (ANEEL 2011a). That traditional modelling approach was enough when wind power installed capacity was only a marginal contribution to the power system. However, due to the fast expansion of wind power, the reliability of the operation of the power system is being threatened by relevant differences between models and reality. To face this challenge, in 2010 ANEEL held technical meetings with ONS and CCEE to discuss the improvements in the modelling of the UNSI within planning and operational tools. Since then, several public audiences (having as participants ANEEL, ABRAGE, ABRAGEL, AES Tietê, APINE, CCEE, CEMIG, CPFL, ONS e ABRACEEL) took place to discuss the same issue. In the same way, the *Comitê de Monitoramento do Setor Elétrico* (CMSE) and the *Comissão Permanente para Análise de Metodologias e Programas Computacionais do Setor Elétrico* (CPAMP) have discussed improvements to their official models, NEWAVE and DECOMP. This clearly shows the need for new modelling approaches and tools.

Figure 1. Workshop to discuss VRE modelling with the representation of some Brazilian energy stakeholders. Source: The authors

These institutions are not only interested in improving the tools and methodologies to better understand what is the role of VRE sources in the energy and power sectors, but also in understanding the capabilities of CSP technology to provide an extra source of flexibility to the system: more specifically, to provide ancillary services such as frequency response and operational reserve due to TES and back-up possibilities. Of course, beyond providing flexibility to the system, the development of the CSP technology in Brazil would supply clean electricity and foster a national solar industry, generating jobs and income (Soria et al. 2015). Finally, an approach to assess the potential of integrating CSP to the Brazilian power grid needs to consider not only the interdependencies between demand and supply, but also the existing limitations of both natural and financial resources.

In that sense, developing and applying specific energy planning tools are paramount to face the challenge.

The objective of this chapter is to show how different energy planning tools can support Brazilian energy policy makers to better understand the role of CSP in the country.

To address the role of CSP technology, as well as its impacts and opportunities in the Brazilian energy and power system, this work tests a suite of tools that can be soft linked. This work describes how two energy planning tools (MESSAGE-BRAZIL (MSB-300) and TIMES-TiPS-B) can be soft linked to a detailed power system operational tool (REMIX-CEM-B). The exercise gains relevance because MSB-300 is an integrated energy model that includes not only the power sector but also all other energy chains, such as supply of primary energy, energy processing, and energy services demand from transport and eleven industrial sectors.

2. APPROACH

To achieve the goals described above, the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES), as part of the Ministry of Education in Brazil, and the *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)* and the German Academic Exchange Service (DAAD), from Germany, supported the project "CSP Tools" under the New Integrated Partnerships (i-NoPa) framework. The goal of this project was to identify and evaluate the potential role for CSP as part of the future Brazilian energy system. Three institutions, using their respective energy planning models, were part of this effort. The Energy Planning Program (PPE/COPPE), from the *Universidade Federal do Rio de Janeiro* (UFRJ), used the integrated energy model MESSAGE-BRAZIL v.1.3 (MSB-300). The Institute of Energy Economics and the Rational Use of Energy (IER), from the University of Stuttgart, used the TIMES-TiPS-B (The integrated MARKAL EFOM System - Power System Model for Brazil). The Systems Analysis and Technology Assessment Department, from the German Aerospace Center (DLR Stuttgart), used REMix-CEM-BR v.1 (Renewable Energy Mix capacity exchange model).

The current status of energy planning approaches in Germany and Brazil was assessed before conducting an initial study on CSP modelling opportunities in Brazil. To that end, researchers from both countries presented and discussed their respective models and methodologies. During September and October 2014, through the course of three weeks at IER and DLR in Stuttgart-Germany, the three teams worked together to analyse and discuss the structure, equations, database and possible applications of the tools (See Figure 2).

Figure 2. Technical meeting in Stuttgart do discuss about the models and SWOT analysis. Source: The authors

MSB-300, TIMES and REMIX were considered as potential alternative tools to improve the modelling of large penetration of VRE in the Brazilian power system, and the opportunities that CSP offers to the system, being a source of additional flexibility and clean electricity. Based on the discussions held in Stuttgart, a SWOT analysis (strengths, weaknesses, opportunities and threats) was elaborated in a cooperative way for the three model generators and their applications to the Brazilian case and tested in a scenario exercise.

Additionally, this chapter proposes some possible interactions, in a soft-linked fashion, between the considered tools in order to address the issue of CSP integration into the Brazilian energy system as an alternative to provide additional flexibility to the power system.

3. RESULTS

Detailed SWOT analysis by model generators (MESSAGE, TIMES and REMIX-CEM) and their application to Brazil (MSB-300, TIMES-TiPS-B and REMIX-CEM-BR v.1) were developed within the project. Based on this analysis, a cross-section comparison of the model generators and their applications to Brazil are presented in Table 1 and Table 2 respectively. Finally, an interaction approach between the three energy models, in a soft-linked fashion, is proposed and presented in the Figure 1.

To integrate the tools, as is shown in Figure 1, a common data base was used. The MSB-300 and TIMES-TiPS-B provide capacity expansion plans by technology. Those plans analysed to design an investment option portfolio by technology (using standard power plant sizes). In the sequence, REMIX-CEM-B optimizes the dispatch of this portfolio to supply the total electricity demand in a reliable and cost effective way. At this stage the energy planner should analyse if the operational objectives were or were not achieved with that expansion portfolio. If not, the cycle must start again, in an iterative way. The new expansion planning will take into consideration outcomes from the operational tool, such as capacity factors by technology and an optimized configuration of CSP plants.

Table 1. Cross section comparison between model generators.

	TIMES	MESSAGE	REMix-CEM
Methodology	Linear, mixed integer linear, non-linear programing	Linear and mixed integer linear programing	Linear and mixed integer linear programing
Programming language	GAMS	Not available	GAMS
Availability	Free available. GUI and solvers not free of charge	Free available for IAEA member countries (including GUI and solver)	Not available for other institutions than DLR so far
Source code	Source code is not open-source, but adaptable	Source code is not adaptable	Source code is not open-source, but adaptable

Purpose	Energy system analysis and energy planning	Energy system analysis and energy planning	Electricity system analysis and power system planning
Sectoral scope	Integrated model that represents the entire energy system (single sector possible)	Integrated model that represents the entire energy system (single sector possible)	Main focus on power sector. Extension to heat sector and electric mobility is possible
Power system operation	Energy and capacity balance. Dispatch optimization.	Only energy balance. No capacity balance. No dispatch optimization.	Energy and capacity balance. Dispatch and unit commitment optimization
Time resolution	Flexible (up to 8,760 time-slices per year)	Flexible but restricted to a max. number of time slices per year	Flexible (up to 8,760 time-slices per year)
Technology representation	Detailed representation of different energy supply technologies and demand options is represented by a standard set of equations	Detailed representation of different energy supply technologies and demand options is represented by a standard set of equations	Detailed representation of different energy supply technologies is represented by individual modules with high level of detail
Technology changes	Exogenous and endogenous learning curves	Exogenous learning curves	Exogenous learning curves
Energy efficiency	Possible through end-use technologies. Endogenous model solution	Possible through end-use technologies. Endogenous model solution	Not available
Non-energy commodities	No restrictions	No restrictions	CO_2 only
Model extensions	Model extensions (e.g. Macro-economic version, stochastic, climate, myopic, load flow grid extension etc.) available	Model extensions (e.g. Macro-economic version, LULUCF) available but need further development	Model extension to use resource data for solar and wind power, for all world regions, with high spatial and temporal resolution (input to REMix-EnDAT) available.

Computational efficiency	Short running time	Short running time	In general, long time due to more detailed technical modelling
Graphical user Interface	Available for Windows operating system	Available for Windows and Linux operating systems	Partially available for Windows operating system
Training material and documentation	Handbooks are available free of charge. Frequent regular courses and on request courses	Only one official course per year with restricted participation. Handbook available. User guide is not friendly	Handbooks are not yet available. No Regular (public) training courses. Documentation and training material is only in development stage
Community	Developed by ETSAP of the IEA. Regular meetings and workshops on the model improvement and model development	Developed by IIASA. Regular meetings and workshops on the model applications	Developed by DLR itself. Continuously improved by DLR. Not yet open-source
Common features	**Storages:** Storage processes available (different daily and seasonal storage options) **Load-management:** available **Time horizon:** flexible (short- to long-term) **User-constraint / policy options:** There is enough flexibility to incorporate capacity, activity, environmental and investment restrictions **Geographical coverage:** flexible, multi-regional, multi-nodes **Solver:** flexible **Operating System:** Linux and Windows **Miscellaneous:** Large data requirements, complexity, possible misinterpretation of results		

Source: The authors

Table 2. Cross section comparison between applications of the models to Brazil.

	TiPS-B (TIMES)	MSB-300	Remix-Brazil NE
Methodology	Linear Programing	Linear Programing	Mixed Integer Linear Programming
Sectoral scope	Focus on power sector with simple residential sector representation	Integrated model that represents the entire energy system	Focus on power sector
CSP technology representation	CSP modelled with TES types and dispatch options	CSP-PT, 12hs HTS; CSP hybridization with biomass. Regional specific capacity factors	CSP module allowing configuration optimization (solar field, storage, back-up boiler)
Technology changes	Exogenous learning curves	Exogenous learning curves	Exogenous learning curves
Storages	Intra-day storage, endogenous storage optimization	Single option of TES for CSP	Multiple options for TES; hydro reservoir; batteries
Load management and energy efficiency	Limited (energy service demand for residential hot water endogenous)	Limited (energy service demand)	Not available (electricity demand)
Time resolution	432 time slices; 6 seasons; 3 typical days; 24 hours	4 seasons; 5 intra-day periods	Hourly resolution
Time horizon	2010-2050; 5 year steps	2010-2050; 5 year steps	One year, pre-defined
User-constraint / policy options	Available, depends on scenario definition	Available, depends on scenario definition	Not available but implementable
Non-energy commodities	CO2 only	CO2; sugar production	None
Geographical coverage	5 regions (South-Central; Northwest, North; Southeast; external)	4 Regions (South-Southeast-Centre; Northeast; North; External)	2 Regions (Northeast; External)

Computational efficiency	Short running time	Short running time	Long running time
Power system operation	Energy and capacity balance, including dispatch on typical day basis	Energy balance only, based on intra-day energy production profiles	Electricity and capacity balance, including dispatch optimization
Unit commitment	No associated parameters available	No associated parameters available	Available

Source: The authors

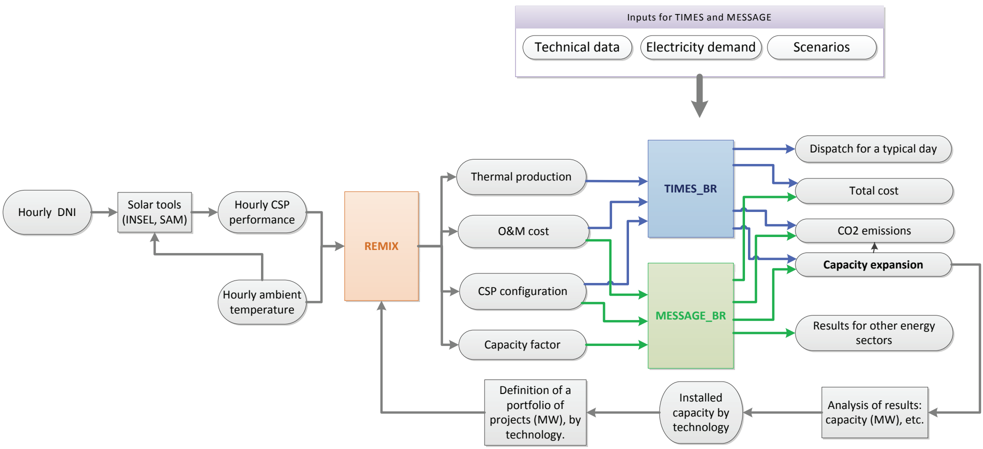

Figure 3. Soft-linked model coupling to improve VRE modelling. Souce: the authors.

4. RECOMMENDATIONS

The SWOT analysis revealed many similarities, but also major differences, between the models applied in the project. For example, all models use linear optimization while some use mixed integer linear programming depending on the specific application. Furthermore, the models differ in their temporal, geographical and sectorial coverage, leading to certain benefits but also shortcomings in the conducted analysis. On the one hand, increasing temporal resolution and considering operational constraints within a single model increases the quality and accuracy of results during the energy planning process; on the other hand, it also increases computational costs and complexity to handle and operate. The advantages to analysing the complete energy system with all its subsectors and interlinkages to long term energy planning are also largely recognized.

The current best approach to deal with the energy planning process of energy systems with large participation of VRE is the soft-linked model coupling technique. In this way it is possible to benefit from the strengths of each tool to obtain significantly improved results. As CSP is an alternative source of flexibility and firm electricity to the power system, this modelling approach also allows energy planners to easily understand the contribution of this technology. By coupling different models, linking power sector models with integrated energy models, this approach also provides data and information related to the possibility of hybridising CSP with different fuels and its impacts on the fuel supply and demand chain.

Based on the tools' capabilities and the analysis of preliminary simulations of CSP integration in the Brazilian electric power system, this study verified that this modelling approach is able to optimize the size and the use of the thermal energy storage system and the back-up system according to the needs of the entire power system. In terms of verifying the role of CSP in Brazil, this modelling approach is able to quantify the annual electricity production of each CSP plant, the contribution of each plant to the spinning reserve (number of hours in the year), and the participation to the load-generation balance (number of start-ups of the back-up system, number of hours at full capacity, hourly use of the thermal energy storage, etc.).

This modelling approach also allows to understand the impacts of developing a solar energy program (forcing a CSP installed capacity/generation into the model) not only in the power sector, but also its indirect and induced impacts on the wide energy system. For instance, it is possible to calculate the impacts of a 30 GW CSP program in the Northeast region until 2050. Policy makers can estimate the total energy system over cost and benefits of developing a CSP solar program, in comparison to a baseline scenario. This modelling approach also allows to propose a cost effective solar program in Brazil. For example, this study also identified that it is more cost-effective to develop a program focusing on electricity constraint targets rather than on capacity targets. In the scenario exercise, through 2050, to produce 100 TWh of electricity from CSP costs less than simply deploying 30 GW of CSP.

The research teams of this study strongly recommend to the Brazilian energy stakeholders to access their modelling approach to understand the role of CSP in the country and its contributions to the power system with large penetration of VRE sources, as it is starting to happen in the Northeast region of Brazil due to increasing penetration of wind and photovoltaics.

Finally, we also propose further studies to use the described soft-linked model coupling for modelling CSP in the Brazilian power and energy system. Outcomes from this effort will certainly allow policy makers to implement regulatory and political improvements to the current Brazilian auctions for selecting power plants not only based on the minimum energy cost but also by taking into consideration regional power features, GHG emissions, ancillary services, and firm energy.

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Harmonizig energy efficiency and preservation of architectural heritage: two case studies

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ABSTRACT

The harmonization of energy efficiency and the preservation of architectural heritage is a challenge that, in Brazil, takes on characteristic features as the country has public architecture built mainly in the 1960s and 1970s under a strong influence of the modern movement.

This article is a result from the project "Energy efficiency in public buildings in Brazil" within the CAPES-DAAD "New Partnerships" program and the result of a Brazil-Germany cooperation. Two buildings were adopted as case studies of architectural heritage and energy efficiency: the Polytechnic Center in Curitiba (Paraná), and Block C of the *Esplanada dos Ministérios*, in Brasília (Federal District).

As a conclusion, despite restrictions set by the need to preserve heritage, there is a real possibility of making these buildings efficient. Part of this would even result from an effort to recover the original design, both considering materials and use of the buildings. Other efficiency gains are expected from new technology applied to the thermal conditioning and lighting of the spaces. These results and their future implementation were discussed with the project partners as well as with the Brazilian Chief of Staff Office (*Casa Civil*) and the federal savings bank CAIXA (*Caixa Econômica Federal*).

Keywords: energy efficiency; architectural heritage; modern movement

1. INTRODUCTION

When one looks to reduce energy consumption in existing buildings, with several measures including the increase in thermal resistance of the building envelope, there are limits set by the need to preserve it as cultural heritage. The difficulty is well-known from countries where single intervention gave place to public policies. In the coldest regions of Europe, technology allows one to extend the life cycle of old buildings and to offer habitability conditions which are closer to contemporary standards by more or less aggressive measures (GRAF & MARINO, 2011). There are cases in which improvement includes replacing original elements like fenestration, finishes, thermal insulation, heating and cooling systems. Lighting and ventilation also affect installations as well as the appearance of buildings.

In Brazil, the challenge of efficiency and preservation appeared more recently and took on particular features:

- it usually responds to the tropical climate, which corresponds to the majority of urban areas in Brazil (particularly in the Southeast and Centre-West regions);

- it is related to public buildings, as the State is the leading actor of more than 40% of the constructions done (IBGE, 2010) and by the recent incentives offered as a compensation for that actions (BRAZIL, 2011);

- it is related to modern buildings, as this is the biggest share of the building stock existing in the country.

This research work stems from the cooperation between UFPR, UFRJ and TUM within the “New Partnerships” program by CAPES and DAAD, in the years 2012 and 2013. In order to conduct it, working teams of architects and mechanical engineers were established in both countries. On the Brazilian side, a building stock of a renewed architectural quality and, at the same time, a high potential of efficiency improvement exists. On the German side, there is remarkable experience in the improvement of buildings’ efficiency, considering the progressive hardening of energy efficiency requirements since 1970.

In Brazil, the modern movement appears with some adaptation: the most frequent challenge was the control of light and direct solar radiation gains. In most big cities (São Paulo, Rio de Janeiro, Recife and Salvador) the hot and humid climate also points at cross-ventilation as a basic cooling strategy. In Brasilia, a hot dry climate, ventilation is not recommended, but instead humidification and thermal capacity are required. Finally, Curitiba, with a temperate climate, combines conditions of both hot and cold climates, to which the building has to respond. Therefore, the superposition or redundancy of systems is frequent.

The 1960s and 1970s combined a huge growth of Brazilian cities with an economic policy which was strongly development-oriented, the State being its promoting agent. 50 years later, the signs of time became visible: shortcomings in maintenance; the accumulation of non-systematic changes due to growth or changes in demands and, not less importantly, a conjuncture which is different regarding the cost and environmental impacts of energy, as well as public finances.

Considering this situation, the present work presents two case studies. One of them was conducted in the *Bloco C* (Ministry of Planning), representing the huge set of 17 standard blocks, which are situated at the *Esplanada dos Ministérios*, built in 1960. Another, a didactic block, of the *Centro Politécnico* of *Universidade Federal do Paraná*, in Curitiba: inaugurated in 1961, and in use after a few changes.

The question here is how to implement the improvement of the thermal and daylighting performance of a modern building under a) a dry, tropical climate, and b) a temperate climate, having as a premise the respective conceptual bases. In order to achieve this, how does each building respond to the climate and which strategies are adequate for its conditioning?

2. PURPOSE

The present research had as one of its goals to explore the thermal and daylighting performance of public buildings in Brazil in order to subsidize actions to improve efficiency, considering the relevant restrictions set by the need to preserve the Modern movement heritage. This article describes results obtained during the NoPa works in the years of 2013 and 2014.

3. MATERIALS AND METHOD

The problem of improving energy efficiency of buildings, which are of interest of the architectural heritage in Brazil, has a particular feature: buildings are predominantly under tropical climate, as well as temperate climate; and those buildings were conceived under the modern movement, reflecting materials and techniques used in the period, as well as a design ideology typical of that age.

As a body of knowledge on the subject is lacking, an approach is needed in order to explain the problem in its present context, with its variables and parameters, actors involved, boundaries of varied nature, and to find guidelines for its solution. The research strategy which is most used in such situations is the case study, which intends to examine various aspects of one example using multiple sources of evidence.

Case studies were selected considering public buildings in different thermal zones of Brazil:

A. Didactic block of the Undergraduate Program of Architecture and Urban Planning at the *Centro Politécnico* of UFPR;

B. *Bloco C* of *Esplanada dos Ministérios*, Brasília.

Both case studies followed same work steps: survey of the original design concepts; evaluation of the current building performance; catalogue of measures for improvement thermal and daylighting efficiency. Different techniques were selected for each buildings.

4. CASE STUDY A: POLYTECHNIC CENTER

Due to its high altitude of 908 meters above sea level, Curitiba is the coldest of all Brazilian state capitals, with a monthly average minimum temperature of 7°C in winter. In the summer, temperatures average around 20°C. These averages do not represent the extant thermal dynamics well since there is a large temperal range throughout the year as is characteristic of subtropical climates. With respect to solar irradiation, the potential for solar energy is quite high, about 45% higher than in Central Europe.

The building called Flávio Suplicy de Lacerda is situated within this context. A project of Rubens Meister on the *Centro Politécnico* campus of UFPR, it consists of a complex of two-story buildings that are separated by open patios and connected by glass pedestrian walkways, as shown in Figure 1. During the project's duration, the thermal and luminous performance of one of the didactic blocks of this building was analyzed (Block 2). The results of this analysis can be found in more detail in Oba and Schmid (2015).

Figure 1 Aerial photo showing the complex's organization. Numbers 1 and 2, the blocks of the architecture and urbanism departments.

