

FINAL REPORT GMI
Community-based Landfill Gas Utilization in Brazil - Phase II
Award # XA-83500201-0

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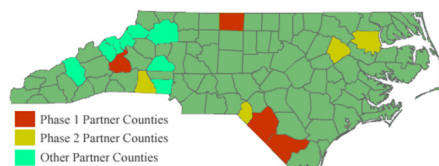
I. Background

Located in the Blue Ridge Mountains, Appalachian State University, in Boone, North Carolina is well known for its sustainable orientation. ASU has approximately 17,000 students, and is one of 17 schools in the University of North Carolina System.



Appalachian State's curriculum includes undergraduate and graduate level courses in appropriate technology, sustainable business, and environmental policy and economics.

The Energy Center at Appalachian State University, established in 2001, conducts energy research and applied program activities in a multi-disciplinary environment. The Center, working through faculty, staff and students, has programs in the areas of energy efficiency, renewables, policy analysis, forecasting, and economic development.



The Community TIES Project of the Energy Center is a landfill gas development initiative working with counties in North Carolina to facilitate development of LFG-to-energy projects that are community-based with a primary focus on generating economic development outcomes. The

Community TIES Project facilitates local economic development by leveraging LFG as a local energy source. The project assists county governments in development of their closed landfills by evaluating the value of their resource, serving as a neutral broker between the county and technology- and service-providing organizations, and providing assistance in fund-seeking efforts. As part of these activities, the project partners with local communities to develop their LFG resources.

The Community TIES Project is modeled on the award-winning EnergyXchange LFG project at the Yancey-Mitchell County landfill which uses LFG as fuel for glass furnaces, a pottery kiln, and land to heat greenhouses used to propagate native species. A present ASU Energy Center staff member was one of the founders of EnergyXchange. Other examples abound within the state of how LFG can be used to drive local development, with an industrial park developing around Catawba County's Blackburn Landfill and the Jackson County Green Energy Park, which uses LFG to fuel blacksmith studios and other local industries.

The Energy Center staff has a strong reputation for "community-based" landfill gas development. The Energy Center staff, including Stan Steury, Jason Hoyle, Dr. Jeff Ramsdell, Jeremy Ferrell, Zach Hobbs and Joey Mosteller, has provided consultation on 33 landfills in North Carolina, and have assisted in the development of landfill gas utilization projects at 15 of

these. In addition, the ASU Energy staff has consulted on “community-based” landfill gas development in other states including Indiana, Kentucky, Georgia, Virginia, Ohio, South Carolina, Mississippi, Tennessee, California, and Washington.

Appalachian State University has ongoing commitments in Brazil which have created opportunities for synergy between Brazilian entities and Appalachian State. ASU has developed strong academic ties to a number of Universities in Brazil. At this time there are four academic partner universities in four separate Brazilian states including Ceará, where UNIFOR is a full academic partner. The relationship with these Universities is a continuing source of human and academic resources for our project. The Federal University of Ceara, UFC, at Fortaleza, while not one of ASU’s academic exchange partner universities, has developed a good working relationship with ASU over the last several years, particularly in the exchange of information about biofuels and other renewable energy technology.

ASU’s Office of International Education and Development (OIED) is actively seeking opportunities for academic, cultural, and business exchange opportunities with Brazil. In the past year, Appalachian State students and faculty have experienced foreign academic travels in 30 countries on all continents except Antarctica. In July OIED was awarded a FIPSE grant for sustainable development education initiative in Brazil. ASU’s Walker School of Business, has been instrumental in opening doors for us in Ceará. Dr. Martin Meznar, Associate Dean of the Walker School, and a native of Brazil, provided contacts for us in our successful efforts to interview numerous state and local officials and visit 7 landfills in October 2009. These contacts have continued to provide excellent opportunities for partnership development in Ceara.



In 2009, because of its reputation for community-based landfill gas development and its ongoing activities in Brazil, the Energy Center received a grant from the Methane to Markets program to find and develop a community-based landfill gas utilization project in northeast Brazil. During this first phase, under the Methane to Markets program, the Appalachian State University Energy Center team visited 7 landfills in the state of Ceará, gathered technical data on the landfills capacity, and established an extensive network with state and local government for the next phase of implementation of the project. During this process we contacted appropriate state and local officials about landfill gas projects at the selected landfills, and developed working relationships with these people.

During Phase I, the municipality of Maracanaú in the state of Ceará emerged as a major partner in our effort to develop an innovative community-based landfill gas project.

In June 2010, we hosted a delegation of 5 Brazilians from Ceará, including the Mayor of Maracanaú, to successful LFG utilization projects in North Carolina. The goal of the Mayor was to create local economic opportunities for small business, and at the same time create jobs for 75 families of “catadores” or waste pickers, who rely on the landfill as their source of livelihood. The government of Maracanaú hopes to develop an energy park next to the landfill which will use landfill gas in industrial facilities, especially to benefit these “catadores”.

The community-based approach has been the centerpiece of our project, assuring that uses for the LFG were identified based on the energy and community development needs of the landfill community. This community-based approach will have an even greater positive economic impact in Brazil, than it does in North Carolina, because of the “catadores”, the waste pickers. Our approach provides a good way to link the collection of landfill gas to programs in which public-private partnerships can be fostered to improve the lives of the catadores families. It is for this reason that we have already partnered with human services agencies and non-profits in Ceará and specifically Maracanaú to address these needs.

During Phase I of our project in Ceara, we developed a computer model of the gas production and capture of LFG at the Maracanaú Landfill, developed pre-designs and cost estimates for LFG collection, selected appropriate LFG utilization technology for landfill gas utilization at Maracanaú, and prepared feasibility reports for project development. Phase I of our project revealed there was potential for LFG development at several of the landfills in Ceará in the years ahead. Older sites for solid waste disposal in Ceará were mostly open dumps or poorly managed landfills. Eventually these landfills may be good candidates for LFG development, but we noted several hurdles present at these landfills including small cell size, poor leachate management, and poor methane venting. Maracanaú is the largest and most rapidly growing of the Ceará landfills which we considered and there appears to be the technical support needed to allow sound landfill management. More importantly, there is strong political support for a community-based LFG project to improve the lives of the 75 “catadores” families that make their living from the landfill. It is hoped that the Maracanaú Project will be a model for many others in Ceara, and throughout Brazil and all of Latin America.

II. PROJECT SUMMARY

This is a report of activities of Appalachian State University Energy Center and its partners on our project, Community-based Landfill Gas Utilization in Brazil - Phase II, which was funded by Global Methane Initiative grant number XA-83500201-0 for \$120,000, awarded in April, 2011. This grant followed a Phase 1 grant awarded in 2009 to begin this project. The project will take place at the Maracanaú Landfill in Ceara, Brazil in an Energy Park where methane gas from the Maracanaú Landfill will be used for value-added processing of glass and plastic collected from the waste stream by local “catadores” or Brazilian waste-pickers. This project is already being viewed as a model for other similar projects at landfills throughout Ceara and the rest of Brazil, as the handling of solid waste in that country is rapidly transitioning due to federal legislative mandates.

During the period of this grant the following major progress was made.

