

BALEWARE 2016

Sustainable Energy and Clean Water

11-13 December 2016

Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

Sponsors

Aims and scope: Africa and Latin America share great challenges concerning reliable and affordable supply of clean water and sustainable energy. Addressing these challenges can be done most effectively if academia, industry, governments and non-governmental organizations from different regions join forces. This has motivated the establishment of a platform which has been launched during the BALEWARE 2016 conference, where stakeholders from Africa, Latin America and Europe met and interacted.

The BALEWARE 2016 conference focussed on scientific, technical and organizational innovations on water purification and clean water supply, innovations on sustainable energy generation and distributions, and innovation that combine both areas challenges.

The event attended by 50 participants from Africa, Latin America, Europe and Asia was highlighted 4 keynote lectures, lectures, poster presentations, a panel discussions, a Science Slam competition and the signing of an MoU between ANSOLE and the Dar es Salaam Institute of Technology (DIT)

Initiated on the 29th of May 2015 at the Federal University of Parana, Curitiba Brazil, by Daniel A. M. Egbe, the coordinator of the African Network for Solar Energy (www.ansole.org), BALEWARE is a follow up of the EU funded project NMP-DeLA on Deployment of Nanotechnology, Materials and Production Technologies for Health, Water and Energy in Latin America (www.nmpdela.eu). As such, BALEWARE aims at promoting joint initiatives and research proposals on Energy and Water for succeeding in the incoming public funding such as Horizon 2020 and any potential private funding (such as those open by different kind of private or bank foundations).

The next BALEWARE gathering is planned for 2018 in Latin America.



Participants at BALEWARE 2016, 11-13.12.2016, NM-AIST, Arusha, Tanzania

Organising Committee

- Prof. **Daniel A. M. Egbe,** ANSOLE Coordinator, IPMT, Johannes Kepler University Linz, Austria & ANSOLE e.V. Jena, Germany (**Chairperson**)
- Dr. **Ineke Malsch**, Malsch TechnoValuation, Utrecht, The Netherlands (**Co-Chairperson**)
- Prof. **Karoli Njau**, Nelson Mandela African Institution of Science and Technology (NM-AIST), Arusha Tanzania (**Co-Chairperson**)
- Dr **Thomas Kivevele**, NM-AIST, Arusha Tanzania (**Main Local Organiser**)
- Mr. **Niklas Hayek** Project Manager, Africa-EU Renewable Energy Cooperation Programme (RECP), Eschborn, Germany (**Coordinator of Science Slam**)
- Ms **Eva Kagiri-Kalanzi**, Senior Planning Officer FinCEAL, Finnish University Partnership for International Development (UniPID), University of Jyväskylä, Finland (**Co-Coordinator of Science Slam**)
- Prof. **Maria Teresa Alarcon Herrera**, Centro de Investigacion en Materiales Avanzados, Mexico
- Prof. **Noela Invernizzi**, Latin American Network Nanotechnology and Society, Federal University of Parana, Curitiba, Brazil
- Prof. **Wim Sinke**, Professor Photovoltaic Energy Conversion, Van der Waals - Zeeman Institute, Institute of Physics, Faculty of Science, University of Amsterdam, The Netherlands
- Prof. **Reinhold W. Lang**, Director of the Institute of Polymeric Materials and Testing Johannes Kepler University Linz, Austria
- Dr **Revocatus Machunda**, Senior Lecturer, NM-AIST, Arusha Tanzania
- Dr. **Arouna Darga**, University of Pierre and Marie Curie, France
- Ms **Gudrun Haider**, IPMT, Johannes Kepler University Linz, Austria

Scientific Committee

- Prof. **Maria Teresa Alarcon Herrera**, Centro de Investigacion en Materiales Avanzados, Mexico
- Prof. **Angeles López Agüera**, Chairman of the Unesco Special Committee for Sustainable Communities Development, University of Santiago de Compostela, Spain
- Prof. **Daniel A. M. Egbe**, ANSOLE Coordinator, IPMT, Johannes Kepler University Linz, Austria
- Prof. **Jan Hofman**, Director of Water Innovation and Research Centre, University of Bath, UK
- Prof. **Noela Invernizzi**, Latin American Network Nanotechnology and Society, Federal University of Parana, Curitiba, Brazil
- Dr. **Ineke Malsch**, Malsch TechnoValuation, Netherlands
- Prof**. Karoli Njau**, NM-AIST, Arusha, Tanzania
- Prof. **Wim C. Sinke**, Program Development Manager, Solar Energy, ECN, Netherlands
- Prof. **Reinhold W. Lang**, Head of Institute of Polymeric Materials and Testing (IPMT), Johannes Kepler University Linz, Austria
- Western Cape, Cape Town South Africa
- Prof. **Franz-Bernd Frechen**, Head of Department of Sanitary and Environmental Engineering (DESEE), University of Kassel, Germany

BALEWARE 2016 Programme

SUNDAY 11 DECEMBER 2016

Final arrival of participants in Arusha (Sightseeing day!)