4.1 THERMAL PERFORMANCE ANALYSIS

The complex's implantation is square, concentrating activities on the northeast side and mobility areas on the southwest side. Even so, temperatures on the inside of the building on foggy winter days are only few degrees higher than on the outside, and far from what Fanger (1970) proposed as human thermal comfort condition and what is suggested by the international norm on thermal comfort, ISO 773 (2005). Large expanses of glass that rarely undergo maintenance facilitate loss of heat and a high rate of external air infiltration, which reinforces the necessity for heating systems. During the summer these spaces also present performance problems since the passive ventilation systems are deactivated due to lack of maintenance. Said lack of maintenance can also be observed on the brise-soleil panels (absent on some parts of the building) and on the façade cover (darkened by dirt), which compromises the building's thermal performance even further.

To verify the viability of installing a heating system, we simulated the thermal performance of part of the Architecture block, limited on the one end by the external wall present in all blocks, and on the other end by an adiabatic wall. These environments, detailed in Figure 2, were modeled in the Master Performance Simulation System (SCHMID e GRAF, 2011).

Figure 2 – Plans of the complex of buildings of the architecture and urbanism courses of UFPR. Source: Authors (2014).

The analysis done revealed that under current conditions the building does not offer working conditions that correspond to the thermal comfort standards defined by Fanger (1970). Therefore, we estimated consumption relative to air conditioning systems: a simple heating system, a heating system combined with double glazing, and a combined system with double glazing and heat recuperation. From these simulations we concluded that installing only heating is inefficient when compared with the combined alternatives. This holds true both for thermal performance, because the reason of discomfort stems not only from heat generation but also from heat loss due to windows and ventilation, and for energy consumption, which is greatly reduced as can be seen in Table 1.

Table 1- Daily heating and cooling consumption in kilowatt-hour (kWh). Source: Authors, 2014.

	PD05	PD06	PD07	atelier 4	atelier 5	total
Heating only	41,51	46,70	75,40	67,62	68,19	299,43
Heating + double glazing	38,78	42,90	64,74	51,2	49,45	247,12
Heating + double glazing + heat recuperation	19,43	23,89	46,51	29,8	28,20	147,79

1.2 DAYLIGHT USAGE ANALYSIS

In order to analyze luminous performance related to daylight, the ground-level room PD07, shown in Figure 3, was chosen, the same that was previously used for thermal performance data. Within the studied block, this is the space that suffered the biggest modifications due to finishings carried out. The daylight analysis model from the Master System (SCHMID, 2004) was used. It combines ray tracing and radiance techniques to measure illumination levels in defined flat areas.

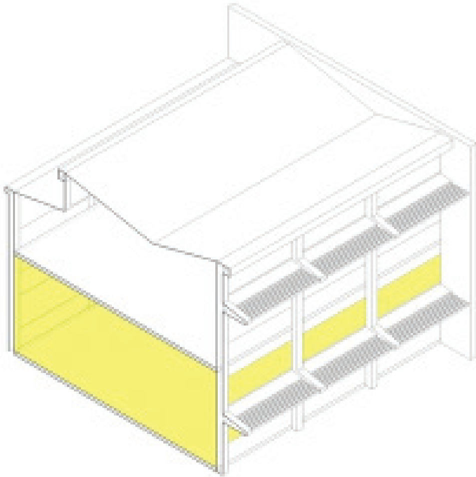


Figure 3 – Isometrics of the northeastern façade. Classroom PD07, used in the case study, is marked in yellow. Source: Authors, 2014.

The first simulation considers the current state of the room in 2014: dark wood floor (original) and medium dark wood panel ceiling (modified from the original project). Externally, the shelf lights and aluminum brise-soleil panels were considered dark since they were dirty and reflected little light. For this model, a clean sky condition on winter solstice (21st of June) at 8 a.m. local time was simulated. Measurements refer to the level that students work on, 75 cm from the floor.

Comparing the current state with a situation with clean shelf lights and brise-soleil panels, there is an average improvement of more than 21 per cent of the room's lighting. This improvement becomes even more relevant if the ceiling is changed for one of light color (in accordance with the original project): 46 per cent better than the implementation without ceiling change, and 83 per cent better than currently.

Simulation results show that maintenance of the natural lighting systems would be sufficient to guarantee good luminous performance for study activities without risk of compromising architectonic integrity.

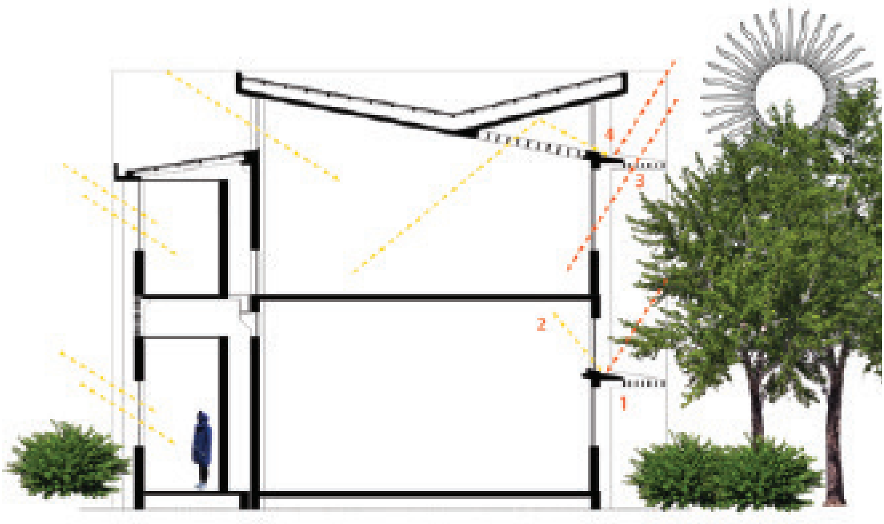


Figure 4 – Schematic cut showing how natural lighting of the room works 50 years after its construction. Source: Authors, 2014.

However, it can also be seen that the lighting level attained is inadequate and needs to be complemented with artificial lighting. Therefore, there is more than one factor to be evaluated in the current state, even wood ceiling, reduced reflectivity of brise-soleil panels and of the dirty light shelves set aside (points 2, 3 and 4 respectively in Figure 4). That factor is vegetation growth in the outside patios (point 1). After 50 years this greenery already has attained adult size, casting shade on the lower classrooms.

5. CASE STUDY B: BLOCK C OF THE *ESPLANADA DOS MINISTÉRIOS*

5.1. ORIGINAL PROJECT PLANS

The standard ministry blocks have tem floors and a total constructed area of 17551 m² each. As a complex, they cover 300 thousand m² constructed area. Other ministries from the construction period of Brasília are located in distinct buildings, as is the case of the Ministry of Justice and the Ministry of External Relations.

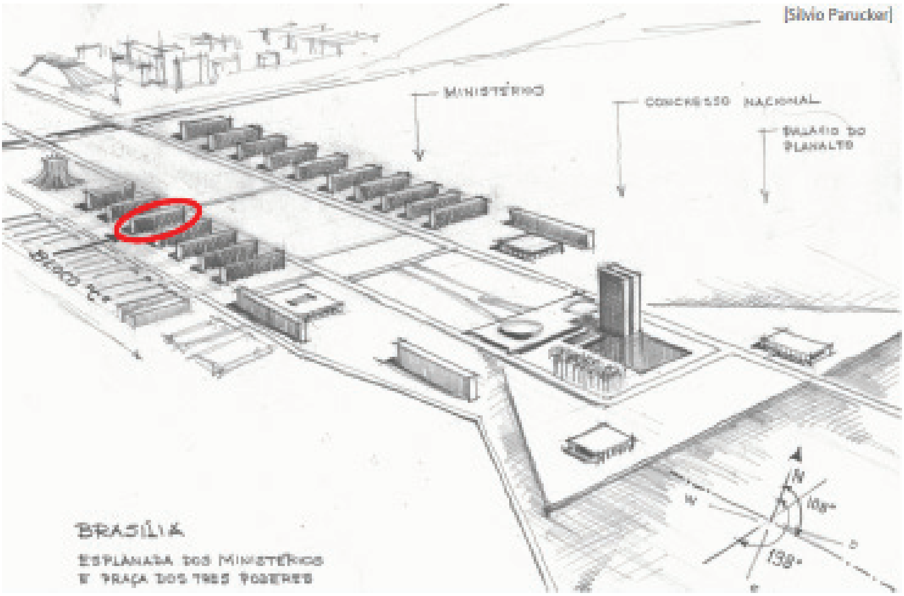


Figure 5 – Esplanada dos Ministérios. Author: Sílvio Parucker

Examining the building's history, it's possible to understand the incorrect and random use of the fundamental concepts of the International Style from World War II onwards. Coupled with the belief that building system theory offered means for the full control of the environmental conditions of any building, this led to a repetition of glass block architecture and its inherent exacerbated energy consumption in the following decades, spread in cities throughout the world (GONÇALVES e DUARTE, 2006).

The standard blocks of the *Esplanada dos Ministérios* that currently count 17 units were positioned in accordance with the implantation concept of the Monumental Axis, that is positioning the main and longest façades in the direction of *Praça dos Três Poderes* and the National Congress. The Pilot Plan was conceived in order to make the sun rise between the towers of the National Congress annex buildings on 21st November. This corresponds to an azimuth direction of approximately 108° to the Monumental Axis. Consequently, on the *Esplanada* the standard ministry blocks of tabular shape, 103m along and 17,5m² across, are approximately oriented along the North-South axis.

The eastern façades, where entrances are located, do not have any form of solar protection. The western façades have vertical brise-soleil panels.

The glass used, blue for solar protection, was not included in the original plan. Neither were the light green brise-soleil panels. Functioning hiccups are notable: windows on the western side cannot be operated due to the brise-soleil panels.

Block C, like the other standard blocks of the ministry buildings, was conceived to function as an open space building. Nonetheless, at some point all ministries opted to compartmentalize spaces, usually employing a central corridor system. It appears that only the Ministry of Culture, under the 2002-2006 government, opted again for an open space arrangement. Privacy was gained; yet compartmentalizing caused moderate prejudice in space quality, especially as concerns natural ventilation and daylight.

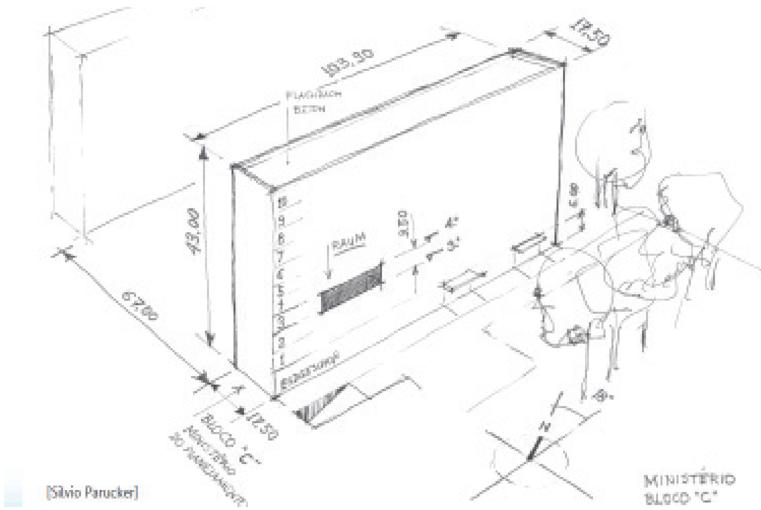


Figure 6 – Dimensions of Block C. Author: Silvio Parucker.

As Brasília was built in 1956-1960, during construction of the Esplanade's standard blocks they were all assembled from metallic structures reflecting the technological standards of an era when building materials were produced partly in Brazil and partly in the USA. The absence of higher attention to material compatibility and unity of the steel of the main structure (pillars and beams connected by rivets), the pre-fabricated concrete slabs (floors and vertical finishings on the northern and southern façades) and of the galvanized steel framework, for instance, resulted in a built complex with high potential for solar energy absorption on all its sides.

Some standard blocks constructed in subsequent decades were built as reinforced concrete structures without adding adequate technology to address thermal comfort. The major challenge of these complexes is offering an adequate set of solutions within the already existing architecture, and without disrespecting the original construction plan of architect Oscar Niemeyer and of the UNESCO World Cultural Heritage Pilot Plan, authored by architect Lúcio Costa. Historical importance notwithstanding, it is necessary to implement technical solutions to minimize the problems mentioned, chiefly among these the thermal bridges between materials, structures and the framework.

The sequence of alterations to the original construction plan is complemented by central air conditioning installations, individual air conditioners on façades, and condensers of small air conditioners also fixed to the façades. The most diverse models and formats are visible accompanied by their cables, supporting structures and connections, electric lighting systems, utility overhauls, and telephone cables.

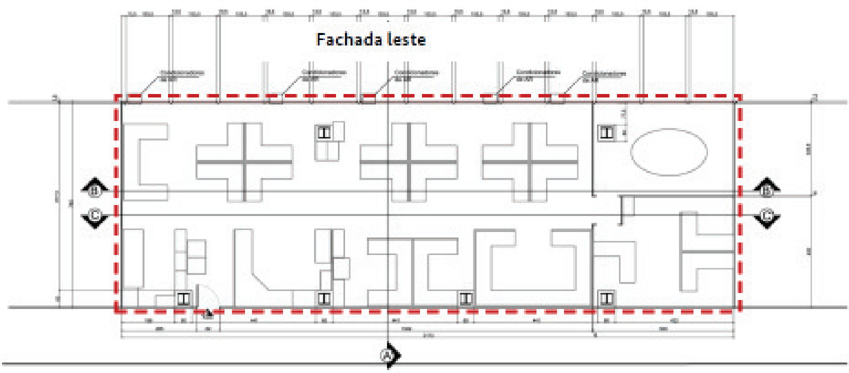
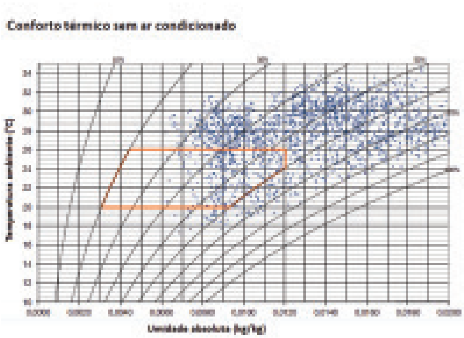


Figure 7 – Typical floor of Block C. Mapped by the authors and TU Munich team.

5.2. CURRENT PERFORMANCE OF THE BUILDING

An evaluation of Brasília's climate, carried out by the project team, resulted in a diagram that shows the inadequacy of a building without planned strategy to deal with climatic conditions. The comfort zone, in the orange box, contains few points, which represent every hour of a typical year. Energy for cooling is required throughout the year and represents an inefficient consumption standard per area.

Figures 7 and 8, obtained from computational simulations carried out by the German project partner, illustrate this.



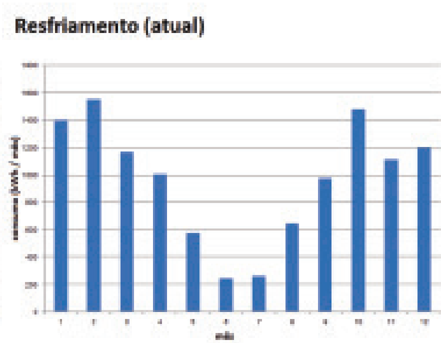


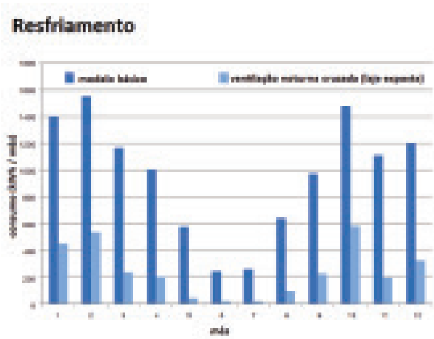
Figure 8 (left) – Typical year in Brasília. Source: TUM
Figure 9 (right)– Current conditions: cooling energy per month

5.3. INCREASING ENERGY EFFICIENCY

Some simple measures were studied. The first was using nighttime ventilation as a way of cooling the building, extracting heat from its concrete slabs (fig. 10).

The second aimed at increasing said effect by removing materials such as carpets and linings from the slabs, allowing for better heat exchange between the building's components (fig. 11).

It was further tried to increase that effect through cross-ventilation. This requires internally rearranging the partition walls that, as previously stated, don't feature in the original construction plans (fig. 12).



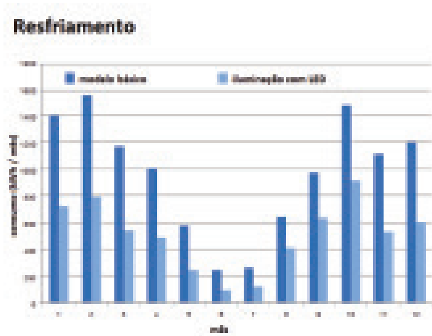


Figure 12 (left) – Nighttime cross-ventilation scenario with exposed slabs
Figure 13 (right) – LED lighting scenario

The last suggested solution is to replace the current lighting with LED. The diagram below shows the impact on energy required for cooling (and not the consumption of light bulbs in itself), as detailed in Figure 13.

Moreover, thermal storage technologies that integrate phase change materials (PCMs) or thermal absorption materials are an adequate alternative for service buildings with low thermal inertia which are not used at night. The dimensioning of ceiling cooling systems by using PCMs also contributes to increasing the efficiency of conditioning systems (heating, ventilation and air conditioning).

In parallel to the use of PCMs it is necessary to overhaul the passive architecture, in order to potentially insert light tables in the intervals of the framework, apply photovoltaic panels on the outside surface of windows, install double glazing for thermal and acoustic isolation, install inlets for cross-ventilation and daytime mechanical ventilation by draft on the raised floor.

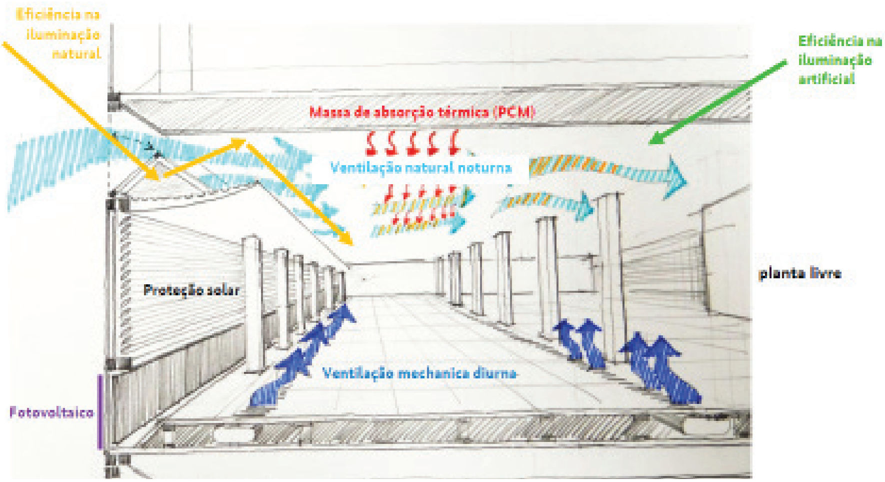


Figure 14 – Inerventions complex. Author: Silvio Parucker

6. CONCLUSIONS

The case studies carried out in *Bloco didático do Centro Politécnico in Curitiba* (temperate climate) and Bloco C in Brasília (dry tropical climate) both demonstrate that:

- The original construction plans featured some passive mechanisms that were lost;
- Usage added up and compromised the spaces' quality;
- Inevitable degradation aggravates the problem.

These three factors appear concomitantly, frequently leading to a negative evaluation of the architecture and not doing justice to reality, to historical context and the authors' intentions.

However, technological deficiencies of the construction period suggest the necessity of renovation. This is particularly notable regarding the frameworks used, with especially poor acoustic performance, and regarding electrical installations. Demand for numerous power outlets did not occur, unlike today. Neither personal computers nor extensive telephone networks existed.

Making buildings more energy efficient requires a renewed vision of architectural concepts in order to promote viable interventions with minimal visual impact. Ventilation and lighting systems based on modern technologies such as microprocessors, LED and phase change materials perfect these interventions.

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A German-Brazilian Research Network on Energy Meteorology:

Supporting the Energy Future ('Energy Meteorology')

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ABSTRACT

As Brazil and Germany both are strongly developing renewable energies to become their major source of energy, it seems evident that they should join part of their efforts to achieve these ambitious common goals. The National Institute for Space Research (INPE) and Oldenburg University are contributing to this by establishing a research partnership in Energy Meteorology. Aiming at long-term activities in the fields of joint research, public-private sector services, and qualification in Energy Meteorology, this partnership is strongly directed towards a sustainable research and development (R&D) infrastructure.

The establishment of a long-term partnership between INPE and Oldenburg University is built on four pillars: structured collaboration, transfer of business model, capacity building, and preparation of a research and development (R&D) project.