- Successfully passed leadership of the project from Appalachian State University to the partners in Ceara, Brazil.
- Comitê Metano Verde (Green Methane Committee) organized to lead project development.
- Capacity of Green Methane Committee developed and Project Managers selected.
- Design for landfill gas collection system completed. The estimated cost for this system is US\$340,000.
- The catadores’ association, COOMVIDA, obtained a warehouse, remote from the landfill, where recyclables will be received to comply with new federal regulations.
- Plans for value-added processing of plastic were completed by COOMVIDA (the local waste pickers cooperative) and the NGO ANIMA which assists them.
- Equipment for value-added processing of plastic at Maracanaú Energy Park obtained. Cost was US \$199,000.
- Training for recycled glass processing completed by COOMVIDA and ANIMA leaders at Studio Xaquixe in Oaxaca, Mexico.
- Plans for COOMVIDA’s value-added processing of glass completed.
- Completed pre-design plans for Maracanaú Energy Park.
- A business plan was developed for the landfill gas collection and utilization and value-added processing of glass and plastic at the Maracanaú Energy Park. Estimated Cost for the entire Energy Park including electricity generation, plastic processing, and glass processing systems total about US\$910,000.
- A contract was developed for donation of land and free use of landfill gas from Municipality of Maracanaú to COOMVIDA for the Maracanaú Energy Park.
- New, local Municipal Solid Waste legislation drafted to clear the way for federal and state funding of the project.
- Funding agencies identified and recruited for the construction phase of the project.
- Relationships developed with various supporting and partnering agencies for project.

III. ADDRESSING PROJECT NEEDS

At the beginning of Phase II of this project, and the beginning of this grant, several needs were identified in our project plan. Following is a list of these needs and progress made toward meeting them during this phase of our project.

1. During the first phase of our Community-based Landfill Gas Utilization Project we selected the Maracanaú Landfill as our pilot project. US engineering firms, with whom we contracted in Phase I, had developed preliminary designs and cost estimates of the landfill gas collection and utilization systems. Construction-ready designs were not available, however.

Phase 2 Progress - We now have construction-ready designs thanks to Dr. Jose Capelo.

2. While our Landfill Gas Task Force in Ceará provided a lot of volunteer manpower, there was no one in Brazil to officially assume leadership of the Maracanaú project to facilitate the final planning, design, and construction.

Phase 2 Progress - During Phase II, the Maracanaú Green Methane Committee was formed to provide leadership to the Maracanaú project. This committee selected a Project Manager, Dr. Albert Gradwohl, of the University of Fortaleza, who was to provide overall leadership for the project. Dr. Gradwohl did a good job during three months following his appointment. However, he was unable to continue in that post. In his place, two other leaders emerged from the Green Methane Committee to assume these duties beginning about January of 2013. These two continue to serve as Project Managers. Dr. Jose Capelo, professor of engineering at the Federal University of Ceara at Fortaleza (UFC) and consulting engineer to the Municipality of Maracanaú for the landfill, has taken over the technical aspects of the project, including design and construction supervision of the landfill gas collection system. Meanwhile, Edson Martins, of the NGO ANIMA, has taken over the management of this project in relation to the value-added processing of glass and plastic recovered from the waste stream by the catadores. He also has assumed a leadership role in dealing with potential funding agencies and other potential partners. These two have done an outstanding job.

3. It was unknown whether carbon credits could provide financing and/or ongoing support to a small landfill gas project in Brazil, such as the one at Maracanaú.

Phase 2 Progress - While we do not expect the sale of carbon credits to be the primary source of income for this project, we do expect the sale of carbon credits to be a good supplementary source of income. Jason Hoyle of the ASU Energy Center staff has prepared carbon credit analyses for this final report and also the one for Phase 1. Going forward, Dr. Jose Capelo will see to it that gas flow meters, methane analyzers, and other necessary carbon credit monitoring equipment is installed in the landfill gas collection system. Federal Labor Judge Carlos Alberto Tindade Rebonatto, who has experience with carbon credits at other landfills has offered assistance to the project in creating a carbon credit enterprise.

4. There was no pilot or model landfill gas project in Ceará to prove that it can be done.

Phase 2 Progress - The Maracanaú community-based landfill gas project is increasingly recognized as a viable option for other communities in Ceará and throughout Brazil for improving the lives of catadores and their families, while meeting requirements of the new federal Solid Waste Law for Brazil of 2010. There seems to be a good deal of awareness about the Maracanaú project among the regulating agencies which deal landfills and the social service agencies that serve the catadores. In a series of meetings with federal and state agency representatives during our trip to Ceará in October 2014, we heard several times that this project could be the model for many others in Ceará and the rest of Brazil to help meet the requirements of the new Solid Waste Act. We believe that there is also increasing awareness of the Maracanaú project in the general public. While we were in Fortaleza and Maracanaú in October, we were interviewed by both television and newspaper reporters covering this story.

5. There was a commonly held belief that even medium-sized landfills in Brazil are too small to support an economically feasible project.

Phase 2 Progress - The business plan for the Maracanaú project, documents the potential for projects of this size to be economically viable, and a growing number of agencies in Brazil recognize the potential for the Maracanaú project to succeed and be duplicated. We feel that there are now many true believers that this project is big enough to succeed.

6. Trained Brazilian LFG engineers and development firms were rare in Brazil and Ceará.

Phase 2 Progress - While this is still true in Ceará, Dr. Jose Capelo has emerged as a leader in this field, due to his experience on this project and contacts made as a result, a growing number of agencies, groups, and individuals are learning of his work. Dr. Capelo presented on his landfill work at a World Bank Conference in 2013.

7. There was a great lack of awareness of the potential for LFG utilization in Ceará.

Phase 2 Progress - While this is still true, the Maracanaú Project is rapidly raising the awareness of many and agencies about the potential of landfill gas. This is due to the tireless work of the Brazilian partners and growing publicity about the project. The major newspapers in Fortaleza have had features on the Maracanaú project and even international publications like the Huffington post have give it coverage.

8. A high percentage of Ceará residents do not have access to electricity.

Phase 2 - This is still an accurate statement. We hope that in the near future, our project will demonstrate that electricity can be generated locally at smaller landfill gas and biogas projects.

9. Far too many people in Ceará still found it necessary to make their living by digging through the garbage at the landfills. At Maracanaú for instance, there are about 75 families (about 250 people) who make their living in this manner from the landfill.

Phase 2 Progress - While this is still true, the catadores here at Maracanau are hopeful that the development of this project will result in better jobs, more income and safer conditions, for the members of their Association. There has been a degree of success in moving some catadores from the jobs on the waste at the landfill to collecting, sorting, baling, and shipping recyclables before the waste reaches the top of the landfill. When our value-added processing center is in place, this shift in jobs will hopefully become complete at Maracanau, showing the rest of the country how landfill gas can leverage the creation of a better way of life for Brazil's catadores.

IV. PHASE 2 TASKS

The following table displays tasks which were identified in our plan for Phase 2 and progress toward completion of these tasks.