The German-Brazilian network on energy meteorology was therefore successfully established, and currently carries out studies for Brazilian and German institutions and companies: several physical meetings of senior scientists and PhD students as well as two medium-term stays of PhDs from INPE in Oldenburg strengthened this collaboration. Today, many informal contacts between various members of both groups attest a living partnership. Through the research stays of two PhD students from INPE at Oldenburg University a significant transfer of methodologies within Energy Meteorology could be achieved while simultaneously valuable feedback of research requirements from Brazilian applications was given. Moreover, the Brazilian Energy Research Institute (*Empresa de Pesquisa Energética* – EPE) added the developed projection methods for energy demand and offer to their own projection mechanism and is currently applying them.

Another major aim was working towards joint German-Brazilian cooperation in a larger R&D project and many activities focused on that point. A post-doctoral researcher from Oldenburg University extensively visited Brazilian stakeholders from R&D and industry with respect to renewable energy integration. This process led to a workshop in December 2013 in Recife in collaboration with Brazilian power company *Companhia Hidro Elétrica do São Francisco* (CHESF).

1. CONTEXT

Both Brazil and Germany have set themselves ambitious goals in order to effectively tackle the challenge of climate change and to follow a more sustainable path in the use of natural resources. In this context the energy sector has always played a vital role. Both nations plan to significantly intensify efforts to reduce energy consumption and to introduce renewable energies as the major energy source in the future.

In this context, the National Institute for Space Research (INPE) and Oldenburg University initiated a partnership in the research area of Energy Meteorology with a long-term perspective. The specific objectives are the establishment of a joint research agenda, the transfer of experience in establishing public-private sector services for the energy industry, and the qualification of trained experts in Energy Meteorology.

The research field of Energy Meteorology is advancing rapidly following the progress of renewable energy technologies for power generation. The expected large-scale integration of renewable energies into the existing energy supply structures – regulated by national and international authorities – will significantly increase the importance of meteorological information due to the strong impact of weather and climate on planning and operation of solar and wind energy systems. The expected future extension of renewable energies will result in large needs of scientific methods for the generation and application of energy-specific meteorological information and its integration in new tools for planning and control of energy systems. Already today, products in the area of energy meteorology show substantial value in the energy market, especially in regions with significant contributions of wind and solar power to electricity supply, where solar and wind power forecasts and user-specific data for resource assessment have been introduced. An increasing number of small and medium but highly innovative companies have addressed this new field of services and are becoming an integral part of the energy industry chiefly in Europe.

Fig. 1 schematically summarizes the influence of the weather on the different aspects of energy production in modern energy supply systems. Due to its strong variability, the energy production rate will have an inherent temporal and spatial variability.

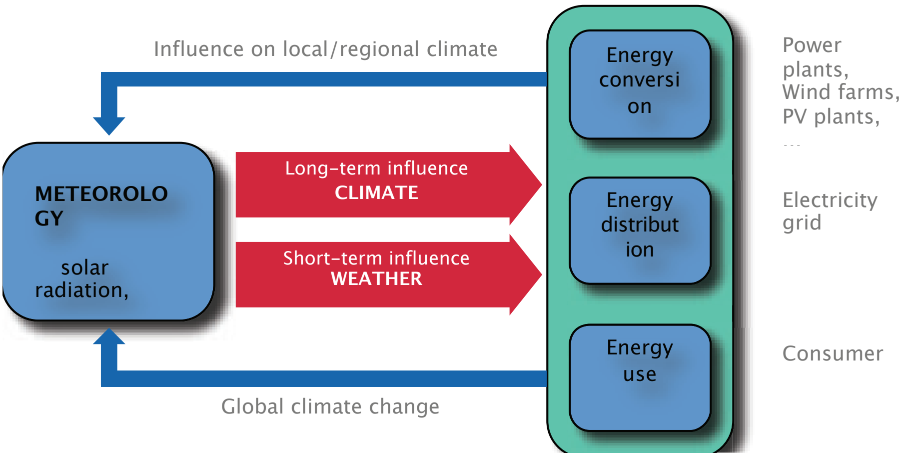

Fig. 1: Schematic description of the influence of weather on production, distribution and use of energy.

One of the main goals of the collaboration was to enable both partners to assess the joint knowledge gained in this area and therefore improve their specific role in their respective domains as well as to contribute to an overall development in this research field by closing gaps in fundamental research and provide operational solutions to problems identified by the energy industry. A major aspect with respect to the relevance of the project was the transfer of basic knowledge through to the application stage. This was ensured by close cooperation with public and industrial partners and the participation of target companies both in the project to be developed and in the planned workshops and seminars. The already established industrial cooperations of the University of Oldenburg were intended to provide some guidance for the Brazilian partner in this context and to establish an industry-related infrastructure. Especially an adaption of the business model for the prediction of solar and wind power production to the Brazilian system is of interest. In addition, significant attention was given to the establishment of a durable educational framework in Energy Meteorology. This will assist in the establishment of appropriate scientific capacity and the ability to successfully participate in international scientific networking.

The Energy Meteorology group at Oldenburg University is a research group addressing this new field of R&D and has been contributing to this field for more than 15 years. The group accrued from the renewable energy research carried out in Oldenburg and consists of more than 25 researchers working on both solar and wind power meteorology. The Energy Meteorology group was one of the first of its kind and is still the only German university group in that area. The group is both developing fundamental methods and providing applied tools in close cooperation with industry.

The Laboratory for Studies and Modeling of Renewable Energy Resources (LABREN) constitutes the Energy Meteorology Team at the Earth System Science Center (CCST) of the Brazilian National Institute for Space Research (INPE). The LABREN is a multidisciplinary laboratory that carries out research and teaching activities of meteorology applied to the energy area and on the impacts of energy in the climate system through the use of satellite data, computational and modeling activities of observational data in the field.

Within its field of activity, the LABREN has installed and maintains the SONDA network of stations for measuring surface solar radiation data (global, diffuse, direct normal, tilted plan, illuminance, spectrophotometry and solar weather data) as well as towers for providing wind speed measurements equipped with anemometers and thermometers. Stations are located in the main climatic macro-regions of Brazil.

2. APPROACH

The main goal of this cooperation was the establishment of a long-term sustainable partnership between the University of Oldenburg and the Brazilian National Institute for Space Research (INPE) in the research area of Energy Meteorology. As both partners are leading groups in this field in their respective countries, this linkage should strengthen their ability to initiate and participate in national and international research programs by complementing their knowledge and providing a critical mass for effective research and education. In the framework of this general collaboration, more specific objectives are the establishment of a joint research agenda, the development of meteorological tools to support public private sector services in the energy sector, involving actors from the industry into the collaboration and the qualification of trained experts in Energy Meteorology. Therefore, to fulfill these objectives, the work was mainly focused on the following activities:

Establishment of cooperation through academic exchange in Energy Meteorology

To pursue this objective, the core of the cooperation was made up of regular mobilization of scientists and post-graduate students from both institutions. A joint research agenda was fixed during the first techno-scientific meetings that took place at the University in Oldenburg and at INPE in Sao José dos Campos in the initial phase of the project. In these meetings, besides the definition of subjects for research work, topics for MSc and PhD theses were proposed and work was initiated. It was settled that German and Brazilian academics and researchers jointly supervise theses, and the Brazilian students which should go to Germany were selected. Regular courses on Energy Meteorology and related topics were set up to be held at each partner's sites. Other important activities in the collaboration were the academic stays of the Brazilian project leader and project coordinator in Germany. During these stays, several seminars and technical visits to different renewable energy institutions and projects were organised. Brazilian and German scientists and students exchanged knowledge and experiences in their field during diverse technical meetings and in seminars and workshops in both countries.

Several research topics were defined for the work in the collaboration: satellite-derived solar irradiance, solar irradiance forecasting, solar spectral information, simulation of large-scale solar and wind power generation, wind power forecasting, offshore boundary layer modeling, atmospheric flow modeling and wind farm effects.

Techno-scientific meetings and contacts with Brazilian and German industry

As a main task of the project extensive contacts, tele- and video-conferences, e-mail correspondences and technical visits to Brazilian stakeholders from R&D and industry were planned and executed. The majority of these contacts were made with the leading electric utility companies in Brazil (CHESF, CEMIG, etc.), Brazilian universities, class institutions like ABEEN, ABRADEE, ABEEolica, ABENS, governmental organizations such as ANEEL, MME, ONS, ELETROBRAS, and EPE.

In parallel, extensive contacts were made with companies and institutions related to energy and renewable energies in Germany with the intention of presenting the collaboration and its objectives. From these contacts, some companies like TenneT TSO GmbH, Suntrace GmbH, Fraunhofer ISE, Overspeed GmbH & CoKG, and Solar Tower Systems GmbH Germany reacted with much interest in future cooperation work, including sending personnel to project meetings and workshops in Germany and in Brazil.

A very valuable contribution to generate contacts in the Brazilian energy sector originated from the project's cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH's team in Brazil. After a first meeting in Rio de Janeiro with GIZ and EPE members, an intensive cooperation with GIZ was initiated. A great deal of synergies between the project activities and some activities of the energy program of GIZ in Brazil were identified. Due to the fact that GIZ has been an important and long-term partner to the energy sector in the country, this considerably facilitated the contacts that had to be made in order to integrate actors from industry and energy market in the project development.

Organization and realization of workshops in Brazil and Germany

A very important mechanism to achieve the objectives of the project was the planning, organization and evaluation of various international workshops in both countries. Two of the workshops were organized as side events of international congresses. One within "The IV Brazilian Solar Energy Congress (IV CBENS) and V ISES Latin American Conference (V ISES-CLA)", which took place in São Paulo, Brazil, and the other during "The German Wind Energy Conference DEWEK 2012", which took place in Bremen, Germany. A third workshop was organized jointly with CHESF and took place at CHESF's headquarter in Recife in December 2013.

Firstly, the workshops were an instrument to present the project to a large public at an international level and to open a platform for discussion between institutions and professionals from industry and science involved in the subject of integration of renewable energies to the electricity grid of both countries. Besides this, the workshops served as a valuable tool for disseminating the concepts of Energy Meteorology in the framework of the collaboration between Brazil and Germany. The workshops, besides providing a more intense integration of the experts involved in the collaboration, also served as an opportunity to initiate further partnerships with other research-related institutions which could contribute to the project's overall objectives.

The subjects for the workshops were chosen in a way that it was possible to identify the state of the art and the real needs for meteorological tools and methods applicable to the Brazilian energy market in its current situation. In this way the project team could gather important information directly from end users about the real demands in this area, which should be used to focus and to adapt the research work in order to attain the project's objectives.

With this in mind, stakeholders from industry and science from both countries were brought together to exchange and share knowledge on the development of Energy Meteorology services. Experienced invited speakers from both countries took part in the events as lecturers. The Brazilian guests presented the state of the art of renewable energies in Brazil and the different efforts that are taking place to the integration of solar and wind energies to the country's energy matrix. The German speakers gave a broad overview of how the German energy industry is utilizing methods and tools from Energy Meteorology to operate and control the electricity grid. Discussions during and the talks after the events were of great interest to all participants and after the second workshop a first concrete idea for a future collaboration with the Eletrobras Utility Company CHESF had been outlined.

Fig. 2: Photo from the workshops in Sao José.

Capacity building

One of the major aims in establishing this cooperation project was the advancement of young scientists within the new research area. Therefore, the core of the project was based on regular exchange of post-graduate students and researchers from the partner institutions to develop the research work necessary to attain the project's goals. Following the definitions of the specific topics for PhD theses, students from Brazil, with financial support from CAPES, started their studies in Brazil and continued them in Germany under the joint supervision from Brazilian and German academics. The subjects were related to solar and wind energy applications in Brazil taking into consideration of the impact of climate change on these technologies. German and Brazilian academics and researchers jointly supervised the PhD theses.

Preparation of R&D project proposals involving the industry

A substantial part of the work developed in the present project focused on the preparation of a R&D project proposal involving the energy industry of both countries. A great deal of effort and time were dedicated to establishing contacts in order to establish conditions for the integration of industrial partners into the project. For this task, a post-doctoral researcher from Oldenburg University extensively visited Brazilian stakeholders in the area of renewable energy integration, both in the field of R&D as well as in the energy industry. Contacts with the leading private energy companies and governmental institutions were established, resulting in a detailed identification of potential collaborations between German and Brazilian partners in R&D and industry. As one outcome, a large joint R&D project with actors from industry and energy market was outlined and became the subject of a dedicated workshop held in December 2013 in Recife, organized by CHESF.

In addition, both research teams worked together to identify suitable Brazilian R&D initiatives to provide solar radiation data and contribute to prospective assessment of Concentrating Solar Power (CSP) technology for electricity generation in Brazil. This work was funded by GIZ and provided a survey of projects, initiatives and studies that aim to support the evaluation of available solar measurements and its potential for the development of projects related to CSP in Brazil.

3. RESULTS

Establishment of long-term partnership with INPE and the establishment of a network in Energy Meteorology

The establishment of a long-term sustainable partnership between INPE and Oldenburg University in the area of Energy Meteorology was the overall objective of our NoPa project. Besides the project activities already mentioned, it is important to highlight the close contacts, formal and informal, that exist nowadays between senior scientists and PhD students of both institutions. The exchange of teaching material is also an important activity in the cooperation. Taking into account the ongoing joint supervision of two PhD theses, a study carried out in collaboration with GIZ and EPE, and the preparation of future collaborations beyond NoPa, we can affirm that the partnership is established on a stable basis.

The establishment of an interdisciplinary network in the new research area Energy Meteorology was intended to be a result of the partnership and was another focus of the project. The four workshops that happened during the project played an important role towards the achievement of this objective, since on those occasions several scientists, technical experts and stakeholders from the energy sector of Brazil and Germany were brought together. In Germany or in Brazil they discussed ideas concerning the increasing contribution of renewable energies to the energy supply and the great importance of weather and climate factors, and the development of scientific tools for planning and operation of energy systems. These contacts continue to be preserved, formally and informally, and new contacts are constantly being made by both partners concerning the enlargement of the network.

Research proposal 'Supporting Development for Renewable Energy in Brazil's Northeast Region'

Most of the activities developed during the entire project focused on the definition of a concept and the preparation of a joint comprehensive R&D project planned in collaboration with the company CHESF. Following extensive contacts and technical meetings with the utility's representatives, a technical workshop was jointly organized with CHESF, which took place at CHESF headquarters in Recife in December 2013. As an outcome of this workshop, a preliminary project proposal was prepared and discussed with

CHESF's staff. According to these negotiations and the following discussions, the project proposal encompasses the following topics:

- RE Master plan for the Northeast of Brazil;
- SP Feasibility studies and development support;
- Support for research and selection of a pilot plant site.

The intended research proposal was prepared jointly with partners from German industry and academics (Suntrace, Solar Tower Systems GmbH and Fraunhofer ISE) and the project partners. It particularly concerns the assessment of solar data available in Brazil, and the potential of its use for the evaluation, development and monitoring of projects related to CSP technology for electricity generation and other purposes. In general this topic encompasses aspects like technology screening and modeling (including conventional power generation like hydropower), and methods for site selection and feasibility studies for large solar energy projects in Brazil. One interesting aspect of the proposal is the analysis of the viability of combining CSP, hydropower and biogas technologies as a hybrid system to generate electricity in Brazil.

A broader project proposal is intended to strengthen the sustainability of this initial cooperation, extend the initiated research work of both partners, and integrate actors from industry and energy market. The latter may also act as possible financial support to the establishment of an international technological and scientific focal point in the interdisciplinary field of energy meteorology research concerning specifically the CSP technology.

Study on "Identification of R&D Initiatives to evaluate the prospective of Concentrated Solar Power (CSP) for electricity generation in Brazil'

As a result of an offer submitted in response of the Term of Reference announced by the GIZ-BR in August 2013, the NoPa project partners jointly carried out the study "Identification of Initiatives to Evaluate the Solar Potential of Brazil for the Generation of Electricity by Concentrated Solar Power (CSP)" in collaboration with EPE in the framework of the bilateral German-Brazilian program "Heliothermal Energy (DKTI-CSP)" from GIZ and the Brazilian Ministry of Science, Technology and Innovation (MCTI). The study deals with an assessment of solar radiation data for the application of CSP technologies in Brazil, and encompasses the identification and analyses of projects and initiatives related to the measurement of solar data with respect to its usefulness for future CSP applications. A proposal for the creation of a Brazilian network of solar measurement stations and a corresponding database has been an output of this study. Fig. 3 presents the direct normal solar irradiance in Brazilian territory together with the data acquisition site locations for the proposed Brazilian Network. The study was finalized in July 2014.

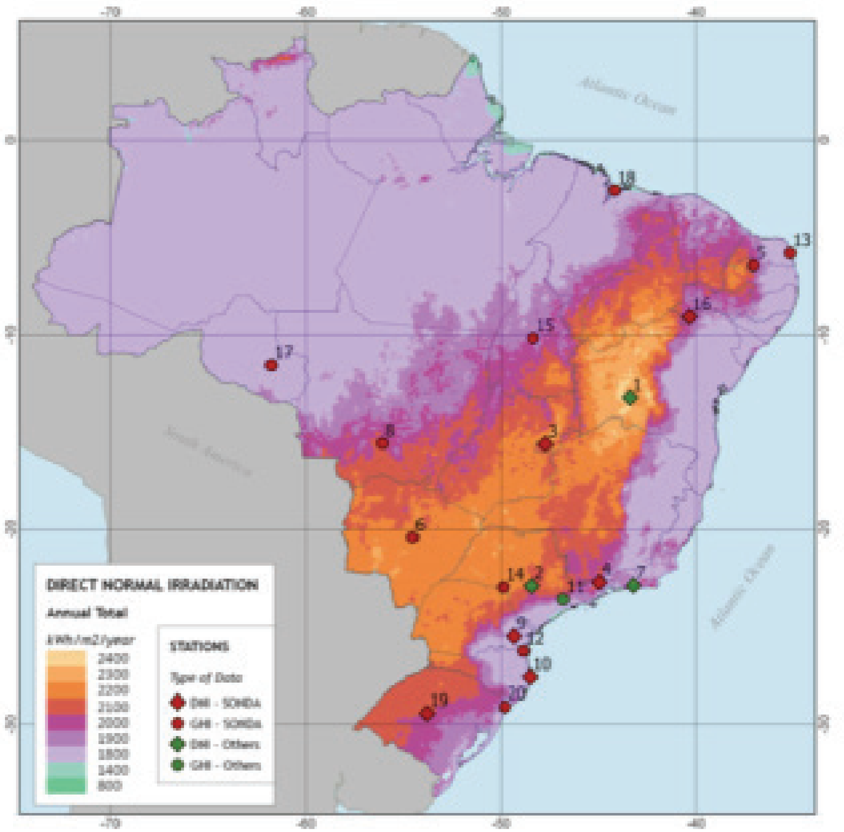

Fig. 3: Map with recommended stations for measurements of Direct Normal Irradiance (DNI). Additional stations from UNESP, USP and CEPEL are shown.

Scientific reports of Brazilian PhD students related to their study missions in Germany

The PhD student Francisco J. L. Lima developed part of his research at the University of Oldenburg. The title of his research is "Forecast of solar irradiation in Northeast of Brazil using WRF models and Artificial Neural Network (ANN)". The PhD research aimed to develop a method to forecast surface solar radiation in Northeastern region of Brazil by using the Weather Research and Forecasting (WRF) meso-scale model integrated with Artificial Neural Network (ANN) technique. The ground data acquired at automated weather stations (AWS) managed by the Brazilian Institute for Meteorology (INMET) was used in this study covering the seven year period from 2005 to 2011. Several predictor combinations and network topologies were evaluated in order to define the ANN setup. The best ANN configuration was achieved using a group of ten predictors taking into consideration the lowest forecast deviation from observational data. Besides that, comparison between ANN and multiple linear regression (MLR) outputs were prepared and the results pointed out a significant difference between the two techniques. The ANN provided solar radiation forecasts presenting lower bias and Root Mean-Square Error (RMSE) than MLR and genuine WRF outputs. The Pearson correlation coefficient value obtained for ANN forecasts was higher than the MLR or WRF forecasts. Two articles are being prepared as result of this research and will be submitted to international journals. The thesis defense is scheduled for June 2015 at INPE.

The Ph.D. student Marcelo P. Pes developed part of his research at the University of Oldenburg. The title of his PhD research is "Impacts of variability and climate changes on extreme winds and its effects in Brazilian energy sector". His study focuses on the aspects of the occurrence of minimum and maximum extreme winds at 10m height, its probability distribution, return period and climate trends. The analyses, making use of historical wind speed time series at 10m height acquired at 42 stations managed by the Brazilian Airspace Control Department (DECEA) in Brazilian airports, as well as time series from the meso-scale regional circulation model Eta HadCM3 for the period from 1960 to 1990 and future projections between 2010 and 2100. The results of the trend analyses indicate an increase in the minimum wind speed along the Brazilian coast, mainly on the Northeastern coast, and inside the continental area near the coast. On the other hand, the maximum wind speed increased within the North, Midwest and Southeast of Brazil. The study also identified regions with higher risks of structural damage in wind turbines based on the frequency of occurrence for the maximum wind speed. A research article has been prepared and will be submitted to the Renewable Energy journal. The thesis defense is scheduled for May 2015 at INPE.