Action	Responsibility	Progress
Project Management	ASU Energy	Form Green Methane Com
Hire Project Manager	Green Methane Com	Filled by Capelo, Martins
Collection System Design	UFC, Consultants, ASU	Done by Capelo
Capacity Building NGO (ANIMA)	ANIMA, Maracanaú	Done by ANIMA/COOMVIDA
Collection system construct oversight	UFC, Consultants, ASU	Capelo ready
Collection system construction	UFC, Contractors, ASU	Pending
Design Energy Park	UFC, Maracanaú, ASU	Done by Capelo, Martins
Pro-forma of LFG utilization system	ANIMA, UFC	Done Holanda, Martins, Capelo
Carbon Credit Marketing Plan	ASU	Developing ASU, others

V. SPECIAL THANKS

During the last 4 years, a strong working relationship has developed between the Appalachian State University Energy Center and several partnering groups and individuals in the U.S. and Brazil. The Energy Center would like to offer our special thanks to the following groups and individuals who made this phase of the Community-based Landfill Gas Project at Maracanaú a big success.

1. Mr. Chris Godlove, US EPA, Landfill Methane Outreach Program
2. Mayor Jose Neto Fimus Suede, Municipality of Maracanaú, Ceará, Brazil
3. Mr. Edson Martins, Biologist and Executive Director, ANIMA
4. Dr. Jose Capelo Neto, Professor of Engineering, Univeridade Federal do Ceará, Fortaleza.
5. Mr. Fernando Henrique Ribeiro Holanda, Graduate Student of Jose Capelo
6. Mr. Luis Carlos Marreiro de Souza, President of COOMVIDA
7. Mr. Marcos Viera, Secretary of Infrastructure, Municipality of Maracanau
8. Ms. Glauciane de Oliveira Viana, Secretary of Social Services, Municipality of Maracanau
9. Mr. Idalmir Carvalho Feitosa, Legal Council for Municipality of Maracanau

10. Ms. Stella Monteiro Montenegro, Assistant Legal Council for Municipality of Maracanaú
11. Mr. Dmitri Montenegro, Pro-bono Attorney, ANIMA
12. Mr. Joufre Montenegro, Pro-bono Attorney, ANIMA
13. Dr. Cleber Dutra, University of Fortaleza, UNIFOR
14. Dr. Alfred Gradvahl, University of Fortaleza, UNIFOR
15. Mr. Chris Godlove, US Environmental Protection Agency, LMOP
16. Mr. Christian Thornton, Co-owner Studio Xaxique, Oaxaca, Mexico
17. Mr. Francisco Caminha, Former Congressman from Fortaleza, presently assistant to Governor of Ceara
18. Mr. Roberto Pessao, outgoing Mayor Municipality of Maracanaú
19. Mr. Paulo Roberto de Silva Leonardo, Our guide for our first visit and excellent networker
20. Ms. Waleria Sampaio, Former Chief of Staff for Congressman Caminha
21. His Honor, Carlos Alberto Tindade Rebonatto, Federal Labor Judge
22. Ms. Ieda Maria de Castro, Maracanaú City Council & Fortaleza Dept of Social Services
23. Mr. Claudio Ricardo Gomes de Lima, Fortaleza Dept of Social Services
24. Ms. Patricia Cornette, Research and Sponsored Programs, Appalachian State University
25. Mr. Roberto Pessoa, Former Mayor Maracanaú
26. Mr. Adriano Sampaio Borges, AEDI, Association of Industries

VI. GREEN METHANE COMMITTEE

Initially it was necessary for the Appalachian State University Energy Center to assume a leadership role in this project as Maracanaú was selected as the site for a community-based landfill gas project, partners were recruited for the project, and the capacity of these partners was developed. However, the goal of the Energy Center was to transfer the leadership in the project to the Brazilian partners to enable successful development of the project. This process culminated in the establishment of a Task Force made up of Brazilian Partners to facilitate project development. This Task force was selected during the visit of the Appalachian State University Energy Center team to Ceara in August 2012, and was officially organized during the three months immediately following. The group was named Comitê Metano Verde or Green Methane Committee. This group is made up of representatives of the partners in the following section. The organizational charter is an addendum to this report and can be found on the ASU Energy Center web site.

The original Chairman of the Metano Verde Committee was Mr. Albert Gradvohl of the University of Fortaleza, UNIFOR. Mr. Gradvohl served in this capacity during the organizational stages of this Committee. When he was unable to continue in this capacity, his duties were divided between Dr. Jose Capelo, of the Federal University of Ceara at Fortaleza (UFC), and Mr. Edson Martins of ANIMA. Dr. Capelo has taken responsibility for most of the engineering and technical aspects of the Committee's work, while Mr. Martins has taken responsibility for the social aspects of the Committee and for the fundraising and partnership development.

VII. PROJECT PARTNERS

1. Maracanaú Municipal Government - We have been quite fortunate in having been able to develop a strong relationship with the municipal government at Maracanaú. Before our project started, ASU had a budding relationship with many institutions in the State of Ceará. Members of University of Parliament along with about 30 other students and university and government personnel visited ASU in July 2009. The relationships developed during this visit paid off many times over when our ASU Energy Center team visited Ceará in October 2009. This strong network of contacts helped our team during our visit to Ceará and enabled us to visit the offices of appropriate government officials, landfills in seven municipalities, and municipal government offices in Taua, Sobral, Maracanaú, and Horizonte. Maracanaú's current administration is entirely supportive of the project, in particular, the positive social-economic aspects of the project. The current administration is determined to use the energy available from the landfill gas there to fuel economic and community development for the 75 catadores families who depend on this landfill for a living. The administration of new Mayor Jose Neto Fimus Suede, has continued the strong support of his predecessor.

2. ANIMA Institute of Technology – The ANIMA Institute of Sustainable Technology is a Non-profit organization based in Fortaleza , Ceará , Brazil and carries out a program to assist other environmental organizations and associations of waste-pickers (catadores) to improve the social well - being and quality of life of individuals. ANIMA promotes ethics, peace , citizenship , human rights , the environment and democracy.

ANIMA serves Maracanaú, Fortaleza, and Aquiraz , interacting with public organizations , the private sector , universities and businesses , assisting in activities related to research, income generation , education , environment and culture for the catadores.

ANIMA assists COOMVIDA, the Catadores Association of Maracanaú with activities related to mobilizing their workforce and capacity building. The goal of ANIMA is to help COOMVIDA become a self-sufficient and strong organization through workshops, technical assistance, and teambuilding activities. ANIMA gives COOMVIDA's members training related to the environment, logistics of waste management, law, manufacturing, and marketing. In addition to Maracanaú, ANIMA works with catadores cooperatives at Fortaleza and Aquiraz. ANIMA also works to strengthen members of COOMVIDA through workshops, seminars, and training courses. This training includes affirmative action, socio-economics, environmental protection, education, and cultural awareness.

ANIMA has taken a leadership role in the formation of the Green Methane Committee formed to enable development of a landfill gas project and an Energy Park at Maracanaú. In accordance with their Agreement on Social and Environmental Cooperation ANIMA and COOMVIDA have developed a program of selective collection of recyclable materials from the solid waste stream and have worked with the local government to provide infrastructure, public policies, and services which support that activity.

ANIMA has also carried out international activities with other groups related to its mission. As a part of this project, Edson Martins of ANIMA and Luis Carlos of COOMVIDA traveled to Studio Xaquixe in Oaxaca, Mexico to provide training to staff and a glass value-added processing business plan to COOMVIDA for its glass value-added processing center at the Maracanaú Landfill and Energy Park. At Oaxaca, ANIMA also linked with the Mexico-based aid group, SKIKANDA, which assists Mexican waste-pickers and their families, much as ANIMA does in Ceara. ANIMA has also collaborated on projects with JICA, the Japan International Cooperation Agency, and other international groups.