Research visits of Brazilian researchers in Germany

During the course of the project two work missions occurred. The Brazilian researchers, Dr. Fernando Ramos Martins and Dr. Enio Bueno Pereira visited the University of Oldenburg as short time exchange visitors to carry on the preparation of a comprehensive R&D research project proposal according to the project's goals as described in this paper. Also during their stay they presented their research findings to German students and researchers concerning satellite-derived solar irradiance, solar and wind power forecasting, and solar spectral information. Both missions also contributed in deepening exchange of knowledge in energy meteorology by discussing radiative transfer modeling techniques, satellite data handling, and wind forecasting methods. Also, both visits were very productive in the preparation of further partnerships with other research-related and energy-related institutions. Dr. Pereira will continue his cooperation with Oldenburg University during a planned stay at Hanse-Wissenschaftskolleg (HWK) Institute for Advanced Study in Delmenhorst, located near Oldenburg.

Minutes and Workshops

Four workshops were carried out during the NoPa project. The kick-off meeting was held in February 2012 at INPE in São José dos Campos and aimed at promoting the integration between the research groups from both institutions. Five investigators from the Energy Meteorology team at University of Oldenburg went to Brazil and were engaged in lectures and round-table discussions together with Brazilian students and professors from several interested Brazilian institutions: INPE, the Federal University of Alagoas, the Federal University of Brasilia, and the Federal University of Itajubá. Approximately twenty people participated in the three day event that allowed an interesting opportunity to discuss the basic concepts and approaches of meteorological science applied to the energy sector. The German experience was presented and compared to the activities under development by the Brazilian participating institutions. Simultaneously, the goals and agenda for joint activities of INPE and Oldenburg University in the framework of the NoPa project were proposed, discussed and established in the last day of the workshop.

The second workshop occurred during the IV Brazilian Congress for Solar Energy (CBENS) held in September 2012 in São Paulo. The event aimed at disseminating the research activities related to solar and wind resource assessment and forecasting developed by INPE and Oldenburg University. The major focus was to provide relevant information on solar and wind energy assessment and forecasting related to requests provided by the Brazilian energy sector. Invited lecturers from the Federal University of Santa Catarina (UFSC) and of the Empresa de Pesquisa Energética (EPE) presented the information demand and required data from energy sector for energy meteorological services.

The third workshop was held in Bremen, Germany, as part of Deutsche Windenergiekonferenz (DEWEK) 2012, a major wind energy conference. The event was very similar to the one held in São Paulo. It presented the same goals but focused on information dissemination on wind energy in Brazil for the interested German wind energy researchers and energy entrepreneurs.

The last workshop occurred at Universidade Federal de Pernambuco in Recife in December 2013. This meeting was focused on planning a long-term research proposal involving INPE, Federal University of São Paulo, Federal University of Pernembuco, Oldenburg University and CHESF. The proposal aimed at the regional evaluation of solar energy resources for a CSP plant located in Northeastern region of Brazil.

4. CONCLUSIONS AND FINAL COMMENTS

The NoPa program systematically promoted the long-term partnership in the field of Energy Meteorology between INPE and Oldenburg University. Although not aiming at research, it provides the framework for extended research collaborations and projects. As a result, the cooperation between the partners is built on a solid basis with many formal and informal contacts and scientific exchange. Further activities are already planned.

However, it would be very helpful for the sustainability of the initiated partnerships if follow-up programs would allow already existing partnerships to participate. Thus cooperation initiatives started within the program could be further developed.

The contributions from DAAD ad GIZ to the process of establishing contacts in the Brazilian energy sector has shown to be very successful. The strong interconnection during the project was essential for effective communication with stakeholders from Brazil.

A successful exchange of PhD & MSc students depends highly on local constraints and conditions. This should be improved, especially so that Brazilian students do not face any disadvantages in their studies when returning from their stay in Germany.

5. PUBLICATIONS

Joint publications form the Brazilian and German partners related to the collaboration:

Lima, F. J. L., Martins, F. R. and Pereira, E. B.: d WRF models with statistical refinement over northeast of Brazil, in preparation, 2015.

Capacity Building and Fundamental Research to Develop and Implement a Mechanical Biological Treatment Facility (MBT) with an Integrated Fermentation stage in Jundiaí (Brazil)

Dr. Prof. Klaus Fricke (TU Braunschweig), Esp. Eng. Adva Christiane Pereira (TU Braunschweig), Dr. Prof. Tacio de Campos (PUC-Rio), Esp. Aguinaldo Leite (Prefeitura Municipal de Jundiaí)

Technical University of Braunschweig
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ABSTRACT

Waste management has changed significantly in the last years, becoming an icon of sustainable development, contributing to environmental protection and guaranteeing climate protection and the preservation of natural resources. In this context, Brazil recently passed a National Solid Waste Policy, which provides for selective collection and treatment of waste before final disposal, and reverse logistic, among other requirements.

The development of technology, technical consulting and state-of-the-art machinery are necessary to implement the Policy. In addition, sustainable waste management systems must be developed to mitigate the environmental impact generated over the last few decades in the country. This poses a considerable challenge due to the limited expertise available to develop the necessary technology and to streamline them into the Brazilian market, which, in its turn, results in faltering decision-making at all public levels (federal, state and municipalities) as well as other relevant stakeholders, such as financing and environmental licensing agencies.

In this project we accumulated differentiated and pioneering knowledge, given that the National Solid Waste Policy is recent and the first actions in Jundiaí were taken less than two years ago. Through this experience, it was possible for the involved actors to understand the problem of solid waste generation in the city, the instruments of the National Solid Waste Policy, learn the ways of generation, treatment and disposal of residues adequate to their natures, meet treatment and minimization of environmental impacts technologies, thus broadening the discussion with society on the sustainable management of solid waste.

Further, the experience lived by both internal and external capacity building makes them able to establish relationships with other areas of knowledge, present a systemic view regarding the organization of work capacity and alignment with the trends related to the area. For instance, the municipality of Jundiaí established a working group with all stakeholders to implement results of the project and pursue German-Brazilian cooperation in the area. The establishment of the Brazilian Center for Research, Education and Demonstration in Waste Management (CREED) also ensures further capacity building and the practical implementation of research results.

Thus, the experience of sharing is not limited to the executing team. It spreads through society that had its horizons expanded: it received access to information which outlines new practices of waste management and mainly enters into a common commitment for environmental preservation and climate protection for the benefit of future generations.

Keywords: Capacity building. Research. Cooperation. Residues. Mechanical and Biological Treatment.

1. CONTEXT

The urbanization of Brazilian cities and rising living standards present new challenges for the waste management of the consequently growing waste deposits. These changes demand an adaptation and creation of new strategies in the area of waste management with the objective of promoting recycling and valorization as well as creating sustainable development and intensifying environmental responsibility in Brazil.

The differential impacts generated by urban solid waste justify the necessity of concrete interventions, possible only from the design of appropriate management programs. In this sense, the use of technology, machinery and technical assistance is essential, both specialized and compatible with proper management, covering issues such as waste management, economic viability, environmental preservation, quality of maintenance of the public health, urban landscape and even generate employment and income.

Currently, approximately 42 per cent of the municipal solid waste (MSW) in Brazilian cities is deposited inadequately as regards environmental protection, while the index for composting only reaches 5 per cent in 211 municipalities and the recycling rate doesn’t reach 4 per cent of the produced MSW, meaning that currently the proper solution is still sanitary landfill.

In this context, the Brazilian government passed the new legislation Nº 12.305 in 2010, the Solid Waste National Policy (SWNP), to facilitate and enforce selective collection, waste treatment and recycling strategies before final disposal in the whole country by the end of 2014. Hence, garbage dumps are forbidden, emissions must be reduced and the recycling rate must increase.

But due to the limited expertise available to develop the necessary technology and products and to streamline it into the Brazilian market, faltering decision-making causes negative effects on all public levels as well as on other relevant stakeholders. For example less than 30 per cent of the municipalities submitted a MSW management plan until the end of 2013, which was demanded in the SWNP.

In addition, the field of waste treatment and secondary products shows a distinctive lack of knowledge about the quantity and quality of possible resources from the residues sectors. This also has an effect on the qualified human capital, which is absolutely necessary to build a substantial waste management on all levels. Moreover, corresponding strategies and methods regarding capacity building and further training and education centers are missing.

It is in this context that the research project implemented in Jundiaí has the objective to generate results aimed at fostering multidisciplinary discussion integrating various market segments to enable the design of tools for the implementation of sustainable management of municipal solid waste.

The completion of the project also provided comprehensive global knowledge of this new market and also the construction of an interrelationship with the waste sector in a Brazil - Germany framework, establishing an exchange with German institutions that are experts in practice, ensuring climate protection and the preservation of natural resources. This way a permanent exchange of experiences through vocational and technological education was made possible.

2. APPROACH

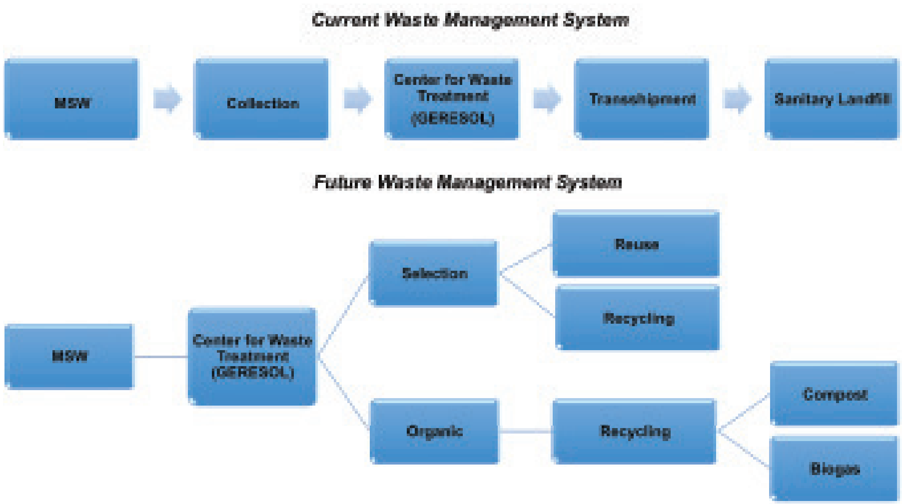
To fulfill the governmental requirements and create sustainable knowledge in this area, the municipality of Jundiaí aims to develop an eco-efficient urban solid waste management system and, more specifically, the construction of a fermentation plant in order to enable a Mechanical Biological Treatment (MBT) for MSW.

For the concept development, it is essential to determine the potentials of the different feedstock and remnant materials which are available in the region of Jundiaí and can be used for fermentation and other purposes. By conducting this potential analysis, possible raw materials can be differentiated into the sectors of municipal and private waste.

In addition, the formation of qualified personnel will be ensured through the Brazilian Center for Research, Education and Demonstration in Waste Management (CREED). It includes an on-site laboratory to conduct all relevant analysis and researches, offers training, information and consulting for decision-makers, the public administration, the waste management and energy industry as well as the regulating agencies in the Jundiaí region and beyond.

This project also increases the research and education capacities of two local universities (PUC-Rio and Anchieta Jundiaí) in the field of waste management. In this context, the TU Braunschweig, in cooperation with the PUC-Rio, developed a waste treatment concept for the city of Jundiaí (see Picture 1).

The city of Jundiaí is located 60 km northwest of São Paulo, with 397.965 inhabitants and an area of 431.969 km2 (IBGE 2014). The Department for Public Services already covers 95 per cent of the collection of MSW, which reached an amount of 140.000 t/a in 2014. Furthermore, wastewater treatment is covered for 100 per cent in urban and rural areas of Jundiaí. The municipal annual budget for 2014 was 500 million Euro, while the Department for Public Services receives 8,5 per cent of the total budget, approximately 42 million Euro.



Furthermore, a market analysis concerning the product lines of compost and biogas including their succeeding products was conducted in the region of Jundiaí. The gained product information and knowledge fed into a modeling of the feedstock mass flows, which can be integrated into process engineering and helps to create and manufacture products at the MBT and the downstream infrastructure.

Basically, this project consists of three main blocks: the collection and evaluation of data on the implementation of the fermentation stage, building and extending both academic and non-academic training as well as education capacity and, finally, extending research capacities at PUC-Rio.

This research approach addresses the current state of the art in technology and economy, which is based in the practical research and creates an interdisciplinary and transdisciplinary environment. All in all, the following activities have been implemented so far:

1. Continuous development of the qualification provided to relevant technical staff of the Jundiaí Municipality;

2. A statistical survey and evaluation of the waste generation of large generators, to obtain qualitative and quantitative data in order to predict a proper dimensioning of the treatment plant;

3. Equipment surveyed to be implemented at the specialized laboratory;

4. Legal conditions assessed for the formation of the CREED;

5. Waste studies planned and conducted, focusing on the qualitative and quantitative assessment of MSW;

6. Communication conducted to disseminate project information;

7. Basic project developed for the specialized laboratory; and

8. Pilot composting technique.

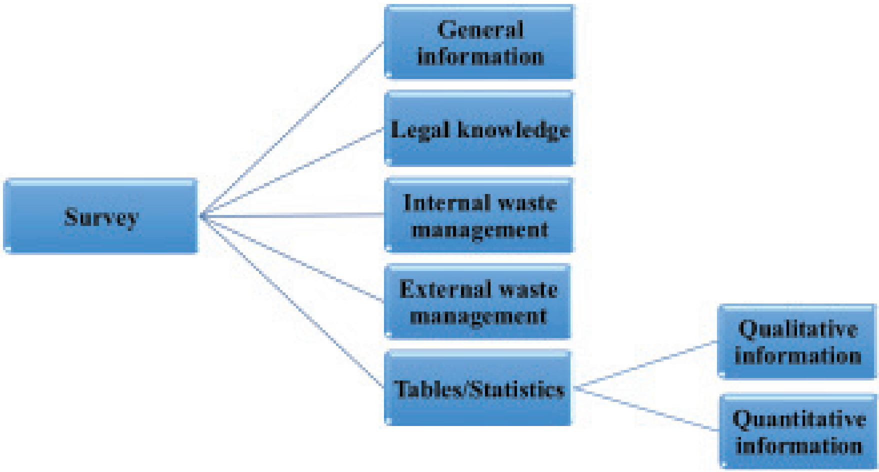
During the implementation of the project we were faced with a number of challenges, namely: lack of legal prerogatives, lack of awareness in the community and the private sector, need for protection of industrial property, bureaucratic procedures tied to government practices, non-existent databases, lack of interaction between actors, communication difficulties and individualization of practices.

3. METHODOLOGY

Products developed from the implementation of the project corroborated to generate an intelligent information network, facilitating access to the database for all involved, even identifying the demands of training and producing results that bolstered the city's decision-making as refers to the development of the environmental education program and definition of the technological route. The project was divided into a survey for evaluation of large generators, waste analysis, capacity building, technical cooperation and CREED implementation.

3.1 CHARACTERIZATION OF LARGE GENERATORS

Through questionnaires, it was possible to characterize the scenario where the municipality of Jundiai fits, from the generation of municipal solid waste, but also in relation to large generators, understanding on the allocation of various materials and the difficulties of managing systems, both public and private. The prepared questionnaire contained 58 questions and addressed the following aspects: project identification and general information, legal analysis, system of waste management in the company, external solid waste management, evaluation of services, and composition of waste (see Picture 2). The statistical survey focused on the evaluation of large generators, that is private companies such as industries, services and commerce.



This first-time characterization of large generators is important for a proper definition of future waste streams and an analysis of potential partners in the industry and service sectors.

3.2 WASTE CHARACTERIZATION

The characterization of municipal solid waste is an important tool for the development of technological concepts of treatment plants, allowing to select the best technologies and adapt them to the existing material flow from the gravimetric, granulometric and analytics analysis. It not only allows for sizing the equipment but also choosing the best techniques according to their employability potential in the operational flow and responsiveness of the consumer market of secondary resources.

Throughout the gravimetrical analysis, it was possible to gain basic information about the waste composition and quality of the MSW in Jundiaí as well as obtain a prognosis about future waste generation. Furthermore, the waste collection for the analysis was divided into two campaigns in order to gain significant and representative laboratory results.

Factors like spending capacity, socioeconomic aspects, urban development and the commercial, industrial and residential activities separated the selected districts.

The first campaign was performed in April 2014 and contained waste samples from the districts Jardim Paulista, Malota, Eloy Chaves and São Camilo, while the second campaign was performed in October/November 2014 and additionally contained samples from the districts Jundiaí Mirim, Sta. Gertrudes, Fazenda Grande, Champirra, Morada das Vinhas and Vila Maringá. All in all, 25 routes covered approximately 49 per cent of all municipal districts. Detailed information on the waste characterization is summarized in Table 1.

During the gravimetric analyses, the quartering process was realized according to standard norm ABNT NBR 10007:2004. For campaign 2, residues also suffered actions of disruption of the bags in order to obtain more homogeneity and thus, representative samples. This procedure involved the sharing of a waste stack in four parts to achieve a total mass of 180-200 kilograms. The screening process enabled representative grain size data for every fraction of the collected waste samples, which got weighted before and after the screening. Both campaigns included gravimetric analyses and further laboratory studies to define the amount of dry solids and the ignition loss in the material. Subsequent to the grain size and gravimetric analysis, the major samples (>80 mm) were analyzed for their potential use as combustible derivate, while the minor samples (<80 mm) were also analyzed for their potential of valorization, utilization for biogas and composting. The amount of biomass was determined as well.

Waste characterization	Campaign 01	Campaign 02
Realization period	10 working days	30 working days
Persons involved	~ 16	~ 26
Sample routes	5 routes	15 routes
Total routes	25 routes	
Percentage of routes attended	80 %	
Total quantity of sampled waste	818.3 kg	2853.05 kg
Quantity sampled daily	180 kg	
Percentage sampled from the truck	2 %	
Population attended	54524	111200
Total population in 2014 (IBGE)	397965	
Percentage of attended population	42 %	
Quantity of neighborhoods attended	63	141
Total quantity of neighborhoods of the Municipality	420	
Percentage of attended neighborhoods	49 %	

4. RESULTS

4.1 TECHNICAL COOPERATION

The binomial signed by technical failure and business demands of the Brazilian market of MSW corroborated for an interlaced intervention of various institutions that dominate remarkable knowledge in Germany, such as TUBS, DBFZ, DAAD, GIZ, BMBF and KFW.

The concept of technical cooperation adopted during the project consolidated sharing efforts and benefits, in light of the impact and scope of the market in the public, private and academic sphere, enhancing mechanisms of negotiation, evaluation and management of the projects, in order to expose them to the national priorities, ensuring necessarily to climate protection and preservation of natural resources, and strengthening institutions.

As was expected, the project reverberated beyond the borders of Jundiaí, arousing interest from entities sensitive to the topic such as the municipalities of Florianopolis, Votuporanga, Paulista, Petrolina, Cuenca and Lüneburg, but also renowned institutions as CIESP, KFW, FINEP and SENAC.

These institutions, each one according to their skill, acted in the form of technical cooperation, constituting an important instrument of development. This helps Brazil to promote structural changes in their production systems toward a sustainable management of solid waste as a way of overcoming restrictions that are hampering the natural growth of this new market.

The technical cooperation programs implemented allowed to transfer knowledge, experiences of success and sophisticated equipment and management programs. Thus, it contributed to empower human resources and strengthening institutions, enabling a qualitative upgrade of the waste market.

4.2 CHARACTERIZATION OF LARGE GENERATORS

First of all, a definition of the term large generators was submitted: establishments, such as restaurants and bars, hotels, barracks, markets, cemeteries, public buildings as well as commercial and industrial sectors, which generate waste up to 400 liters/d, and hence demonstrate the responsibility of the municipality of Jundiaí. Further parameters of the statistical survey are shown below, in Table 2.

Parameters of the statistical survey		
Survey period	5 months	(May to September)
Involved workers	23	
Amount of questioned institutions	232	
Amount of participants	224	1% of the population
Amount of registered institutions in Jundiaí	22.726	Department of Economic Development, Science and Technology, Base 2013

Based on the questionnaire, the economy of Jundiaí is defined as intensely industrial and service-oriented with an amount of 30 per cent and 33 per cent respectively, while the commercial sector represents 19 per cent of all surveyed companies. Although there is a wide range of different products fabricated in Jundiaí, the production of packaging dominates with an amount of 25 per cent. Overall 85 per cent of the companies offer a staff restaurant, which illustrates a significant production of biological waste and therefor a high potential for valorization.

The survey showed that a rate of 31 per cent of the companies already possesses a waste management division and 22 per cent have a waste plan available. Meanwhile, 50 per cent of the companies just assign the responsibilities to the technical or safety staff, which demonstrates a lower interest for this area in the company.

Moreover, this survey revealed management issues in the commercial and service sectors as well as in schools, which expressed faltering data knowledge regarding the disposal of waste, such as quantities, input and output values of materials, recycling and disposal. Even in more instrumented companies, such as the industry, the survey pointed out an insufficient handling of quantitative and qualitative data control, with surprisingly marked lacks of experience, and ignorance.

Some employees answered the questionnaire tentatively, because they seemed not properly guided and informed about the data and activities of the company regarding waste management, thus undermining the questionnaire by the interviewers. However, 91 per cent of the companies already separate their waste on the basis of minimum two fractions and 52 per cent gain a recycling rate over 50 per cent. Yet, the companies revealed major difficulties with the system of reserve logistic, especially with the disposal of electronics, batteries and fluorescent lamps, which is included in the SWNP.

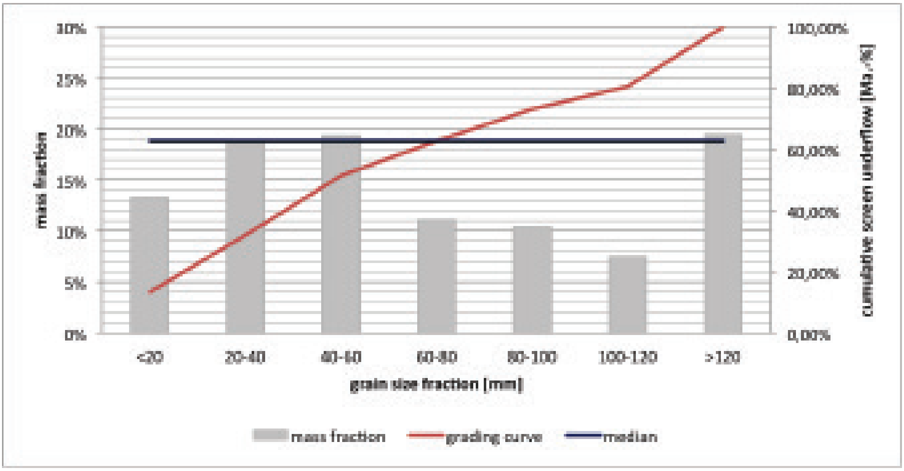
The survey showed that 81 per cent of the companies are interested in a partnership with the public sector in order to improve their entrepreneurial waste management and offer further training and education.

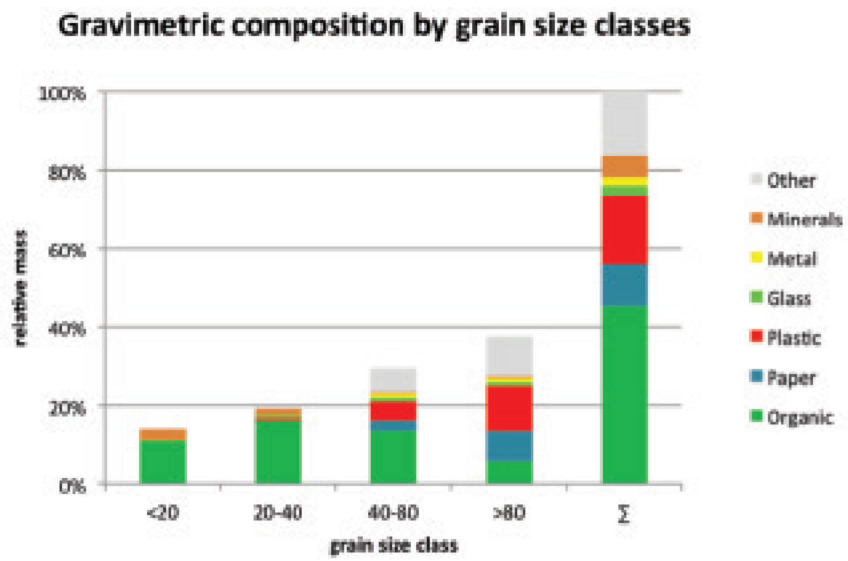
Considering that communication between the public and private sectors in Brazil is quite unusual and therefor a lack of information exists, this survey helped to gain important information about the entrepreneurial waste management for the Municipality of Jundiaí and also showed potential for further cooperation and an exchange of information between the sectors.

On this basis, the Municipality of Jundiaí identified weak points as well as various possibilities, which facilitate further strategies for an enhancement of the regional waste management. This enforces a foundation for the achievement of a comprehensive sustainable waste management in the region.

4.3 WASTE CHARACTERIZATION

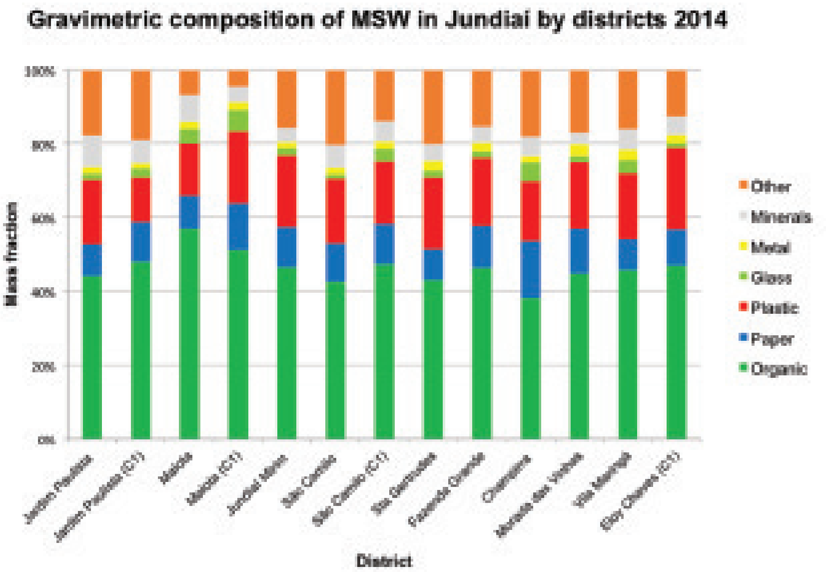
The results of the gravimetrical analysis showed significant data on the composition of the MSW in Jundiaí including a characterization of grain sizes. The chart in Picture 3 contains the results of the screen analysis, which shows the highest mass fraction lies between the classes 20-60 mm and over >120 mm. The grain size classes up to 80 mm contain a large amount of organic materials, whereas the classes above 80 mm contain mostly plastic fractions and relatively high amounts of textiles and other adequate materials for the use of RDF (see Picture 4).



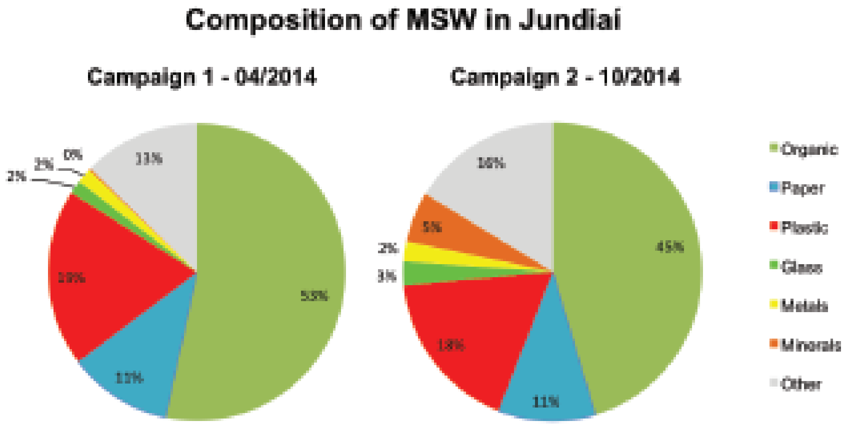


In addition, the waste composition of the analyzed samples showed almost no significant differences between the districts in Jundiaí, as it can be see in

Picture 5. Only the collected samples from the wealthier district of Malota presented higher rates of organic material and significantly less residual waste in both campaigns. These may correlate with a divergent consumer behavior (e.x. package orientated), a higher income or a proper will for waste handling and separation in this neighborhood.



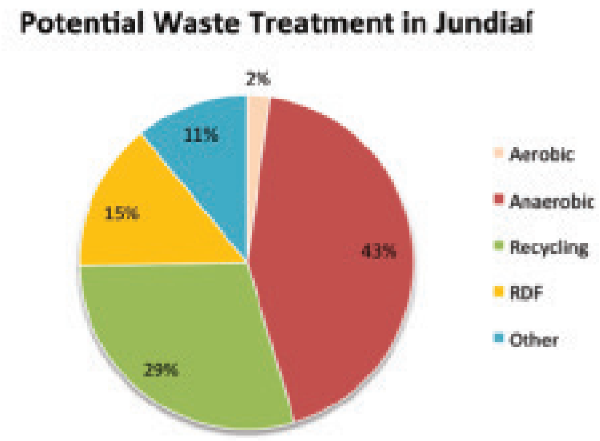
In total, the composition of the analyzed data represents a distinctive amount and prevalence of organic fractions (kitchen and green refuse, toilet paper, dry wood and organic <40 mm) in both campaigns (see Picture 6), which demonstrates a high potential of valorization for the intended fermentation plant. The fractions classified as "other" contain mainly textiles, leathers and diapers.



Thus, these results confirm the introduction of a biological stabilization technique which is intended as a Mechanical Biological Treatment for the region of Jundiaí. Recyclables, in their turn, accounted for approximately 19 per cent of the waste, justifying their recovery and reintroduction to the market as a secondary resource.

Additional analyses of potential waste treatment techniques in Jundiaí not only proved the potential of fermentation but also outlined the recycling of materials, which are shown in Picture 7. The gravimetric analyses of the waste provided relevant data to support further developments to the methods and equipment to be adopted for waste recovery practices.

The laboratory analyses showed that RDF production is suitable for all grain sizes between 40-120 mm, with a request of dried material to water content of maximum 20 %. The average calorific value reaches 20-22 MJ OS, although that value can be raised to 22-26 MJ OS with a separation of minerals from the dried waste fractions. Therefore, aerobic drying systems and belt dryers are possible techniques for drying, while ballistic and hard material separators can contribute for the separation of minerals.



4.4 CAPACITY BUILDING

The actions and decisions taken throughout this project are not restricted to the municipality border but also served as a reference for other segments in the public and private sector from the economy of solid waste.

In the events held, various sectors of society participated, such as researchers and entrepreneurs or public managers, who have been transferred functional knowledge to establish sustainable waste management systems, also integrating the fermentation and other waste recovery models. The technical events also served to build bilateral cooperation of knowledge for the successful implementation of projects. This also includes the development and adaptation of technologies for Brazilian conditions.

Important events and professional qualification conducted during the project are listed in Table 3.

	EVENTS AND PROFESSIONAL QUALIFICATION	LOCATION	DATA	PARTICIPANTS
1	1° Technical Congress Brasil Germany	Parque da uva (Grape Park) - PMJ	Dec/13	780
2	Workshop PUC - RJ	PUC- RJ	Mar/14	18
3	Capacity Building	Sala de situação - PMJ	Mar/14	30
4	Workshop CIESP	CIESP - Jundiaí	Apr/14	145
5	2° Technical Congress Brasil Germany	Florianópolis	Mai/14	330
6	7° Technical High Level Meeting: Composting	Cetesb- SP	Aug/14	85
7	Specialized training for Characterization of large generators	Conference room SMSP - PMJ	Jun/14	30
8	Exhibition RWM Brazil	São Paulo	Sep/14	30
9	1° Connective Dialog Latin America Cities	Cuenca - Equator	Nov/14	40
10	Gravimetry study of Municipal Solid Waste	Geresol - PMJ	April + Oct/14	30
11	Visit Cooperlinea Ambiental do Brasil	Paulinea	Nov/14	10
12	Technical Course in Sustainable Management of MSW	DAE - Jundiaí	Nov/14	230
13	Technical Visit LOGA	São Paulo	Nov/14	15
14	Specialized training in analytical interventions for characterization of MSW	Hotel Serra de Jundiaí	Jan/15	30
15	Training: Composting and drying of Solid Waste and Organic Waste Separated with the system ON FLOOR AERATION WITH GORE COVER	Auditorium 8th floor - PMJ	Mar/15	30
16	Workshop Project closure I-NoPa	Hotel Serra de Jundiaí	Mar/15	60
			total	1893

4.5 IMPLEMENTATION OF CREED BRAZIL

CREED is a Non Governmental Organization that emerged in 2009 and has more than 70 members, with an international center for research & development and both basic and advanced training on waste and natural resource management with an international focus. At the same time, the center functions as a demonstration site for the environmental technology, management of waste and resources sector of Germany.

The CREED of Brazil has the purpose to cross boundaries and introduce a holistic perspective of sustainable management of MSW in Latin America, ensuring a multidisciplinary and transterritorial intervention, joining what is most developed in Europe with the new demands of Latin America.

Thus, the CREED of Brazil will be a physical space (see Picture 8) dedicated to the development of alternative energy sources and improvement of social reality and also a showcase of exhibitions and dialogues between consumers, researchers, entrepreneurs, opinion leaders and the general public. The goal is to contribute to a formation of sustainable tools for the benefit of society as a whole.

Area destined to CREED

Total area of GERESOL

4.5.1 SPECIALIZED LABORATORY

Considering that waste treatment is a new market in Brazil, there are peripheral aspects that also contribute to waste management success such as for example the appropriate material evaluation. In order to fulfill the need of better knowledge about physical, biological and chemical materials, the demand of introduction of a laboratory specialized in solid waste analyses was identified.

During the project, a 210 m² excellence laboratory was implemented that will perform physical-chemical and biological analysis in order to evaluate the potential of waste to recycling, composting, digestion and RDF. This laboratory was provided with the latest equipment, becoming a reference for the Brazilian market in the search for qualified analytical interventions (see Picture 9). Products purchased were:

Eudiometer (GB21)	Muffle	Scales
Centrifugal	Water Pump	Screens
Spectrophotometer	Heater	Shaker with heating
PH Meter	Gas Chromatograph	Conductivity meter
Filters	Refrigerator	Greenhouse
Freezer	Containers	Reagents
Filters	PPE	Other materials

4.5.2 PILOT PROJECTS

Within the framework of Jundiaí's interest in becoming a model for waste treatment, some research facilities have just been installed or in preparation. An area of 525 m² for pilot-projects is prepared with two different aerobic technologies, with roof and sealed surface.

The technologies are build in a modular way, offering alternatives for small and medium cities, where both of them can be technically adapted for biological stabilization, composting or biodrying purposes.


5. TECHNICAL AND POLICY RECOMMENDATIONS

The challenges of promoting sustainable management of municipal solid waste can be mitigated through the exchange of experiences and technical, scientific and technological knowledge. In addition, trainings, seminars, discussion forums, technical visits and database training can reverse the external vulnerability in high-technology sectors; encourage continued implementation of research and development; increase the competitiveness of the Brazilian industry; support the inclusion of innovative global markets; encourage the participation of private capital in innovation and minimize the impact mainly due to insufficient technical capacity.

Considering the great demand of projects and its technical sophistication, more knowledge should be developed. It is therefore essential to interact with experts with international experience and professional training centers including current technologies to design, implement and monitor effective waste management systems.

We also have the following suggestions to ensure the continuity of the project:

- Availability of project data for community access on the website of Jundiaí City Hall and print booklets;

- Public consultation realization for presentation of results;

- Details of technological alternatives and economic analysis of selected processes;

- Formation of technical agreements with other municipalities to gain multiplication of results and technical training promotion;

- Formation of technical cooperation agreements with research and academic institutions to promote basic and applied research;

- Promotion of partnerships with the private sector to share information and offer to them an opportunity to recover their waste through the public waste management system;

- Formation of internal and external training courses and promoting broad participation events;

- Promotion of CREED of Brazil competences to bolster sustainable waste management in Brazil and Latin America;

- Regional approach with the public and private sectors.

5.1 CAMPUS OF ECO-EFFICIENCY IN WASTE MANAGEMENT - CER

From the provided legal requirement that establishes the recovery of waste and considerations that concern the protection of natural resources and climate, we propose the implementation of a technological park called CER-Campus of Eco-efficiency in Residues. It should aim not only to promote productive activities, but mainly ensure educational components for these activities, thus enabling the multiplication of instruments designed for the citizenship and sustainable development.

The multidisciplinary concept incorporates to the area of CER diverse environments such as an auditorium, offices, environmental education room, laboratory, center for training and research, and technological drivers to ensure lower quantities to the landfill as well as the incorporation of secondary resources in the economic chain, by means of the following technologies: sorting of recyclable, fermentation, composting, drying to generate biomass and aggregates from the construction. The renewable energy that will be produced by the treatment plant through biogas processing will be used for own consumption and can be expanded according to market demand.

As a consequence of the project, there is a plant being planned with a capacity to meet municipal domestic generation with starting capacity of around 200,000 t per year, considering a lapse of generation of 10 years, but, through the studies to be undertaken, the proposed plant may have its capacity increased, thus meeting the demand identified in large generators and domestic generation in the region, offering an appropriate destination of choice for both the government and private entities.

6. CONCLUSION

Waste management has changed significantly in recent years, becoming the icon of sustainable development, greatly contributing to environmental protection and also ensuring better environmental conditions through recycling of waste.

The Brazilian market shows lacks on theoretical and practical information for differentiated waste management. This fact is not due to lower market interest in the subject, but to our pioneering condition, with no examples of large scale that give opportunity to the sharing of experiences. Based on this need, the proposed project aroused a lot of attention on the market, resulting in the formation of strategic partnerships for the purpose of not only democratization of data but mainly for the development of joint projects that minimized errors, optimizing the arrangements in favor of consistent projects.

The completion of the project also provided comprehensive global knowledge of this new market and also the construction of an interrelationship with the waste sector in Brazil. The support and the dissemination of practical knowledge brought to Jundiaí enforce an innovative vision and inspiration to transform the current system in an efficient and continuous reality that meets the premises of the National Solid Waste Policy and the global trends.

With regard to large generators, the questionnaires allowed us to conclude that despite multiple challenges to be faced, the minds of those involved are congruent with respect to the prioritization of recovery of waste. Thus, the federal law presents itself as a strong tool of support and promotion of new practices.

Industries are committed to meeting the demand regulated in order to improve the internal management system and ensure reverse logistics. The trade and services sector has not shown to have much knowledge of the subject, since their waste management is simple and requires no more than an overview of actions, which are often inefficient.

The city has a very homogeneous generation of waste materials, which are not being identified with significant variations according to the social status. As for waste characterization we conclude that there is a high potential for use due to a significant portion of recoverable fractions, both organic and recyclable.

The conditions identified in the region regarding the flow of secondary resources at the market point to the establishment of a Mechanical Biological Treatment plant, as well as a focus on energy recovery, the use of recyclable and RDF production. For selective organic waste is pointed the introduction of small composting plant for the local agriculture activities.

With the research and development project, an interdisciplinary and transdisciplinary approach was pursued. Crosscutting issues such as law, economy, ecology, energy, agriculture, horticulture and social scientific topics were covered. Within the levels of action, a special focus will be given to the creation of positive prerequisites for the implementation of fermentation stages.

These measures are not only seen as a massive contribution for the development of future-oriented and advanced waste management, but also as a contribution for the substantial usage of the fermentation stage, including all upstream and downstream steps of the process. The developed technology demands efficient processing of the substrate and generation of secondary resources that are valued by the market.

This project not only demonstrated a high potential for recycling and valorization in the Municipality of Jundiaí, but also created a link between the public and private sector, which enables new cooperation and partnership activities so that the mutual objective can be achieved and governmental demands accomplished. Furthermore, this project provided international knowledge transfer through university cooperation and the construction of state-of-the-art technology for the Brazilian market. It also contributed to sustainable development and helped to create solid waste management in Brazil.

Thermodynamic and economic evaluation of a solar aided sugarcane bagasse cogeneration power plant

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ABSTRACT

Solar power and biomass are both renewable energy sources which generate electricity at low CO2 emission levels. One important problem related to operation of biomass power plants, however, is its availability throughout the year. This is also true for the sugarcane bagasse power plants in Brazil that are operated mainly during the sugarcane harvest period. In this regard, the objective of this research project was to evaluate the technical and economic feasibility of integrating Concentrated Solar Power (CSP) with the sugarcane bagasse cogeneration power plants operated by the sugarcane sector in Brazil in order to extend their operation to the off-season period and, as a consequence, to improve their electricity production.

The project's first step consisted in identifying a base case sugarcane bagasse cogeneration power plant. Layout and operational parameters were defined in cooperation with equipment suppliers. Based on a capacity to process three million tons of sugarcane per harvest, three integration layouts of CSP into the cogeneration cycle were evaluated, namely: (1) solar feedwater pre-heating; (2) saturated steam generation with solar energy and post superheating in biomass steam generators and (3) generation of superheated steam in parallel with biomass steam generators. Linear Fresnel and parabolic trough collectors were implemented for integration layouts (1) and (2), while a solar tower with direct steam generation was implemented in integration layout (3). We demonstrated potential gains from the integration of solar concentrators into sugarcane bagasse cogeneration plants equipped with BPST and CEST turbines. Owing to the opportunity of solar-only operation, layout 3 showed to be the best option. The cost of additional electricity generated due to hybridization was found to be 220 US$/MWh. This is considered competitive if compared with other state of the art CSP power plant configurations (200-400 US$/MWh).

Considering the current electricity sector panorama in Brazil, there is a positive horizon for turning CSP technology economically feasible in the near future. In addition to responding to a growing electricity demand, the national electricity matrix needs to be diversified in order to be less vulnerable to hydrological regimes. Today, the inclusion of CSP in the Brazilian energy matrix would require alternative subsidized contracts independently of power plant configuration. It should be kept in mind, however, that there is yet great room for reducing CSP investment and

operation and maintenance costs since electricity prices are expected to increase. In the meantime, we recommend implementing a demonstration CSP-biomass hybridization project. It would be helpful to provide a Brazilian knowledge base to future commercial projects which will lead to the rational use of both solar and biomass resources available in the sugarcane region of Brazil. A demonstration plant is being prepared by the project partners, the *Associação Beneficiente da Indústria Carbonífera de Santa Catarina* (SATC), as well as the companies TGM Turbinas and Valmont.