The Director of the ANIMA Institute is Mr. Edson Martins.

3. COOMVIDA or Cooperativa do Mutirao Vida Nova (Catadores Association of Maracanaú)

There are approximately 12,000 people in the State of Ceará who are classified as “catadores” or waste pickers. Approximately 75 families of “catadores” belong to COOMVIDA the Catadores Association of Maracanaú, with a total of about 250 people in those families. This Association strengthens the bargaining power and cumulative voice of its members. COOMVIDA is working with all project partners in planning for the development of the “Energy Park” at the Maracanaú Landfill.

COOMVIDA aims to provide services to their members which lead to better working conditions and higher personal and family income. COOMVIDA does this by providing training activities for professional, economic, and social development. COOMVIDA works to improve the living conditions of member families and works to eliminate child and spousal abuse, drug and alcohol addiction, crime, and other destructive behaviors. To accomplish its mission, COOMVIDA links with ANIMA and the Social Services Agency of Maracanaú.

COOMVIDA is the core organization of the Maracanaú Energy Park project – the organization which will both perform and benefit from the value-added processing center for glass and plastic. In 2003, this cooperative was formed to unite the waste collectors of Maracanaú in a process of social mobilization, improving the quality of life for its members by more efficiently carrying out the job of recycling from the waste stream at Maracanaú. The cooperative hopes to eventually totally eliminate the need for scavenging through the garbage at the Maracanaú Landfill. Formerly, as many as 200 “catadores” participating in this scavenging at the landfill Maracanaú, actually digging through the garbage as the waste was dumped from garbage trucks. When this landfill gas project began, COOMVIDA’s plan was to install a waste sorting facility where recyclables would be sorted from the garbage more safely. This sorting facility was to be the first stage of processing at the Maracanaú Energy Park where the plastic and glass would then be put through the process of value-added processing. This transformation of the work of COOMVIDA and its members has been redirected, however, because of the new Brazilian federal solid waste act of 2010. This law requires that by 2014, all waste sorting will be done before municipal solid waste is loaded on garbage trucks. This means that the waste will be pre-sorted at the source.

COOMVIDA was already moving in that direction before the 2010 solid waste act was passed. For several years, ANIMA has been assisting COOMVIDA in obtaining contracts with industrial and commercial facilities for the pickup of plastic, glass, cardboard, and other recyclables directly at their sites. By doing this, the number of members scavenging from the garbage at the landfill has been dropped, as more positions became available at the warehousing facilities of COOMVIDA.

Meanwhile, the waste sorting facility which existed before this project started was abandoned because it was located in the flood plain of a new flood control reservoir. To encourage compliance with the new federal solid waste regulations requiring selective collection of waste, Ceara state government encouraged COOMVIDA to relocate its warehouse operations to a donated warehouse facility remote from the landfill, but close to the Maracanaú Industrial District.

These changes in turn caused adjustments to COOMVIDA's long range plans in relation to this landfill gas utilization project and the Maracanaú Energy Park. Present plans call for sorting and warehousing of recyclables at the remote warehouse facility. The glass and plastic will then come to the Energy Park, where value-added processing will be performed using heat from the landfill gas and electricity generated by landfill gas fuel.

It is hoped that this collection of recyclables at the source marks the beginning of a new era for COOMVIDA with better jobs and higher income, without the nasty work of digging through the garbage on the landfill. In years ahead, this difficult and dangerous work will be replaced by collecting recyclables "at the source" at industries, commercial businesses, universities, government agencies, and eventually from residences, in accordance with Article 8 of the National Solid Waste Policy.

To carry out its mission and to fully participate in the Maracanaú landfill gas and energy park project, ANIMA is fully participating with partners including Appalachian State University, the Municipality of Maracanaú, the Association of Industrial Districts of the State of Ceará (AEDI), ANIMA Institute for Sustainable Technologies, the Federal University of Ceará, the Green Methane Committee, and the Secretary of Cities of the State of Ceará and the National Foundation of Health.

The current President of COOMVIDA is LUIS CARLOS DE SOUZA Marreiro'.

4. Universidade Federal do Ceara, UFC

The Federal University of Ceará (UFC), located in Fortaleza, and is providing research and outreach assistance for this project. Appalachian State University had developed strong ties with UFC even before the start of our landfill gas project in Brazil. NuTec, located at UFC is a public/private partnership, an institute where a great deal of work is being performed on biofuel research and demonstration, offering excellent opportunities with our project.

Dr. Capelo, a faculty member at UFC, teaches civil engineering at the University and is a consulting landfill engineer who was hired by the Municipality of Maracanaú, and is now in charge of the Maracanaú Landfill. Dr. Capelo was one of the members of the group that visited ASU and North Carolina in June 2010. Due to his position with Maracanaú, he is the Brazilian engineer who is preparing the design for the landfill gas collection and utilization system at Maracanaú.

5. Universidade do Fortaleza, UNIFOR – Unifor, the University of Fortaleza, is the other major university in Fortaleza. It is a private university of about 25,000 students which has been selected as an academic partner university by ASU. Students at Unifor and ASU are now able to obtain credits from the other school toward a diploma by studying at the partner university for a semester. Three students from Unifor are at Appalachian State University for the spring semester of 2014. All three are currently working on the Maracanaú landfill gas project as interns while they are here. We have also had students from Appalachian State studying at Unifor and working on the project while they are there. Dr. Cleber Dutra, of the Department of Sustainability has been a huge help to the project, especially in dealing with AEDI, the Ceara Association of Industries.

VIII. LEGAL ISSUES

A common obstacle to landfill gas development worldwide is the lack of clarity in the ownership of landfill gas. This is certainly true in on this project, where the garbage comes from Municipality of Maracanaú, which also manages the landfill, and the land on which the landfill is built belongs to the state. Further complicating the ownership issues is the fact that the landfill gas will then be used by COOMVIDA for the value-added processing of glass and plastic. The ASU Energy Center encouraged the Committee to resolve these issues with a contractually. Progress toward resolving these ownership issues was made when a young attorney, Dmitri Montenegro volunteered to provide pro-bono legal services to ANIMA and COOMVIDA for this project. Dmitri was referred to the project by his aunt, Stella Montenegro Montenegro, who is the Assistant Legal Council for the Municipality of Maracanaú. During the visit of the Appalachian State University team to Brazil in October of 2013, Dmitri and Stella, along with Edson Martins arranged for a visit with his Honor, Carlos Alberto Tindade Rebonatto, a federal labor judge located at Maracanaú. Judge Rebonatto had extensive experience with landfills and catadores in Brazil. The purpose for the meeting was to get advice from the judge on contractual arrangements to resolve these ownership issues.

Judge Rebonatto recommended that Dmitri and his partner, Joufre Montenegro, with the assistance of Stella Montenegro, draft a contract allowing for the Municipality to provide landfill gas to COOMVIDA and then have Judge Rebonatto review this contract. Only when the revision is approved by the Municipality, the approved contract will be presented to state and federal agencies for their files. Judge Rebonatto feels that there is no legal precedent for a contract like this, and that this project will be a perfect pilot for other projects in Ceara and throughout Brazil. By gaining the approval of the federal labor judge and the legal counsel for the Municipality before confusing the issue with many “opinions” by government agencies first,

the project will likely move forward much faster. A copy of the latest draft of this contract is an addendum to this report and is included on the Appalachian State University website.

IX. LANDFILL GAS COLLECTION SYSTEM DESIGN & CONSTRUCTION PLAN

Dr. Jose Capelo, engineering professor at UFC, the Federal University of Ceara at Fortaleza, has years of experience with landfill gas management in Ceará as well as a strong education in the field. He studied for his joint doctorate at the Federal University of Ceará and the University of Texas. Dr. Capelo is a very accomplished landfill engineer, whose specialty has been in dealing with leachate. He is the consultant who is hired by the Municipality of Maracanaú to design and manage their landfill. During the early phases of this project, the ASU Energy Center provided training and opportunities for Dr. Capelo to network with experienced landfill engineers, provided US EPA project development manuals, and sent him to visit other successful landfill gas projects in Brazil. As a result, Dr. Capelo has now completed a landfill gas collection system design and is comfortable with the process. The completed design includes design drawings for the wells, collection lines, condensate collection system, blower, and flare. The estimated cost of this gas collection system is about US\$340,000. The design documents and drawings for the landfill gas collection system are included as an addendum of this report and are included on the Appalachian State University website. These design documents are available only to project partners.

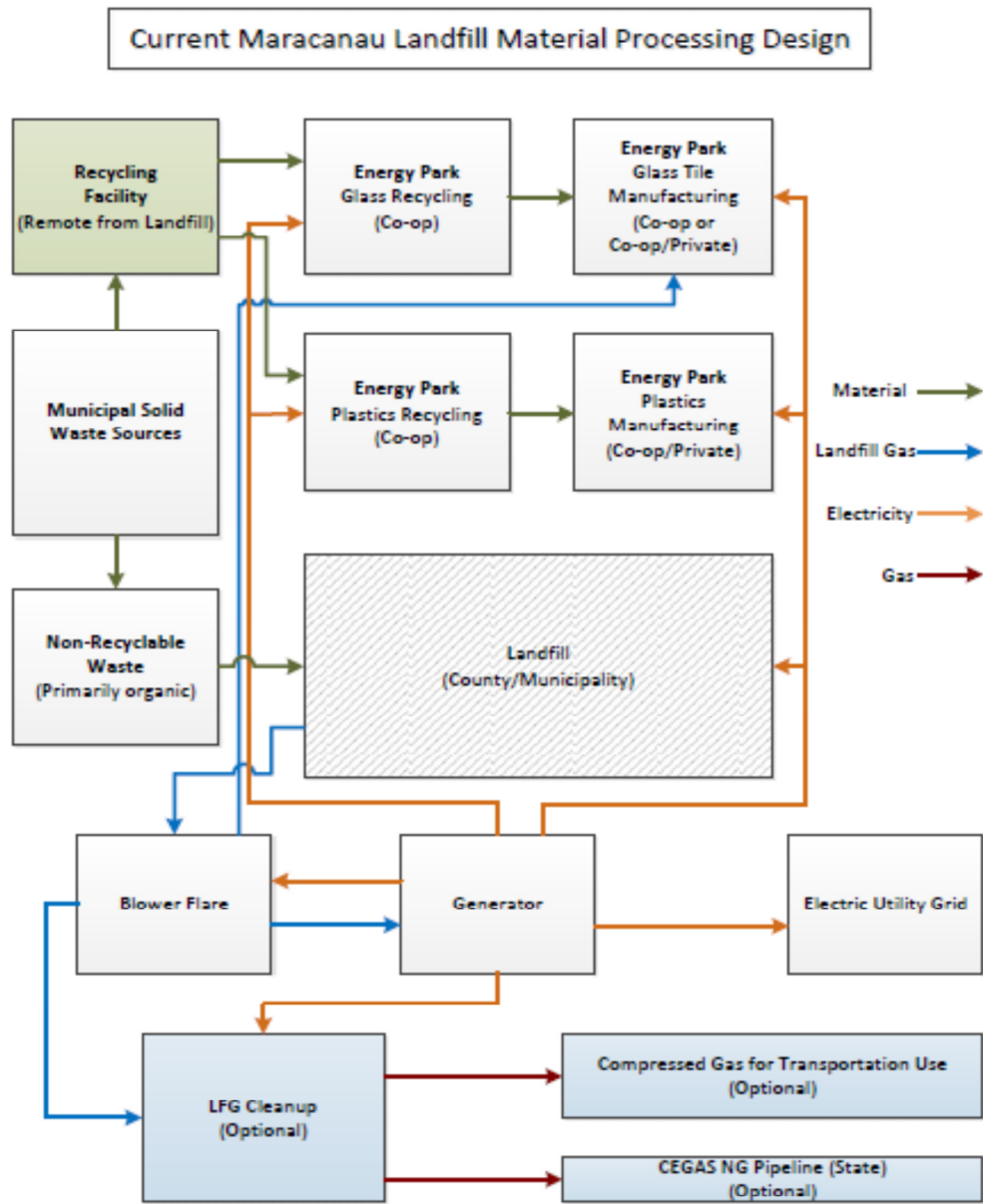
X. MARACANAU LANDFILL GAS ENERGY PARK PRE-DESIGN

The plan for utilization of the landfill gas from the Maracanaú Landfill will include the development of an Energy Park adjacent to the landfill. This Energy Park concept is based on the projects at EnergyXchange, Jackson County Green Energy Park, and the Catawaba Eco-complex – three “project community-based” landfill gas projects in North Carolina. The partners on the Maracanaú project have seen these sites and have chosen this model for their project. The members of COOMVIDA, the catadores of Maracanaú have worked at this landfill site for many years, but until recent years their work has been to sort through the garbage on the landfill.

The 2010 federal Solid Waste law and the catadores reaction to it have caused major changes in the planning for the Maracanaú Energy Center. This new law calls for no municipal waste to be sorted or recyclables removed from the waste after it is loaded on a truck. This rule will keep catadores from working on the landfill, instead encouraging them to intercept the recyclables at the source. This rule, if enforced will also eliminate the sorting lines that were identified as an integral part of the Energy Park when planning began in 2009.

The first draft of the Energy Park flow chart below was developed by the team of 5 Brazilians who came to the US and to North Carolina in 2010. This group was led by former Mayor Pessoa. The revised flow chart below represents the current plan of the Green Methane Committee to allow COOMVIDA to use a portion of the gas at the Maracanaú Landfill to fuel value-added processing of glass and plastic recovered from the waste stream at the Energy Park to make the

whole recycling program at Maracanau more sustainable. A major change in this draft, however, is the removal of the waste sorting facility at the Energy Park. Instead, to comply with the new federal solid waste rules, the recyclables will now be removed before they get to the landfill. COOMVIDA has recently been tentatively promised the donation of a warehouse building approximately 12 kilometers from the landfill. Here recyclables will be received after collection from the source, sorted and/or repackaged to be shipped to the Energy Park for value-added processing. The estimated cost of this Energy Park, including electricity generation and the glass and plastic processing centers is about \$US910,000. A copy of the predesign drawings for the Maracanau Energy Park is an addendum of this report and is posted on the Appalachian State University Energy Center. These drawings can be accessed only by project partners.