1. CONTEXT

A majority of renewable energy resources, like sun or wind, have the problem of inconsistent availability. For that reason, especially targeting a 100 per cent renewable energy era, it has to be considered that power production and power demand must correspond to each other in order to avoid a blackout. To deliver the residual load each time a tow-part problem-solving approach with storage technologies and back-up energy sources will be necessary. Electricity cannot be stored directly. For that reason in all existing storage technologies electricity is transferred into another type of energy, e.g. chemical, heat or elevation. This energy can be reused later in order to produce electricity. Instead, another conceivable approach could be to combine non-storable renewable energy sources with a storable energy sources, like natural gas, coal or even biomass.

But which energy sources should be combined? Regarding renewable energy, the sun is the major source, which can be directly used through photovoltaic or CSP. CSP is interesting for hybridization with traditional fuels like coal, natural gas or biomass because of its similar use of a water/steam cycle in order to transform heat energy into electricity. As mentioned in [1], CSP offers a very large realizable potential with close to 1000 EJ/a in the long term. As partner fuel in a hybrid thermal power plant, biomass is best because of its carbon neutrality. Moreover, the combination of CSP and biomass in the Brazilian context seems to be smart, as both energy sources have a quite interesting potential, which will be shown below.

Already today, electricity generation in Brazil is based strongly on renewable sources. For example in 2011 87 per cent of electricity was produced by technologies using renewable energy sources, where biomass represented a share of 6.1 per cent [2]. The major source of biomass for power generation here is bagasse. In 2014 the thermal utilization of bagasse represented 80 per cent of the overall biomass power generation capacity [3]. Figure 1-a shows the quality of annual solar insolation for Brazil, where the annual direct normal irradiance (DNI) is used as a key figure. Brazil has an moderate to good insolation potential with a DNI in a range of 1,300-2,000 kWh/(m2a). Figure 1-b displays cogeneration sugarcane bagasse power plants. The figures clearly show that both energy sources match in their regional availability.

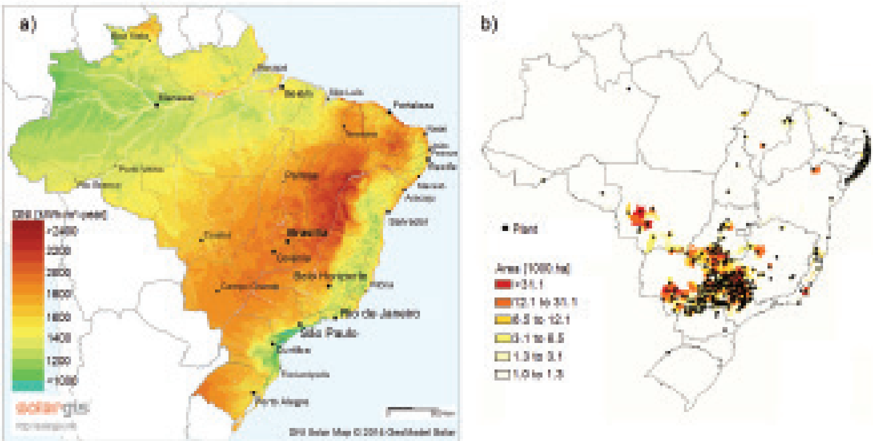

Figure 1. DNI-map of Brazil (left) and location of sugarcane factories in Brazil (right).

Traditionally, the bagasse-fueled power plants are cogeneration power plants directly located at the sugarcane factories in order to deliver on-site power and heat demand. This is underpinned by the large total amount of 386 bagasse-fueled power plants and their average installed capacity of 25.4 MW_{el} [3]. Furthermore, a majority of these bagasse-fueled power plants are located in areas with quite high solar insolation for Brasil: 87 per cent of produced sugarcane originates from the Center-South region, where the annual DNI ranges between 1,300 and 1,700 kWh/(m^2a).

Finally, it is important to clarify why the operator of a cogeneration power plant might be interested in hybridization with CSP. In the last decades, due to the strongly increasing Brazilian electricity demand and the Brazilian electricity sector decentralization in 2000, cogeneration power plant operators increasingly changed their focus from fulfilling the on-site demand to exporting electricity to the national grid. Since 2005 their electricity output for external use was raised by 34 per cent each year, so that in 2013 a total amount of 15,067 GWhel was produced by bagasse-fueled power plants [4]. Future targets are equally ambitious, with a further increase by the factor of 13 until the year 2022 [4]. Besides increasing sugarcane production, co-combustion of sugarcane bagasse and straw, retrofit measures or building new efficient power plants, the integration of solar energy might be an interesting lever in this regard.

2. APPROACH

2.1 SOLAR AIDED SUGARCANE BAGASSE PLANTS

Bagasse is the residue that remains after the extraction of the aqueous sugar solution out of sugarcane. The bagasse is directly used as fuel in the cogeneration power plant integrated into the sugar and alcohol production factory of a sugarcane mill. This interrelationship is visualized in Figure 2.

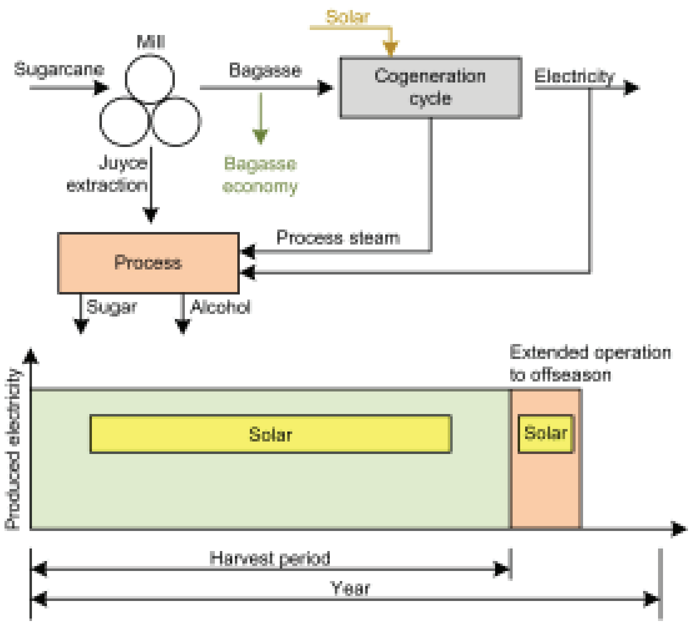

Figure 2. Schematic of the process and illustration of the concept.

The operating time of a sugarcane mill is coupled to the sugarcane harvesting period since sugarcane cannot be stored. The harvest period typically ranges from April to December in the Center-South region of Brazil. Outside this period, the most of the cogeneration power plants are out of operation and no electricity is exported to the grid. In contrast to sugarcane, bagasse is storable. Therefore, in this project we proposed to evaluate the technical and economic feasibility of partially replacing bagasse with solar energy during normal operating season. In this regard, the bagasse saved during harvest period can be used to extend the operation of power plants to the off-season and electricity production can be improved as a consequence.

2.2 BASE CASE POWER PLANT

The first step of the project was to identify a typical state-of-the-art Brazilian bagasse cogeneration power plant to be the reference case for the study. The selected plant is located in Campo Grande, Mato Grosso do Sul, Brazil (-20.45°; -54.62°). Its configuration and operational parameters were identified in cooperation with equipment suppliers of the sugarcane sector. The cogeneration plant was designed to meet the requirements of a sugarcane mill with main boundary conditions as listed in Table 1.

Table 1. Boundary conditions of base case power plant.

Parameter	Unit	Value
Crushing capacity	t/h	600
Annual sugarcane crushing	Mt	3
Effective operation hours in harvest	h	5,000
Harvest starting day	-	01st April
Process electricity demand	kWh_{el}/t	28
Process steam demand (heat demand)	t/h	220 (2.5 bar; x=1)

The layout and main results related to the simulation of the cogeneration plant at design point operation are presented in Figure 3. As it can be observed, the steam cycle is equipped with two 170 t/h capacity steam generators that produce superheated steam at 525 °C / 67 bar (point 1). The base case scenario is operated during harvest, burning 142.5 t/h of bagasse directly from the sugarcane crushing station. The major part of superheated steam (point 2, 220 t/h) is expanded in the back-pressure turbine (BPST) until 2.5 bar as required by process heat demand. Roughly one third of the superheated steam (point 6, 117 t/h) is expanded in the condensing-extraction turbine (CEST). Three extractions are implemented in the CEST turbine (17.5 bar – point 7;5 bar – point 8 and 1.8 bar – point 9) to preheat feedwater until 200 °C (point 20). The CEST exhaust steam (point 10) is condensed in a wet-cooled condenser.

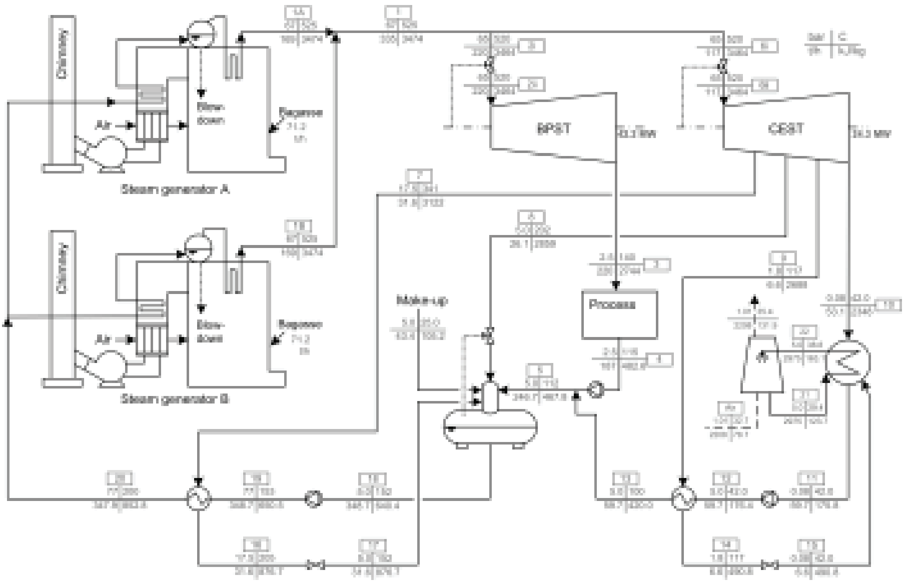

Figure 3. Base case cogeneration power plant layout and simulation results at design point.

The steam generators A and B used in base case plant are identical. Both are natural circulation subcritical water tube steam generators composed of furnace, boiler (the boiling occurring in water tube walls enclosing the furnace), convective superheating system, economizer and tubular air heaters. Again, cooperation with equipment suppliers of the sugarcane sector was important to provide the technical configuration parameters of these components.

The results in design point operation of one of the steam generators are presented in Figure 4. As it can be seen, 208 t/h of air is preheated from ambient temperature to 296 °C. Additional 23 t/h of air (10 per cent of total) is used as bagasse-carrying air. Both streams consist in 30 per cent excess air as required to optimize combustion process. Feedwater (174.3 t/h) is heated in an economizer from 200 to 277 °C. Blowdown consists of 3 per cent of main steam mass flow in order to maintain the concentration of impurities under specification limits. Finally, 169.1 t/h superheated steam is produced by heating saturated steam (x=1 / 72 bar) from a boiler drum until the required final parameters (525 °C / 67 bar). It is important to notice that 17.2 t/h of saturated water (x=0 / 72 bar) is injected in between superheating sections SH1 and SH2 at design point operation. At part load this amount is gradually reduced to keep the main steam temperature constant.

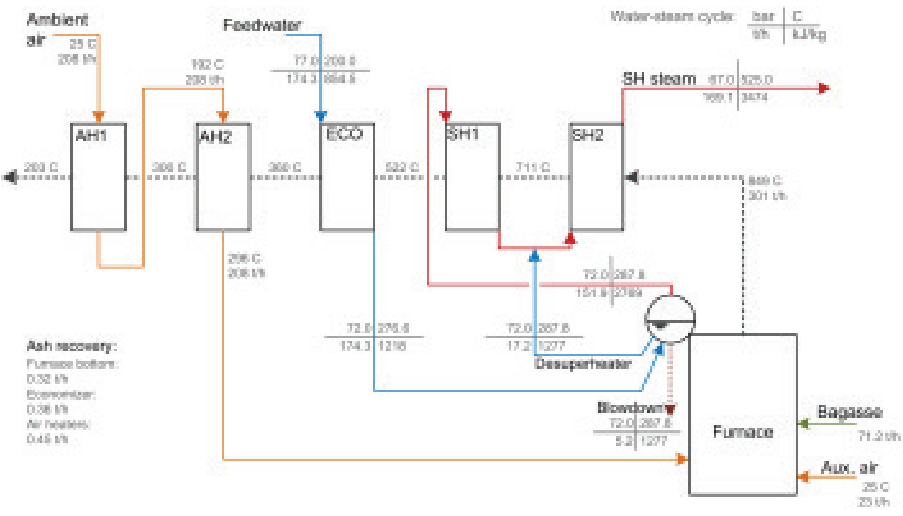

Figure 4. Base case steam generator layout and simulation results at design point operation.

A simulation for the entire harvest period was performed while keeping the net electricity exported to the grid equal to the reference condition (46.6 MWel) and respecting ambient weather fluctuations. The corresponding results are presented in Table 2. The required time to crush 3 Mt of sugarcane was equal to 5000 hours, during which 710,316 t of bagasse was burned and 233,025 MWhel was exported to the grid. The plant operation started on 1st April and was finished by 3rd December. The total harvest period was 5,921 hours, which represented a capacity factor of 84.4 per cent. The total duration of one sugarcane harvest is mainly prescribed by rainfall: during rainy hours as well as during the necessary time for soil drying it is not possible to harvest sugarcane. This result matches with the capacity factor of sugarcane cogeneration plants located in the Center-South region of Brazil that normally ranges from 80 per cent to 85 per cent [5] [6].

Table 2. Summary of the results for the base case cogeneration power plant over the harvest period.

Parameter	Unit	Value (5000 h of operation)
Produced bagasse	t	750,000
Burned bagasse	t	710,316
Stored bagasse	t	39,684
BPST gross output	kWh_{el}	211,255
CEST gross output	kWh_{el}	121,325
Net electricity production	kWh_{el}	317,025
Auxiliary electricity consumption	kWh_{el}	15,555
Process electricity consumption	kWh_{el}	84,000
Process heat consumption	kWh_{el}	691,097
Net electricity exported to the grid	kWh_{el}	233,025
Process steam demand (heat demand)	kWh_{el}	220 (2.5 bar; x=1)

2.3 THE PROPOSED HYBRID LAYOUTS

In general, Concentrated Solar Power (CSP) can be divided into linear and point focusing technologies. Parabolic Trough and Linear Fresnel collectors belong to the linear focusing technologies, whereas the main point focusing technologies are namely central receiver (Solar Tower) and parabolic reflector (Dish). According to the market availability and current state of development, for the present case-study the following three technology options have been chosen: Linear Fresnel (LF); Parabolic Trough (PT) and Solar Tower (ST). For all named CSP options there are different technology configurations possible, whose range is shown in Table 3.

Table 3. Overview to the three considered CSP technologies.

Parameter	Unit	LF	PT	ST	Source
Heat Transfer Fluid (HTF)	-	thermal oil water salt	thermal oil water salt	thermal oil water air	
Concentration ratio	-	25–100	70–80	300–1.000	[7]
Temperature Range Power Cycle	°C	380–600(ST)	380–600(ST)	565(ST)–1.200(GT)	[8]
Performance	MWel	10–200	10–200	10–150	[7]
Ratio of current installed capacity	%	1	88	11	[9]
Ratio of capacity under construction (2012)	%	6	75	18	[10]

(ST): Steam turbine *(GT): Gas turbine*

Different hybridization layouts between CSP and steam cycles based on coal or biomass combustion are possible. In each case the CSP technology to be used depends mainly on the temperature level of the selected integration option. In this case, the added solar energy was used to provide heat for high pressure feedwater preheating (layout 1) as well as for production of saturated steam (layout 2) and live steam (layout 3) in parallel with bagasse steam generators. The process flow diagrams of the three integration layouts are shown in Figure 5.

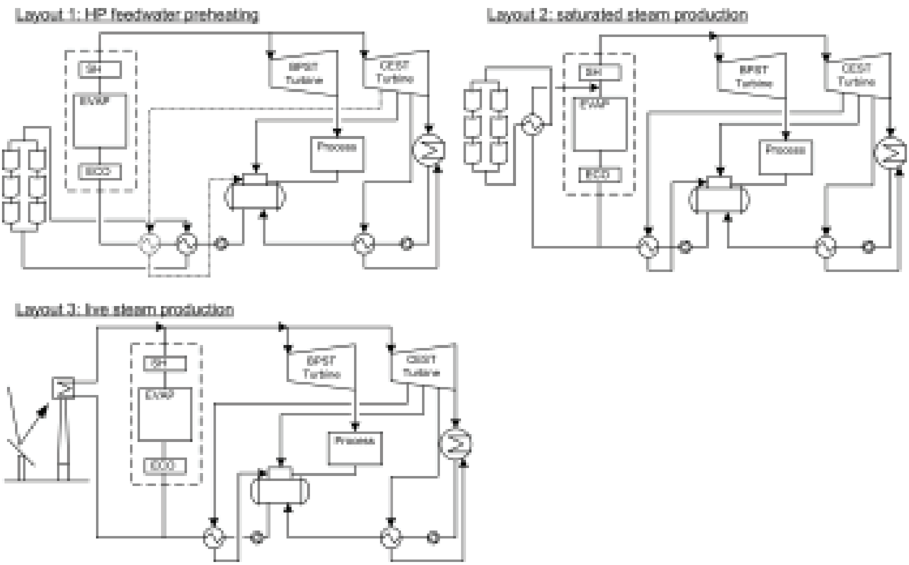

Figure 5. Process flow diagrams of the three considered integration layouts.

In layout 1 solar heat fully replaces the high pressure bled steam of the CEST turbine. For this purpose at design point the solar field provides a thermal output equivalent to the required heat demand for the high pressure feedwater heater in the base case power plant (17 MWth). Due to the fuel saving operation mode this replacement and the reduced amount of burned bagasse (reduction of 8,3 t/h) affects the CEST turbine performance as well as the feedwater heating line. Because of the comparatively low temperature level of 200 °C for the substituted high pressure bled steam the CSP technologies PT and LF were selected. It should be noted that solar-only operation is not possible.

Integration layout 2 enables a parallel production of saturated steam with solar heat in order to reduce bagasse consumption. As also done in case of layout 1, PT and LF technologies were compared here. According to the proposed method, part of the main feedwater mass flow going to the steam generators is diverted. This secondary mass flow passes, in case of PT, through a typical solar steam generator, whereas in case of the LF, it is directly fed to the solar field. In both cases, consistently saturated steam at 67 bar is produced, which is then sent back to the main mass flow within the steam generators for superheating. Accordingly, integration layout 2 only affects steam generators performance, while live steam conditions stay the same. By staying close to technical feasibility with the case study, the technical boundary conditions of the steam generators were respected. In order to avoid strong imbalances in these components it was assumed that it is allowed to reduce both steam generators load to a minimal level of 85 per cent. Therefore at design point the solar field should supply a thermal load equal to 34 MWth for the water/steam cycle. Likewise, this layout does not enable solar-only operation.

In integration layout 3 solar heat is used to displace both steam generators' thermal load. Due to the required operation temperature of solar field to produce superheated steam with the same parameters as it is produced in bagasse steam generators, ST technology is implemented here. According to the proposed method, part of the feedwater is diverted from the main mass flow and bypassed from steam generators. As it is passed through the ST system, superheated steam at 525 °C and 67 bar is produced. This integration affects only the steam generators' thermal performance while the water/steam cycle is operated in normal mode. In comparison with integration layout 2, the steam generators' operation is simplified. This means that the steam generators are operated in normal partial load from 100 per cent to 65 per cent load in fixed pressure mode. In respect to that, by enabling a minimal steam generator load of 65 per cent at solar design point the ST was designed to provide 79.4 MWth. It should be noted that for integration layout 3 solar-only operation is possible and enables an operation even when the sugarcane facility is out of operation.

3. RESULTS AND DISCUSSION

For the cross comparison of all cases presented here, we need to use appropriate evaluation criteria. The solar multiple consists of one figure for the characterization of Concentrated Solar Power plants. The solar multiple displays the ratio of nominal thermal load of a solar field at design point to the equivalent thermal load needed in the solar field to enable a nominal operation of the power block at the design point. In short, the solar multiple illustrates the grade of over-dimensioning the solar field in order to improve the number of operating hours of the power block at nominal load [11]. Energetically, for a fixed size of integrable solar heat, an increasing solar multiple leads to a higher solar share, whereas the curve flattens for large solar multiple. With the objective to enable a fair cross comparison, the economic perspective needs also to be respected. An increasing solar field yields to higher investment. In conclusion, there will be an economic optimum at a certain solar multiple. As economic evaluation criterion the Levelized Cost of Electricity (LCOE) [U$/MWh] was used. It is defined by the following equation [12]:

$$LCOE = \frac{\sum_{t=0}^{lt}(CC + LC + O\&M)\cdot(1+r)^{-t}}{\sum_{t=0}^{lt} AE\cdot(1+r)^{-t}} \qquad Eq.\ 1$$

where CC, LC and O&M [U$] are the capital, land and annual operation and maintenance costs. In the denominator AE is the additional electricity produced due to solar hybridization [MWh]. The parameter r represents the interest rate and lt is the lifetime of plant. The adopted assumptions and cost data used for economic analysis are shown in Table 4.