1. Plastics Value-added Processing System Plans

Plastics are the largest category (volume) of recyclables recovered by COOMVIDA. These plastics, however, have been sold for quite low prices in the past. Even before our project, COOMVIDA had purchased compactors for the plastic. These compactors have reduced the bulk of the plastic and reduced transportation costs. In addition, COOMVIDA has purchased a washer to clean the plastic bottles, a machine to remove labels from bottles, a shredder, and a pelletizer or extruder, using US \$199,000 of grant money received from the Brazilian government. With this equipment, a small amount of value will be added per unit, however the

volume of plastics will be quite high. The plastic will be sold as plastic pellets. The plan for value-added processing of plastic is included on the Appalachian State University Energy Center website as an addendum to this report. There is potential to add much more value to these plastics in the future, however. If the plastic pellets were further processed into a final product, much more profit could be made. For example, there has been interest from a local industry which creates building panels made from recycled plastic bottles - a potential public-private partnership for the Energy Park. Please note that the plastics value-added processing system is evaluated in the Energy Park Business Plan.

2. Glass Value-added Processing

In the US, glass is often one of the most difficult recyclable products to sell when recovered from the waste stream, and unprocessed glass is one of the least valuable of all recyclable products. However, there is an excellent chance of adding very significant value to the glass. That is one of the goals of COOMVIDA at the Maracanau Energy Park. SINDIVEDE, the federal union of recyclers, reports that all glass recovered from the waste stream in Ceara now goes to buyers neighboring states, due to lack of markets in Ceara. While the volume of glass is currently quite low, Edson Martins of ANIMA promises that there is much more out there to be collected from the Maracanau Industrial Park with 200 + industries and from other commercial sources. In contrast with plastic, the volume of glass collected by COOMVIDA may be a much lower than plastic, but the processing planned at the Energy Park will add much more value, than with plastic. A copy of the glass processing plan developed by Edson Martins of ANIMA is an addendum to this report and can be found on the Appalachian State University Energy Center web site.

The Appalachian State University Energy Center was able to obtain the consulting services of Christian Thornton, a well-known international glass artist. Mr. Thornton is also known for his research on and experience with using renewable energy and energy efficiency in his glass processes. Christian has worked with glass for 30 years. His career began in Washington State and matured in New York City from 1990 to 2000 working with Joseph Porcelli, Victor Rothman, Urban Glass and many others. Some examples of that period include creating and performing design projects for Jed Johnson, Daryl Hannah and Richard Gere with glass master Patrick Clark.

The year 2000 marked the start of Thornton's ongoing fascination and experimentation with recycled glass innovative designs and alternative energy sources, beginning with his work at the Maho Bay glass studio in St. John USVI. At the close of 2001, Christian relocated to Oaxaca, Mexico where he designed and built Studio Xaquixe. <http://www.xaquixe.com/glass/christian-thornton.php>

Years of labor and innovation have yielded the creation of the "Enviroglassart" concept (the combination of the necessary components that constitute a sustainable art glass center): formulation of waste glass, recuperation of heat, application of alternative energies and innovation of business models that adhere to the principles of social and environmental responsibility. These concepts and technologies have enabled Studio Xaquixe to make art and

architectural pieces from recycled glass. Christian and his partner train local “waste-pickers” and employ them in Studio Xaquixe to make products from recycled glass. A few of these people become glass artists, but more are involved in semi-industrial glass production.

Christian Thornton continually tests and refines the Enviroglass equipment and is now fabricating a project for a new eco-cluster member in Northern Mexico. While in Mexico, Christian’s appetite for design has not waned. He has conceived an array of distinct glass bottles for international mezcal brands such as: Mezcal Sombra (NY), Mezcal Los Amantes (NY) and Mezcal La Reyna (Chicago). In 2009 Christian was invited to design the signature sculpture to commemorate the 25th anniversary of Montblanc (luxury writing instruments). The following year he created a shot glass for Mezcal La Sombra. These items are produced with recycled bottle glass.

Since the project partners at Maracanau have included recycled glass production as part of their plan for the Energy Park, the Appalachian State University Energy Center contracted with Christian to provide training and a business plan to Edson Martins of ANIMA and Luis Carlos of COOMVIDA for a value-added processing center for glass at the Maracanau Energy Park. In keeping with the concept of the original plan, this value-added processing will concentrate on a semi-industrial process rather than works of art. Products may include a variety of products which can be mass produced, such as decorative glass tile. In September 2013, Edson and Luis traveled to Oaxaca, Mexico to tour Christian’s facility and receive intensive training on collecting, transporting, processing, production, and marketing of recycled glass objects. After this visit, Christian and his partner provided a business plan to COOMVIDA. The glass business plan for Maracanau, developed by Studio Xaxique is an addendum to this report and is included on the Energy Center website.

XI. LANDFILL GAS BUSINESS PLAN

The Maracanau Landfill Gas Utilization Project and the Maracanau Energy Park will consist of several different enterprises, including the gas collection system, creation and sale carbon credits, value-added processing of both plastic and glass, generation of electricity for on-site use, and perhaps the sale of raw or processed landfill gas. A basic business plan for the Maracanau landfill gas utilization project has been prepared by Fernando Henrique Ribeiro Holanda, a graduate student of Dr. Jose Capelo at UFC, with the assistance of Dr. Capelo and Edson Martins of ANIMA. The plan contains the amounts of glass and plastic that must be processed to break even. This plan does not include the sale of carbon credits. This carbon credit enterprise will be added as more information becomes available. In addition, the value-added processing of the plastic and glass recovered from the waste stream will only use a small percentage of the landfill gas available in 2014. This excess gas could be used for generation of electricity for sale to the grid, for production of compressed natural gas or pipeline natural gas, or it could be sold without upgrading directly to a private entity for commercial or industrial uses such as boiler fuel. The additional sale of landfill gas, natural gas, or electricity generated by the landfill gas will add a great deal of extra income and will be included in future revisions

to this business plan. The most current draft of the business plan for Maracanaú is an addendum to this report and is included on the Appalachian Energy Center website.

XII. STEPS FORWARD AND TIMELINE

Project finance – Grants, loans

When work on this Global Methane Initiative grant began, the ASU Energy Center applied for \$300,000 from USAID-Brazil. These funds were to pay for the landfill gas collection system at Maracanaú and social programs to address the needs of “catadores” and other impoverished families who reside in the community surrounding the landfill. Our proposal to USAID-Brazil was not accepted and thus this source of funding was not available to us. However, during 2012 and 2013, COOMVIDA and ANIMA were successful in acquiring grant money totaling US\$ 199,000 which purchased plastic processing equipment which will be used in the Energy Park. This equipment consists of label removers for plastic bottles, bottle washers, cleaner tanks, grinders, and a storage silo. This equipment will get the plastic equipment processed to the point that it is in a shredded form. Still to be obtained is extrusion equipment which will process the shreds into pellets.

Further funding for the development of the Energy Park itself was not possible until legal issues, related to the ownership/use of the landfill gas and the land for the Energy Park, are resolved. Also needed were the designs and cost estimates for the landfill gas collection system and the Energy Park. The designs are now available and the legal contract for the landfill gas and land for the Energy Park has been developed and is currently being reviewed by the Municipality of Maracanaú. Approval is expected soon.