Table 4. Adopted assumptions and cost data used for economic analysis

Parameter	Unit	LF	PT	ST
Solar field	U$/m²	400[a]	360[a]	200 [13]
Economizer	U$/kW$_{th}$	27 [14]	27 [14]	–
Boiler	U$/kW$_{th}$	47 [14]	47 [14]	-
Receiver	U$/kW$_{th}$	–	–	250 [13]
EPC and contingency[b][15]	U$	20 % of DC	20 % of DC	20 % of DC
Site improvements [16]	U$/ha	250,000	250,000	250,000
Land investment[c]	U$/ha	20,000	20,000	20,000
Material replacement [17]	U$/year	1 % of DC	1 % of DC	1 % of DC
Employee charge[b,c]	U$/year	40,000	40,000	40,000
Interest rate, r	–	8 %	8 %	8 %
Life time of plant, lt	Years	25	25	25

[a]Quoted cost; [b]Considered not dependent on solar field area; [c]Estimated cost;

In Figure 6 the solar field area sensitive analysis is exemplified for layout 3. It is easy to identify that with rising solar multiple the additional amount of produced electricity through solar hybridization is increasing but the curve is flattening over a solar multiple of 2.0. On the other hand the total investment amount is more or less constantly increasing with rising solar multiple. These two parameters are the main values for the LCOE calculation. Following this, for the LCOE a curve with an optimum is forming out. In case of layout 3 the optimum lies at a solar multiple of 1.6.

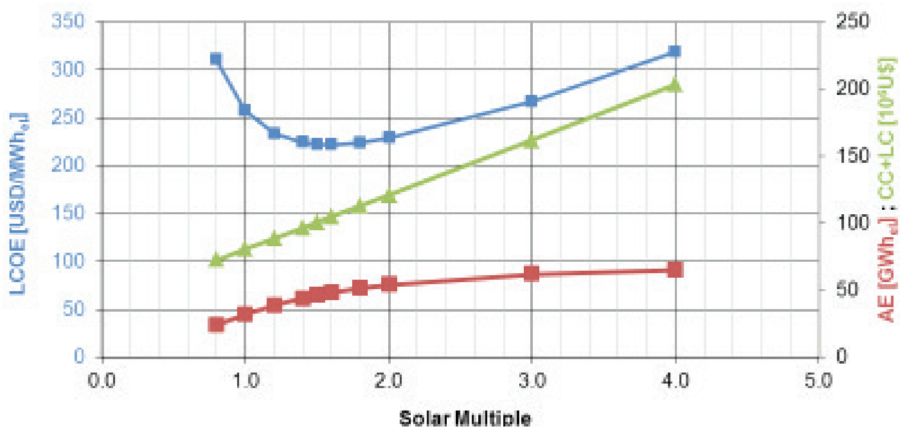

Figure 6. Additional solar equivalent electricity, total capital costs (sum of CC and LC) and LCOE for different solar multiples for layout 3.

For the cross comparison of all studied cases the solar multiple with the lowest LCOE for each configuration is shown in Figure 7. The LCOE of PT and LF lie, depending on the layout, in a range of 500–600 U$/MWhel, whereas in general layout 2 enables lower LCOE values than layout 1. With layout 3 the LCOE could be reduced significantly, reaching 220 U$/MWhel. This is comparable with the range of 170–370 U$/MWh reached nowadays in commercial CSP power plants [18]. For the further understanding of this significant benefit of layout 3, a detailed view on the performance data is necessary.

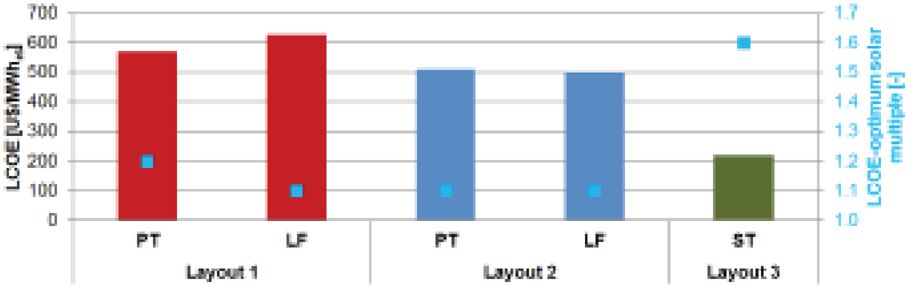

Figure 7. LCOE of additional solar equivalent electricity.

For all cases the additional electricity produced as well as the solar to electricity efficiency for the identified optimum solar multiple are presented in Figure 8. In layouts 1 and 2 the PT technology provided a slightly higher solar electricity output compared with LF. This was related to the higher annual solar field efficiency of PT, which was caused mainly by the smaller incidence angles observed in the beginning and in the end of the days compared with LF. Layout 2 provided higher solar electricity output when compared with layout 1 mainly due to the higher thermal load required to reduce evaporator thermal load of bagasse steam generators. Finally, it is clear that layout 3 provided a significantly higher solar electricity output when compared with other evaluated cases. This was not only due to the higher thermal load associated with the reduction of steam generators load to 65 per cent in peak DNI hours, but also due to the possibility of solar-only operation.

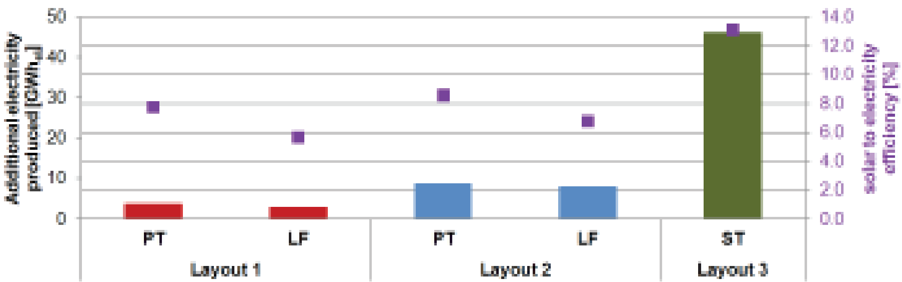

Figure 8. Additional solar equivalent electricity generated due to solar hybridization and solar to electricity efficiency.

The duration curves related to the bagasse steam generators and solar field energy outputs for base case and hybrid layouts 2 and 3 are exposed in Figure 9 to clarify the advantage of solar-only operation. In layout 2 the solar energy was exclusively used to shift a certain part of bagasse from harvest to the off-season period - the same operation strategy was adopted for PT and LF technologies, as well as in layout 1. In layout 3, on the other hand, the bagasse saved during harvest was preferentially used at night or on rainy days. Solar-only operation was possible during sunny hours. This is a very important aspect since the capacity factor of the solar field was maximized by its operation regardless of the availability of bagasse.

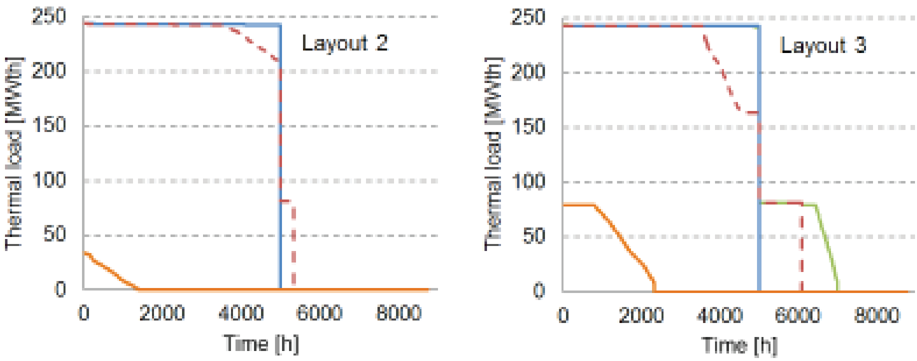

Figure 9. Thermal energy transferred to water-steam cycle related to bagasse and solar energy inputs for base case and hybrid layouts 2 and 3 for comparison.

4. RECOMMENDATIONS

The results presented here clearly show the advantage inherent to year-round operation of a solar aided power plant: the capacity factor of solar integration was improved in the case of parallel steam generation with a Solar Tower system (layout 3). This concept was able operate at solar-only mode independent of the availability of bagasse, which therefore used at hours without DNI incidence. ST provided the best result in terms of LCOE (220 U$/MWhel), which is considered competitive if compared with other state of the art CSP power plant configurations [18]. No major difference in terms of economic feasibility was obtained between PT and LF in layouts 1 and 2 for the considered economic assumptions and problem-specific characteristics (e.g. plant configuration and operational parameters, site weather conditions, operation seasonality of cogeneration plants). In both cases, operation of the solar field was only possible if bagasse was available. This, as a consequence, provided the high LCOE of additional electricity produced once the capacity factor of the cost-intensive solar field was low.

It might be emphasized that the LF and PT technologies should not be excluded from future analysis. They could also be implemented for superheated steam generation depending on main steam parameters of the cogeneration power plant in question or even considering the utilization of molten salt as heat transfer fluid. New projects conceptually fit for hybrid operation, as it is the case of Borges Termosolar power plant in Spain, need to be evaluated in order to improve solar share, solar-to-electricity efficiency, capacity factor and LCOE of produced electricity.

Brazil has great potential regarding solar and biomass availability for electricity power generation. In addition both energy sources have similar regional availability. If on the one hand CSP hybridization with biomass indicates the possibility of base load power supply, on the other hand solar thermal load can also lead to the rational use of bagasse availability by improving the exportation of electricity to the grid. We therefore recommend the implementation of one demonstration hybridized power plant project. The development of the conceptual and basic designs would lead to the careful identification of the technical and economic aspects of the proposed concept. The construction and operation of this pilot plant would be a kind of market-opener. That means it would be helpful to identify and develop local suppliers, to provide data on operation under local weather conditions and finally to bring improvements on future commercial projects with a Brazilian knowledge base.

Considering the current situation of the Brazilian electricity market there is a positive horizon for turning the CSP technology economically feasible in the near future. Electricity demand is estimated to grow by 4.1 per cent yearly between 2014 and 2024 in Brazil [19]. The necessity to diversify the Brazilian electricity matrix in order to be less vulnerable to the uncertainties of hydrological regimes remains. In accordance with the presented facts, the Brazilian Electricity Regulatory Agency (*Agência Nacional de Energia Elétrica* – ANEEL) just defined remuneration tariffs for electricity generated in small unities in order to stimulate individual electricity production. Tariffs depend on fuel type: (a) solid fuels (R$ 388.48 per MWhel); (b) natural gas (R$

792.49 per MWhel) and (c) Diesel (R$ 1,420.34 per MWhel). In the same way, today the inclusion of CSP in the Brazilian energy matrix would require alternative subsidized contracts independently of power plant configuration. It should be kept in mind, however, that there is yet great room for reducing CSP investment and operation and maintenance costs. Regarding parabolic trough technology, it is estimated that in ten years the capital costs will decrease by 40 per cent [18]. Thus, further studies might be developed given the local potential of solar and biomass resources. Solar thermal energy can complement biomass availability in the sugarcane sector and promote the rational use of this resource.

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4 Equitable, mutually beneficial, globally oriented, sustainable:

the future of international cooperation with emerging powers

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"The SDGs (Sustainable Development Goals) turn all nations into developing countries" (Grefe & Albrecht 2015). This statement is part of a long article of renowned German weekly *Die Zeit* on the ongoing negotiations at the United Nations about a future development agenda. A bold statement, certainly; and one that is hard to prove today. If this is the future of development cooperation and if by consequence development cooperation is the fundament of international cooperation, as the sentence seems to suggest, today's global landscape seems to be far from that future ideal.

Today, most still see the world neatly divided into industrialized and developing countries. On the one hand, the rich and well fed; on the other, the poor and hungry. Of course, this is an exaggeration: black and white imagery lends itself only to a caricature of international relations, not to its reality. Yet development cooperation persists in channels of industrialized to developing, rich to poor. It is mainly the prosperous – "Western" – countries that uphold development cooperation (or aid) systems.

Surely, however, if the United Nations – that is all nations, or almost – agree on a text that essentially ascribes developing status to all states, then we should be able to observe some of that change even today. We should see evidence that the line between "developed" and "developing" is not as clear-cut as it used to be. We should notice that relations that differ from aid relationships have begun to form, that some former developing countries refuse that status and that some industrialized countries pursue different forms of communication with them.

One example comes to mind immediately: the BRICS. Brazil, Russia, India, China, South Africa, as originally defined by Goldman Sachs bankers in 2001, have become a real political group on the global stage, asserting their claim to diplomatic and economic power. Their recent decision to establish a development bank of their own (cf. Ministry of External Relations 2015) is but one initiative they have jointly taken. While it is obvious that many differences persist among the group's members – culturally, economically, politically – they are nonetheless working together. They are the most prominent of today's emerging powers.

Their prominence creates a new challenge for other countries on the world stage, the challenge of how to adapt to the changing reality of international relations. Based on the observations detailed above, the puzzle, then, is this: why is current development cooperation not up to date any longer, especially when dealing with emerging powers? And if that is the case, what does a new, groundbreaking international cooperation look like?

To answer this question, this article will first detail some of the changes in international cooperation that were already briefly mentioned in the introduction. On that basis, four ideas for groundbreaking future-oriented cooperation with emerging powers will be discussed. It will be argued that said cooperation with emerging powers is (1) equitable, (2) mutually beneficial, (3) globally oriented, and (4) sustainable.

1 CHANGES IN INTERNATIONAL COOPERATION

After the end of the cold war, multiple changes took place in the international order. The bipolar era of the United States of America versus the Soviet Union – West against East – ended and was seemingly replaced with by a unipolar position of power of the USA. Since then, however, many scholars have talked about multipolarity rather than unipolarity.

Indeed, with the fall of the Berlin wall, Japan's loss of influence and the terrorist attacks of 11 September 2001, to mention but a few globally remarkable events, the international landscape seems to be constantly changing (cf. Gratius 2008). In addition to the above-mentioned events, states' importance and claims to power have been increasingly in flux: "In recent years a number of emerging nations have been challenging the position of dominance of the old powers, which are dropping down the international pecking order. In economic terms, countries from the "South" now account for more than half of global GDP (Gross Domestic Product), are leading world growth –with rates above 11% (China) and 9% (India) – and consume more than half of the world's energy" (Gratius 2008: 1).

Some states of the former 'Third World' – a concept that lost its relevance after the former 'First' and 'Second World' ended their war and essentially disappeared - were emerging. Goldman Sachs' economist Jim O'Neill first described the BRICs phenomenon in his 2001 article, developing a new concept (cf. O'Neill 2001). As Andrew Hurrell (2013) writes, "'emergence' was seen essentially as a market-driven phenomenon that reflected both deep changes in the structure of the global economy and making the 'right' economic policy choices". Liberal modernization theorists saw this as evidence their linear view of development and of the linkages between economic development, political democracy and societal modernization were correct (cf. Hurrell 2013). Although this theory should be examined critically, this article will use it as its underpinning framework of reference since it is prevalent in most analyses of international relations and development today.

China has become the second largest economy in the world, set to overtake the United States' economic performance in a few years' time (cf. Gratius 2008). This evidences a major shift from the former bipolar order to a multipolar world where emerging powers play an increasingly large role, which is perhaps most visible in international relations as such. Taking examples such as the emergence of the Group of 20 (G20) of heads of state or government in 2008, the Doha round of global trade talks or the UN climate talks, it has become increasingly apparent that traditional power balances do not apply any longer.

Yet what exactly are those emerging powers that theorists and practitioners alike regularly refer to? As mentioned above, power relations on the international stage are generally characterized as fluid. Examples include the bipolar world order of the cold war years, the emerging unipolarity of US predominance in the 1990s or today's multipolar world, for instance: power shifts according to global development, economic and military performance and perceptions. Who holds power also depends if one uses a hard (military) or soft (persuasion) definition of power (cf. Nye 1990). Today's emerging (or rising) powers are mostly the BRICS countries – Brazil, Russia, India, China, South Africa – in addition to other states in Asia, and the Gulf. Politicians and the media generally mean the above diverse set of states when they refer to emerging powers nowadays (cf. Mitchell 2011).

Furthermore, new cooperation modalities are emerging. While some states are rising to emerging power status globally, others remain poor and fragile. Nonetheless, the number of recipient countries of development cooperation will progressively decrease until 2030: according to the OECD, 28 developing countries with a total population of 2 billion inhabitants will not qualify as recipients of Official Development Assistance any longer (Janus, Klingebiehl & Paulo 2014). Coupled with an increased political and economic importance of the emerging countries, new modalities of development cooperation are already appearing.

For instance, South-South cooperation efforts have been spearheaded by China, exemplified by heavy investments in African infrastructure (PwC 2015). Similarly, Brazil has been actively pursuing South-South relations in its diplomacy for a long time. As Burges (2005) notes, "[t]he goal [of Brazilian foreign policy, A.L.M.] is not to overturn or delink from the existing international political and economic system, but to prompt a change in how developing countries are inserted into and view the system. In itself, this is not a particularly original ambition and is firmly grounded in Cardoso's persistent calls for reform of international economic governance institutions to make them more inclusive of the south" (Burges 2005: 1134). In line with this observation, emerging powers have also increasingly pursued so-called triangular cooperation with both industrialized countries of the North and developing countries of the South. The goal here is the transfer of successful solutions from one partner country to another and their adaptation to a different country-specific context. Thereby, triangular cooperation generates synergies based on respective comparative advantages and thus benefits all involved (cf. GIZ 2013).

More globally, a shift away from the logic of development cooperation can be observed. Countries of the global South increasingly request their voice be heard in international and bilateral relations alike (cf. Janus, Klingebiehl & Paulo 2013). As shown above with South-South and triangular cooperation initiatives, development or international cooperation can no longer be defined as a transfer of means from an industralized to a developing country. Simplistically, one could argue that bowing down is no longer necessary (or indeed desirable) for one side, nor is looking up for the other (cf. BMZ 2015). Especially with respect to emerging powers, a donor-recipient relation under the aid paradigm is no longer adequate.

The above arguments show why cooperation with emerging powers cannot be limited to a system of development cooperation with clearly defined donors and recipients. Instead, new forms of cooperation are being discussed in practice and academia alike.

2 GROUNDBREAKING COOPERATION WITH EMERGING POWERS IS…

What, then, does groundbreaking cooperation with emerging powers that is up to date and adequate to today's global situation look like? This article will argue that it is equitable, mutually beneficial, globally oriented and sustainable. While these criteria are not exclusive or point to one obvious new cooperation paradigm, they constitute a solid basis upon which to build further reflection and new experimental forms of cooperation.

2.1 EQUITABLE

First, groundbreaking cooperation with emerging powers is equitable. The Oxford Dictionary defines equitable as "fair and impartial; valid in equity as distinct from law" (Oxford Dictionaries 2015a). Synonyms include fair, impartial, even-handed, unbiased, and egalitarian. Equitable cooperation, here, means cooperation at eye level, among equals.

This criterion for future cooperation is very intuitive: if new powers are emerging on the global stage, it stands to reason that they would demand the same treatment from their new peers that these have been granting others similarly placed. Outside the previous aid relationship, states are working together on an equal footing.

In turn, this implies changed attitudes. Industrialized states can no longer define what means they want to devolve. Instead, emerging powers are increasingly requesting cooperation that suits their own country-specific needs and political necessities. They are able to choose from a range of cooperation modalities offered on the global stage. This empowers them to select the modalities they see as most useful for their needs and that they perceive to be most beneficial in their national context.

2.2 MUTUALLY BENEFICIAL

Second, groundbreaking cooperation with emerging powers is mutually beneficial. Therefore, in accordance with the Oxford Dictionary definition of mutual, benefits are "experienced or done by each of two or more parties towards the other or others" (Oxford Dictionaries 2015b). Both sides reap the economic, social and/or political effects of their relations.

This is a clear distinction from development cooperation. There, the donor is usually perceived as granting a benefit to the recipient country. While this has been repeatedly questioned, perceptions would nonetheless have it that one side is acting outside its own strategic interest. Instead, donors in development cooperation are perceived to be altruistic, offering aid without – seemingly – any return (cf. Watkins 2013).

However, a mutually beneficial cooperation relationship implies that both parties clearly state and defend their own interests. Both sides want something out of their bilateral relations. Thus, the emerging power is also able to request a certain form of cooperation that best suits its interest. Empowered partners show the progression from an aid relationship towards relations traditionally associated with North-North cooperation only.

Generally, the mutual interest in cooperation between emerging powers and industrialized states is trade. Industrialized countries expect economic benefits from their presence and/or increased visibility in future markets. Outside of the purely political sphere, the term emerging or rising powers can be used interchangeably with the expression emerging markets (cf. Hurrell 2013). As illustrated above, economic performance of the countries in question is one key criterion for their emergent status. Therefore, industrialized countries want to guarantee future growth opportunities for their companies and establish economic footholds in promising markets.

A key aspect of the criterion of the mutual benefit is its open discussion among partners. Both sides being transparent about their offer and demand, this facilitates diplomatic dialogue. Emerging markets are seen to appreciate this openness in their counterparts (cf. Hackenesch & Janus 2013). Moreover, it also serves to legitimize cooperation domestically. If benefits are clear to all involved, populations can hold their elected representatives to account more easily, which facilitates stakeholder dialogue and improves public perceptions of bilateral cooperation.

2.3 GLOBALLY ORIENTED

Third, groundbreaking cooperation with emerging powers is globally oriented. Of course bilateral relations between nations do not take place in a vacuum and are always in one way or another inserted into a global context. Yet here, cooperation between an industrialized country and an emerging power is something different. Not only does it respond to changing international power dynamics by openly acknowledging the emerging power's value and importance, it also refers to a global challenge in most cases.

Simple trade is rarely the sole focus of such cooperation. Rather, countries choose to couple trade with other areas. This is where the Sustainable Development Goals (SDGs) serve as an excellent example. No longer is poverty and hunger reduction the unique and fundamental goal. Whereas it remains present, the global community's focus has shifted to a more holistic perspective: the SDGs for instance include sustainable and inclusive economic growth, resilient infrastructure and sustainable use of terrestrial ecosystems. They also refer to taking action to combat climate change, reduce inequality in and among countries, and to provide access to justice for all (cf. UNDP 2015). Bilateral relations between industrialized countries and emerging powers can take up these topics and address them in a way that is beneficial for them individually as well as combined (cf. Hackenesch & Janus 2013).

Furthermore, this bilateral action then has regional and global consequences. It contributes to advances in the above-mentioned topics and can provide best practice examples for the global community to follow. However, beyond this there can also be regional spillover effects. Since today's emerging powers are also firmly inserted into their respective regional contexts – China in ASEAN+1 or Brazil in Mercosur and Unasur for example – they also act as role models for their regional peers. As such, best practices and innovative approaches can spread quickly through these regional channels and have an impact far beyond the original bilateral cooperation. Often, issues addressed there stretch beyond one state's boarders, especially in environmental matters. Examples might include marine ecosystem management on China's coasts, combating desertification in India or preserving forest biodiversity in the Brazilian Amazon. These are evident examples of how joint technology development can be both bilaterally and globally beneficial.

Fittingly, the German Ministry for Economic Cooperation and Development (BMZ) refers to its cooperation with emerging powers as "Global Development Partnerships" (BMZ 2015). Their intention is to "align economic growth, protection of the environment and social matters globally" by establishing and extending strategic partnerships for sustainable development (ibid). Here, emerging powers are not limited to the BRICS group – indeed, only three of them are part of the five target countries of BMZ's Global

Development Partnerships: Brazil, India, Indonesia, Mexico and South Africa. This cooperation policy, implemented after 2012, is a good example of how bilateral partnerships can be global in intention and impact.

2.4 SUSTAINABLE

Fourth, groundbreaking cooperation with emerging powers is sustainable. Recently, the term sustainability (from the Latin *sustinere*, to maintain, to hold up, to endure) has become to be associated with human sustainability in its environment. In this sense, sustainability and development are intrinsically linked. Sustainable development has become a keyword of international relations since the 1980s, and today, as previously mentioned discussions on a global agenda explicitly refer to it.

Sustainable development, however, has been present for much longer as a concept. For instance, one of the most famous definitions of sustainable development is the following: “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland Commission of the United Nations 1987). Traditionally, sustainable development has three pillars: economy and society as well as environment, factors that are interlinked (Scott Cato 2009: 36–37). Therefore, the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing.

This is why groundbreaking cooperation between emerging powers and industrialized states should be sustainable: embracing the concept of sustainable development means that economy, society and the environment can be addressed holistically, as interconnected parts of one system. The United Nations Agenda 21 specifies culture as the fourth part of sustainable development, an area where international cooperation can also be very fruitful – for instance thinking of global cooperation for sustainable cities.

There are many examples of how international cooperation can foster sustainable development. Sustainable production, for example, often shows an impressive return on investment after a few years (Haanaes et al. 2013: 111). Two countries working together to generate new technologies and testing their implementation can thus be financially and environmentally beneficial. Especially research and development can yield benefits that also advance sustainable development efforts in the countries concerned.

Furthermore, as previously mentioned, a large number of SDGs are oriented towards sustainable development in every sense of the term. This encompasses not only environmental sustainability – with a deadline for the forest protection goal's implementation set to 2020 – but also economic and social sustainability, focusing on equal rights and distribution of economic benefits.

FINAL REMARKS

Through a brief review of international relations since the fall of the Berlin wall, this article showed that the global order has been in flux for the past twenty-five years. From unipolarity to multipolarity and emerging powers, some states have successfully asserted their economic and political importance on the global stage. One prominent example are the BRICS countries – Brazil, Russia, India, China, and South Africa. Consequently, international cooperation with these countries can no longer only follow the paradigm of development aid or development cooperation: new ways of cooperation are necessary. This article argued that, while there is no one-size-fits-all solution, groundbreaking future-oriented cooperation with emerging powers needs to be equitable, mutually beneficial, globally oriented and sustainable. The argument does not offer a conclusive answer or point to the one correct form of cooperation. Instead, it offers a basis for discussion and experimentation.

Today, even technical cooperation necessitates high-tech solutions that are not available ad hoc and therefore still need to be developed. Maybe, therefore, cooperation in research and development is the most promising form of cooperation among industrialized and emerging countries nowadays. One example of such cooperation is the New Partnerships (*Novas Parcerias* – NoPa) program jointly implemented by GIZ, DAAD and CAPES and presented in this volume. Two German and one Brazilian institution fund and support research projects in the areas of protection and sustainable use of tropical forests, and renewable energies and energy efficiency. The following paragraphs will demonstrate how the NoPa program relates to the four criteria for future-oriented international cooperation established above: NoPa can be seen as equitable, mutually beneficial, globally oriented and sustainable.

With respect to the criterion of equitability, partners are on an equal footing with regard to developing selection criteria: these are discussed and decided upon by both the implementing agencies CAPES, DAAD and GIZ and a

German-Brazilian group of experts and practicioners (GAT) in the thematic areas. This GAT then also provides feedback on the content of submitted research project proposals. Afterwards, the research funders CAPES and DAAD select projects to be funded, taking into account the expert opinions. The development of selection criteria and the selection process itself are but two examples of equitable participation in NoPa.

Second, NoPa brings together German and Brazilian actors for mutual benefit: Both thematic areas – tropical forests and renewable energies – are of political and economic interest to both countries. This, in turn, means that scientific research results are mutually beneficial to Germany and Brazil. Yet it is not only the research results themselves that are beneficial, it is also their application. In working together, Brazilian and German actors from the academia, private and public sector share their expertise and develop joint best practices. This leads to increased and improved cooperation in both thematic areas. Since generally partners work together to implement results on the ground in Brazil, the country benefits from state-of-the-art innovative technologies and can consolidate its domestic knowledge in the field in question. German partners, meanwhile, not only have a chance to gather further savoir-faire, but also to gain a foothold in the promising emerging market that is Brazil. Therefore, German and Brazilian project partners as well as both countries clearly benefit from the NoPa program.

Furthermore, the two thematic areas related to tropical forests and renewable energies were chosen in response to current global challenges. These are climate and biodiversity protection. Internationally, those key areas are addressed in the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD). Through the binational research cooperation projects, NoPa can contribute to attaining Brazil's and Germany's national and international goals in protecting biodiversity, adapting to and mitigating climate change, and protecting the environment. Research results and their application in both thematic areas are therefore of great value. Generally, NoPa is not limited to one aspect of sustainable development only. Rather, it is part of a holistic approach, the Cooperation for Sustainable Development, which is part of German cooperation with Brazil. Therefore, NoPa fulfills the criterion of being globally oriented.

These arguments also show why NoPa is sustainable: as mentioned previously, international discussion has been focusing on the concept of sustainability for several years. In fact, both thematic areas also directly relate to the proposed Sustainable Development Goals that form the post-2015 agenda of the UN. For instance, the area of energy addresses proposed SDG 7: "ensure access to affordable, reliable, sustainable and modern energy for all" (UNDP 2015). In addition, the area of tropical forests addresses proposed SDG 15: "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation, and halt biodiversity loss" (UNDP 2015). Other SDGs, such as the ones on sustainable water management, sustainable economic growth and combating climate change, can also be linked to the thematic areas. Not only do research projects thus take up key challenges to ensuring a more sustainable future, they also strive to build long-term sustainable relationships and networks between German and Brazilian partners.

Therefore, the NoPa program fulfils all four criteria established in this article: it is equitable, mutually beneficial, globally oriented and sustainable. This makes it one of hopefully many future-oriented groundbreaking cooperation initiatives between industrialized and emerging countries.

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The opinions herein are those of the author and do not necessarily reflect those of GIZ.

4

10 SECRETS FOR GOOD RESEARCH PRACTICE

Oriented to Impact and Concrete Application

1. BUILD ON HIGH-QUALITY AND RELIABLE SCIENTIFIC PRACTICE

Good scientific practice is oriented to the accepted principles of scientific work. Therefore, good scientific practice works *lege artis*, documents it sources, approach, results and interpretations, systematically doubts all own results, is honest towards itself and others, fair and can be held accountable at all times. Through this, the authenticity of scientific practice is guaranteed.

Likewise, respecting formal criteria like mentioning academic property through citations and source acknowledgement is a defining characteristic of good scientific practice. In publications, all involved authors need to be mentioned. Readers without academic background in the topic should also be able to understand a scientific article. The article should be formulated as concretely as possible, and technical terms should be explained as appropriate for the target audience. Tables and images can help illustrate scientific publications and explain connections. They need to be referenced in the article's text and also have a self-explanatory title.

Moreover, the internal organization of a research team is also characteristic of diligent quality management and good scientific practice.

Empirical analyses are based on the quality criteria of objectivity, validity and reliability that show the independence and impartiality of good scientific practice.

Further details regarding these aspects can be found in the 2013 publication "Safeguarding Good Scientific Practice" by the German Research Foundation (*Deutsche Forschungsgemeinschaft* – DFG).

2. DEFINE A GOAL AS A VISION OF THE FUTURE AND BASIS FOR COOPERATION WITH OTHER ACTORS

Defining a goal always starts from an intended change. A positive state is aimed at, a state which is different from the starting point and which should be attained at the end of a proposed process. Therefore, a goal describes a vision of the future.

It is of crucial importance for a project's success that all project partners identify with that vision of the future. Therefore, the goal should be the result of a negotiation process between all involved institutions. This negotiation process becomes more complex if a large number of partners are involved in the project. It should both highlight common desires and take into account differences between the partners – in interests, means, knowledge and experience.

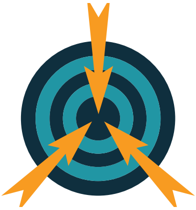
The involved institutions' common view of the starting point sets up the framework for a goal. Coupled with unequivocal, attractive and realistic wording, this provides a basis for a goal to function as guideline and orientation for all involved. Moreover, a clearly defined project goal is the basis for efficiently establishing contact with additional, as yet not involved potential partners.

The main questions for formulating a goal are:

- What do we want to do?
- How do we want to do it?

The question "how" deals with the process of attaining the goal, and is answered in the project strategy. Developing a project strategy therefore takes place directly after formulating the goal.

The process of developing a strategy is composed of steps that logically follow one another: first, the *status quo*, the already extant experience and knowledge as well as competencies of project partners are analyzed. On that basis, different strategies are developed. The strategy that seems most sensible in light of what is to be attained and how is then chosen. Afterwards, concrete activities and indicators, which contribute to reaching the goal, are outlined.



3. PLAN A REALISTIC BUDGET AND ENSURE SOLID FINANCIAL MANAGEMENT

Allocated funds should be spent in accordance with the financial plan elaborated at the beginning of the project and in accordance with the funding application. Any changes must be communicated to the respective funding institution and subsequently approved.

The leadership structure of the project is responsible for its financial management. Budget planning should be included as one dimension of the process plan or operations plan.

4. INCLUDE ACTORS RELEVANT FOR THE PROJECT IN AN APPROPRIATE WAY

High-quality research with high application potential is always a joint effort of scientists and practitioners. The potential for application increases if the subject of the research stems from societal needs. Nowadays, these are highly complex and require close cooperation between different institutions and actors with their respective specific competencies. Sustainable solutions and innovation can only be attained if complementary actors – public and private sector as well as civil society – are part of one project team. Thus, results reached can be adapted to the respective context. This requires transparency and decisions from joint negotiations and the successful cooperation between all project partners.

In addition to the common project work, each project partner has his own interests, functions and positions. Therefore, it is important to find equilibrium between individual responsibilities and common goals, since partners are mutually dependent in their cooperation towards a joint project. The project leadership – with its coordinating and moderating tasks – should always be based on negotiation processes in which partners are willing to concede part of their independence in favor of the common research interest.

Efficient relations between all involved parties need to be established. Each project partner should be able to gain visible use from this cooperation, partners should complement each other in their strengths (synergies) and clear rules should define cooperation.

In order to use all partners' competencies in an optimal way in the research project, it is necessary to take into account their interests and positions towards the goals, their influence and their role in the field, as well as their network. During project implementation, it is recommended to check the effectiveness of current cooperation forms, the amount of trust and conflict, of contentment and advantages.

Two kinds of partners can be distinguished: internal partners are those which contribute to the operationalization, which take important decisions for the project's development and take on an active implementing role. Laying down the roles of internal partners usually also results in a clearly defined project leadership structure. External partners don't assume responsibility for project goals. However, they provide help – knowledge, means or relations – for a specific subject on a one-time or continuous basis. Moreover, additional actors or institutions may have to be taken into account: those that don't directly participate in the project but may indirectly exert influence or may be interested in research results.

5. ESTABLISH RESPONSIBILITIES AND ROLES OF THE ACTORS INVOLVED

In addition to mutual trust, clearly defined roles and responsibilities provide the basis for efficient and well-functioning project teams with little conflicts. These roles and responsibilities should already be defined at the start of the project. The higher the trust among the project team, the more probable the delegation of responsibilities will be. Thus, individual workload is reduced.

Inside a project team different partners assume different roles. These depend on their position within the team, their identification with project goals, and their possibilities or capabilities to meaningfully participate in the research project. These roles should already be defined in the funding application.

Generally, there are the following roles, which can be distinguished mainly by the importance of their contribution for reaching the project goals: secondary actors occasionally support the project. Primary actors are directly involved in or targeted by the project. Key actors are directly involved in the project and take decisions. Without veto players the project's goal cannot be reached; their participation is essential for the project's progress and success. Key actors as well as primary or secondary actors can all be veto players.

In order to sound out partners' ability to participate in the project, it is useful to analyze their reasoning, their field of action, their capabilities, strengths, experience and potentials as well as their possibilities for interaction with other actors. Project needs and competencies of individual partners should be aligned in this step. That is also crucial to define roles and tasks of partners for the project's leadership structure.

6. DEFINE A LEARNING STRATEGY AND OFFER INVOLVED ACTORS AN ACTIVE ROLE IN JOINT LEARNING

Innovation that is to lead to sustainable development needs to promote and enable capacity development processes on all three levels of capacity development:

- The level of societal and political framework conditions,
- The level of organisations and institutions, and
- The level of persons as individuals.

In a research project, a capacity development process occurs when and if the project team is able to adapt to a state different from the original situation.

Developing a strategy for capacity development primarily means enabling learning processes and interaction between the levels mentioned above. The goal is to jointly draw up a learning process that emphasizes sustainability.

Changes in the learning process require time, since the project team's learning is preceded by learning processes in the organizations of the partners, which in turn is preceded by individual learning processes.

Research projects function as model scenarios for learning processes because solutions need to be reached together and sustainable changes can be attained through pooling resources and competencies.

Interactions between the different project partners with their diverse ideas, perspectives and backgrounds open up room for learning processes.

7. ESTABLISH A GOAL-ORIENTED PROJECT PLAN AND ENSURE PROCESS ALIGNMENT WITH THE PLAN

A project with concrete goals needs to define a way of reaching these goals. Said way starts with an agreed strategy and then develops through processes. Relevant processes are those that help operationalize strategic ideas. Therefore, they guarantee that goals are reached.

There are three kinds of processes in a project: core processes, support processes and steering processes. Core processes influence the quality of activities and results of the research project and directly contribute to reaching the defined goals. These processes can be split into three sub-categories: service processes lead to direct added value for project partners (i.e. analysis of energy profiles); cooperation processes serve to agree and coordinate activities and to strengthen cooperation between the project partners (i.e. internal project meetings); learning processes support project partners in reflecting on the quality of activities and measures in the project and promote exchange among partners (i.e. continuous evaluation). As their name indicates, support processes support other processes (i.e. accounting). Steering processes provide a framework for the other processes since they provide guidance through decisions.

Separating the processes into individual steps offers the opportunity to align strategy and operative work of the project.

8. DETERMINE HOW DECISIONS ARE MADE

During the implementation of a research project different strategic and operative decisions need to be made. Decision-making and project leadership are determined by the framework of roles and responsibilities of all involved project partners, which are identified and defined during the initial stages of the project by the partners themselves. Leadership is a process which consists of observing, deciding, implementing and revising.

A research project's leadership is a team of people – generally composed by the involved project partners – and has the task of elaborating a project strategy, taking strategic and operational decisions, and identifying and resolving difficulties and conflicts. Additionally, the project leadership is responsible for monitoring and financial management. It is also the project leadership's task to open up space and possibilities to integrate productive, relevant contributions into the project and to prevent paralyzing contributions from hindering progress.

The leadership structure of a project should serve its goals and be dimensioned according to size and complexity of the project. Avoid excessive proximity, in which leadership itself becomes more important than reaching the goals, and a weak leadership, where tasks are not led or supported with sufficient attention.

All project partners have a major role to play because they contribute with their knowledge and experience. They take part in decision-making, drawing on different perspectives and information. In order to do this, all activities that are dealt with by project leadership as well as the type of participation of each partner in each activity need to be defined: information, information and communication, advice, involvement, as well as direct responsibility.

A clearly defined operation plan can be of great help here: who does what when? Thus, an operation plan contains responsibilities, goals, indicators, work packages and deadlines. Financial planning should also be included in the operation plan.

Depending on the complexity of a given research project, it can be useful to distinguish between normative, strategic and operational leadership level. Normative leadership deals with goals and values, strategic leadership with the way to reach goals, and operational leadership is tasked with implementing concrete measures that are carried out.

9. ADEQUATELY MONITOR PROGRESS AND ADAPT THE PROJECT TO CIRCUMSTANCES AS THEY OCCUR

Good project management requires the objective evaluation of progress made in relation to original plans. During project implementation, activities and project development are constantly assessed: are they progressing in accordance with the original plan, and does their performance need to be improved in line with project goals? This systematic assessment is called monitoring.

Monitoring is based on indicators which operationalize the common goal. Indicators always refer to an initial and a final value. Using them, the adequate development of the project is checked.

All this provides a basis for decision-making. It is the project leadership's task to pool and systematize all information relevant for monitoring, to compare the original situation with progress made to derive strategic conclusions. Should there be large differences between defined and attained (interim) results, strategy and work processes need to be adapted in order to reach the research goal. Therefore, project monitoring functions as a constant control mechanism which records activities, successes, risks, impacts and efficiency of the project's process.

If adapting the project strategy also has an influence on project finance, the funding institutions need to be informed.

Recording information on the project's course and efficiency is also useful to communicate with external project partners and other groups interested in the research project. Significant progress motivates the continuation and the strengthening of cooperation.

10. COMMUNICATE RESEARCH RESULTS AND DISSEMINATE THEM IN THE POLITICAL SPHERE AND AMONG RELEVANT ACTORS

Those research projects whose results have a high potential for application are the ones with the highest innovative and sustainable value. Research results and further relevant findings from the project need to be edited and made accessible for their target audience. Knowledge management can support this process.

In a project, knowledge management serves on the one hand the partners' joint leaning process and on the other hand the transmission of knowledge gained in the project to actors interested in the topic and able to further use innovative research results. It is a matter of disseminating those research results that can effectively contribute to the learning process of other organizations. Therefore, it is important to process those research results to suit the target audience. One format for this is knowledge products, for instance.

Knowledge products include for example:

- A strategy that provides orientation,
- An explanatory model to better understand a situation,
- A story about learning from mistakes and how these can be avoided in the future,
- A description of a transformative process that aligns interests and pursues goals,
- A tool that helps solve a concrete problem.

These products contribute to adapting winning strategies – such as the results of a research project – to new contexts and to repeating them. On the one hand, they facilitate internal communication in the project, and on the other hand they enable exchange with external actors. They present relevant results and identify potentials in a simple and easily understandable way.

The format of a knowledge product depends on its respective target audience. Possible formats are:

- Scientific papers,
- Informative folders or leaflets,
- Website.

Here, it is crucial to adapt language to suit the respective target audience and to present information in an attractive format. This also facilitates exchange with and dissemination among the target audience.

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