During the visit by the ASU Energy Center team to Ceara in October of 2013, Edson Martins of ANIMA had arranged for meetings with some major Brazilian funders. These meetings resulted in the emergence of BNDES, the Brazilian Development Bank, and possible “earmark” funding from the local Congresswoman who serves Maracanaú, as the two leading sources of funding for the landfill gas collection system and the Energy Park. Fernando Ceasar Aragao of the BNDES Institute for Industrial Development indicated during our meeting with him that while funding was not available for the Maracanaú project in 2013, there is an excellent chance of funding in 2014. There is one funding program of BNDES which provides both low interest loans and grants to programs which benefit catadores. To access this fund, however, a new local resolution governing the selective collection of municipal solid waste must be passed. This resolution has been drafted and is currently being processed through the Maracanaú system.

A list of potential funding sources for the project developed by the Appalachian State University Energy Center is included below and is also an addendum of this report and can be found on the Appalachian Energy Center website. Another list of project funders developed by Edson

Martins of ANIMA is an addendum of this report and is also found on the Energy Center website.

Potential Funding Programs - US Foundations & Corporate Giving

1. Alcoa Foundation – Building, equipment, program development, seed money, operations
2. American Express Company Contributions Program- program development, seed money, general operating
3. Brazil Foundation – Construction
4. Coca Cola Foundation – Program development
5. Cummins Inc. Corporate Giving Program - Building, general operating
6. Eaton Corporations Contributions - Capital, program-related investments and loans
7. Empower –The Emerging Markets Foundation-Program development, catadores, youth
8. Endeavor Global, Inc - Energy Park, entrepreneurship
9. Ford Foundation - Program development, general support, endowment
10. Gifts In Kind International - Building, equipment
11. Goldman Sachs Group Corporate Giving – Program development, capacity building, catadores
12. Hershey Company Contributions - Building, programs development, capital
13. Institute of Current World Affairs, Inc - International fellowships
14. Levi Straus & Company Contributions - Program development, catadores, disadvantaged, seed money, general operating
15. Ogilvy Foundation - Program development, continuing support, catadores
16. Prudential Foundation - Investments, loans
17. Raytheon Company Contributions - Building, general operating
18. Rockefeller Foundation - Program development, Energy Park, catadores
19. Synergos - Capacity building, program development
20. Timken Foundation of Canton - Building, equipment, land, capital
21. Western Union - Building, general support

Potential Funding Programs - US Government Agencies

1. US Export-Import Bank - Loans and loan guarantees – Working capital, equipment, for US goods/services, insurance policies
2. USAID Brazil
3. US Trade Development Agency

Potential Funding Programs - Multi-national Programs

1. The World Bank Group includes the International Bank for Reconstruction and Development (IBRD) and International Finance Group (IFC). Solid waste management is a current Program in combination with Caixa Economica Federal to support development of good solid waste practices. Carbon credit projects are a possibility. Usually used to help develop the capacity of the local government to sustain supported projects. Also for infrastructure investments in solid waste,

construction of sanitary landfills, closing of open dumps, and alternative waste treatment facilities such as waste transfer stations, composting, and recycling facilities. Support may be in the form of direct loans and stimulation of public-private partnerships.

The IFC web site states:

“IFC fosters sustainable economic growth in developing countries by financing private sector investments, mobilizing capital in the international financial markets, and providing advisory services to businesses and governments.” IFC helps companies and financial institutions in emerging markets create jobs, generate tax revenues, improve corporate governance and environmental performance, and contribute to their local communities. The goal is to improve lives, especially for the people who most need the benefits of growth.”

2. Inter-American Development Bank – Support for projects that promote sustainable development, reducing poverty, enhancing social equity, increased citizen participation, encouraging public-private partnerships, improved living conditions, capacity building of local government in Latin America and the Caribbean. Largest source of development financing in Latin America. Strong reform agenda.

Potential Funding Programs - Brazilian Bank Financing

1. Brazilian Development Bank (BNDES) – One of the leading entities in financing of development projects in Brazil, especially infrastructure development and expansion of industry. Of special interest to this project is an initiative developed in cooperation with the Ministry of Sports providing loans to host communities for the 2014 World Cup and 2016 Olympic Games.
2. Caixa Economica Federal (Ciaxa or CEF) – One of the largest government-owned financial institutions in Latin America, and the 2nd largest Brazilian bank. Loans and loan guarantees to municipalities. Has been directly involved in environmental problems related to landfills and also social issues related to the presence of catadores.

Potential Funding Programs - Non-governmental Organizations

There are numerous NGO's working in Brazil, many of which have goals that are compatible with the goals and objectives of this Maracanaú Community-based Landfill Gas Project. During early 2012, the AEC will assist the Municipality of Maracanaú in identifying several prospective NGO's with whom a project partnership may be possible. The AEC will then assist Maracanaú in approaching these NGO's as possible partners.

The Appalachian State University Energy Center is currently processing a request to the Coca Cola Foundation for grant funding to pay for personnel of the project partners and consulting expenses during the construction phase of the project. Meanwhile Edson Martins of AVINA has identified the AVINA foundation as another foundation which we may target for funding soon. Another source of funding from the European Union is now being explored by Mr. Martins.

XIII. Carbon Emission Reductions (Carbon Credits)

The ASU Energy Center has experience working with carbon trading firms to provide revenue and even up-front capital for LFG projects in North Carolina. These carbon credit deals in the US are being traded through voluntary carbon markets in the US, since the Kyoto Protocol was not adopted here. The market currently being used most often here currently is the Climate Action Reserve. In the US, however, the large landfills are required to destroy their methane emissions. Since this destruction is not voluntary, there are no carbon credits created by this destruction. Thus, carbon credits are possible in the US only from the small to medium-sized landfills in Brazil.

In Brazil, carbon credits are available from the destruction of methane at even the largest landfills. Thus these large landfills are where these projects have been concentrated. One of the objectives of our project will be to develop an income stream from carbon credits at the Maracanaú project which is much smaller than the projects developed for carbon credits previously in Brazil. In addition to carbon credits from the destruction of methane, the Kyoto protocol allows for carbon credit creation from the diversion of recyclable materials from landfills. In this regard there has been some activity internationally to assure that “catadores” or “waste-pickers” receive their portion of the proceeds from these carbon credits, since they are the ones who are doing the separation. Our project at Maracanaú will include an effort to capitalize on carbon credits from both methane destruction and diversion of recyclables and that this income is utilized to benefit the catadores directly through increased income, new job creation, and improved quality of life.

The Maracanaú Landfill is owned by and located near the City of Maracanaú in Ceará, Brazil, and currently contains about 1.75 million metric tons of waste, and is estimated to continue accepting waste for the next 40 to 50 years. Landfill gas (LFG) recovery is expected to peak at about 975 scfm around 2040 at which time gas production is expected to decrease¹. The voluntary collection and destruction of LFG at the Maracanaú Landfill would be the primary source of CERs available from the project. However, other activities planned for the project could also produce CERs. Using LFG energy to generate electricity or provide thermal energy for some industrial process are also potential sources of CERs.

The recycling activities of the Catadores are also potential sources of CERs, although perhaps not directly. The manufacture of products from recycled plastics can be eligible to earn CERs, and the Catadores could potentially benefit as they sort recyclable plastics from the waste streams and may participate to some extent in the shredding and pelletizing of this material.

¹

Other recycled materials such as glass may also be eligible to earn CERs as they are processed and re-manufactured into end-use products. Furthermore, the use of LFG energy at any phase of these processes may offset the use of fossil fuels or other more carbon-intensive energy sources and possibly be eligible to earn CERs as well.

While carbon credits are not as valuable as they were a few years ago, they still offer the possibility of substantial project income over the next several years. A report by Mr. Jason Hoyle, MBA, the ASU Energy Center expert on carbon credits and other environmental attributes, is an addendum of this report and is included on the Energy Center website. In the months ahead we expect that (federal labor) Judge Rebonnato and the young attorneys assisting Edson Martins, will develop a framework for the sale of carbon credits for COOMVIDA.

XIV. Maracanaú - A Pilot For Other Projects

Our Brazilian partners on this project feel that they are developing the first “community-based landfill gas energy park” in Latin America. The partners hope that this project is a pilot for many similar projects in Latin America and the world. More than once, while we were meeting with state and federal government agency representatives in Brazil in October 2013, we heard them say that they thought this project at Maracanaú could become a very effective model for similar projects throughout Ceara and the whole of Brazil. Brazil has been, for more than a decade, trying to eliminate uncontrolled dumps and modernizing its solid waste collection and disposal system, primarily using sanitary landfills. Meanwhile Brazil has been a leader in the developing world in trying to improve the lives of its semi-formal industry of waste pickers (catadores). The number of catadores in Brazil is estimated at over 250,000.

There has been a lot of success in Brazil in the last decade in helping the catadores to form associations or cooperatives and in empowering these organizations to strengthen their place in the solid waste industry. The **National Policy on Waste Management**, passed in 2010 offers synergistic opportunities with our landfill gas project in Brazil. It calls for strengthening the status of the catadores as the major workforce component of the recycling industry in Brazil by encouraging “*programs and actions for the participation of interested groups, particularly cooperatives or other forms of association of waste-pickers collecting reusable and recyclable material, set up by low-income people.*” This new policy also calls for requiring the development of state and municipal solid waste management plans in the next four years. Our work with the Municipality of Maracanaú in planning this project could be an important step toward the development of an overall plan for Maracanaú. In addition, the act calls for encouraging the recycling of materials recovered from the waste stream. The 2010 National Policy on Waste Management for Brazil, currently in effect, requires that municipal solid waste be sorted at the source. This will eliminate the way of life in which tens of thousands of Brazilians participated previously – digging through the garbage for recyclables when dumped on the landfill by garbage trucks. At Maracanaú, this regulation will eliminate over 50 positions by the end of 2014, when this provision is scheduled to be fully implemented. Prior to this law, COOMVIDA hoped to install a waste sorting line at the landfill, where recyclables would be separated in a more safe and efficient manner. Early in our project, we were expecting this to be the method

of sorting recyclables at Maracanau. However, one of the provisions in the National Policy on Waste Management calls for a prohibition on any sorting once the waste gets to the landfill – or perhaps once it is even loaded on a trash truck – will effectively eliminate these sorting lines at the landfill. This caused a major change in the planning for the Energy Park. To address this need for removing the recyclables remote from the landfill, a new warehouse facility has been acquired about 12 km from the Maracanau Landfill.

International Opportunities

The goal of the Appalachian State University Energy Center is to use the project in Maracanau Energy Park as a model for other projects around the world. Most countries in the world have a population of people often known as scavengers or waste-pickers. The World Bank estimates between 1 and 2% of the world's population are waste-pickers. These waste-pickers are the core of the international recycling industry, although their industry is usually informal or, at best, semi-formal. Many of these waste-pickers glean from the incoming garbage at landfills where they recover anything they can sell or use, including food. In Brazil, unlike most countries, Brazil has gone out of its way to help the waste-pickers, called catadores in Brazil, to improve their lot in life by helping them to organize and empowered. In other countries, the catadores are not as well taken care of by the government of their countries, but are mostly left to their own devices. The most commonly recovered commodities of the waste-pickers are plastic and glass, which they sell for next to nothing.

Also common to all landfills is landfill methane gas which results from the decomposition of organic matter buried in the landfill. The ASU Energy Center hopes to utilize this common resource, the methane gas, to add value to the plastic and glass recovered by waste-pickers everywhere to increase the financial power of the waste-pickers. We hope that as the project in Maracanau is fully developed, we will be able to use that pilot project to leverage others in other countries around the world.

We recognize, however, that not all waste-pickers work at landfills. In many third world countries there are few landfills, or even none at all. Haiti is one of those countries and it is here that the ASU Energy Center has gone to pursue it's second international project. Most of the country, however, has no waste collection and no landfill for waste disposal. Further 75% of the country has no access to toilets. There is a terrible problem with disposal of human and food waste, leading to serious disease problems.

In Haiti, however, there is a growing informal waste-picker industry, with plastic bottles being the major commodity. Our hope in Haiti is to demonstrate the use of anaerobic digesters to properly dispose of human and food waste and to use the methane gas, generated by the decomposing organic matter in the digester for value-added processing of the plastic gathered by the waste-pickers. A similar project looms – absent a landfill!

XV. Power Point

Two power point presentations describing progress on the Maracanau are available on the Appalachian State University website and is an addendum of this report and can be found on the Energy Center worksite.

XVI. Alternative Solid Waste Systems

The ASU Energy Center has recognized that the Maracanau Landfill and other landfills we visited in Ceara have great potential to establish cost effective systems of treating solid waste which could reduce or even eliminate the need for landfills. This switch may be more likely in Brazil than in the US for several reasons.

- a. Higher organic matter content in the waste in the landfill.**
- b. Less consumer non-organic waste produced.**
- c. Effective sorting of recyclables by the “catadores”.**

When the US team visited the landfill at Horizonte in 2009, we saw a dozen catadores working on the sorting lines at a waste sorting facility at the landfill. When the waste was passed before them, the catadores took out the recyclables as it passed by on conveyors. What remained to be landfilled was just organic matter. It is not much of a jump to think that what is left can be disposed of in some other way than to be deposited in a landfill. We believe that Brazil has the potential to pass the US in the management of solid waste, just as it has done with renewable transportation fuels and renewable electricity production.

- d. New federal Solid Waste Act of 2010**

The Solid Waste Act of 2010 changed the approved way that recyclables will be sorted from the waste stream in Brazil in the years ahead. The federal government has legislated that after 2014 recyclables will be sorted at the source of their creation. Although it may take years for this process to fully be implemented, it is expected that over time the sorting of non-organic materials will be more efficient and complete.

- e. Less control of the solid waste sector by large corporations (WM, Republic, etc)**

The entrenched solid waste industry in the US has steadfastly prevented the introduction of other methods of waste disposal on the American scene. There is not the same degree of development by a private solid waste industry in Brazil.

In the years ahead, the ASU Energy Center will continue to work with the Municipality of Maracanau as the landfill gas system and Energy Park are completed. As we do, we will try to help the local partners try to incorporate other waste handling methods into the solid waste handling system. COOMVIDA is already collecting waste grease from several sources under a contract with Petrobras. COOMVIDA has a lot of experience now in contracting for waste. It is not much of a stretch for COOMVIDA to contract for other organic waste in the future which would be a natural path towards anaerobic digestion.