MONDAY 12 DECEMBER 2016

8.00-9.00	Registration	All participants
	OPENING CEREMONY	Moderated by **Ineke Malsch**
9.00-9.10	Welcome address	VC of NM-AIST
9.10-9.20	Welcome addresses	**Daniel Egbe/Karoli Njau**
9.20-9.30	Signing of MoU between DIT and ANSOLE	**Daniel Egbe/Preksedis Ndomba**
9.30-10.15	**Keynote 1:** Renewable energy and water for the world:A challenge and opportunity for polymer science and the polymer industry	**Reinhold Lang**, *IPMT, Johannes Kepler University Linz, Linz, Austria*
10.15-10.45	Conference photo + Coffee break + posters session	All participants
Session on Societal and Economic Aspects		
Chair: Prof. Preksedis Ndomba		
10.45-11.05	Nanotechnology for social challenges: Latin American Research in the areas of energy and water	**Noela Invernizzi** *et al.*, *Universidade Federal do Paraná Curitiba, Brazil*
11.05-11.25	Do-It-Yourself Ethics in International Cooperation on Water and Renewable Energy	**Ineke Malsch**, *Malsch TechnoValuation, Utrechts, Netherlands*
11.25-11.45	Remanufacturing as a sustainable strategy for water purification and renewable energy equipment and distribution network maintenance and upgrading	**Kim Jansson** and Tapani Ryynänen, *VTT Technical Research Centre of Finland Ltd., Espoo, Finland*
11.45-12.00	Comprehensive energy planning for sustainable energy solutions in developing countries	**Jacopo Barbieri,** Emanuela Colombo, *Politecnico di Milano, Milan, Italy*

MONDAY 12 DECEMBER 2016

Session on Water Solutions		
Chair: Sameer Hameer		
12.00-12.30	**Keynote 2:** Sustainable Gold Catalysis in Water	**Norbert Krause**, *Dortmund University of Technology, Dortmund, Germany*
12.30-12.50	Constructed wetlands for drinking water treatment	**Karoli Njau** *et al*., *NM-AIST, Arusha, Tanzania*
12.50-13.10	Occurrence and and removal of pharmaceutical residues in Sub-Saharan Africa urban hydrological cycles; a case of Nairobi River Basin	**Elijah Ngumba** *et al*., *University of Jyvaskyla, Finland & Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya*
13.10-14.10	**Lunch Break + Posters Session**	
14.10-14.30	PAUL Station: achieving universal and equitable access to safe and affordable water in rural areas by using simple and cheap membrane-based decentralized water systems	**Jose A. Ordonez Andrade** & Franz-Bernd Frechen, *Martin Membrane Systems AG, Berlin, Germany & University of Kassel, Kassel, Germany*
14.30-14.50	Prevention of Groundwater Contamination from Pit Latrines - Case study of a proposed risk modeling approach	**Jan Back** *et al*., *MCI – The Entrepreneurial School, Innsbruck, Austria & University of Strathclyde Glasgow, Scotland, UK*
14.50-15.10	Local activated carbon production for the removal of water pollution by pesticides in Burkina Faso	**Lae Titia Marelle Ndjientcheu Yossa** *et al*., *International Institute for Water and Environment Engineering (2iE), & University of Ouaga, Ouagadougou, Burkina Faso*
15.10-15.30	Impact of Renewable Energy on Development of Alpine Villages in Nepal: Case Study of Photovoltaic-Small Hydro-Wind	**Sung-Hoon Ahn** et al. *Seoul National University, Korea*
15.30-16.00	Long storage stability of biodiesel made from croton megalocarpus oil with the influence of metal contaminants	**Thomas Kivevele**, *NM-AIST, Arusha, Tanzania*
16.00-16.20	**Coffee Break + Posters Session**	

Young Scientists and Entrepreneurs @Baleware 2016

16.20-16.30	Science and Business Slam Committee: - **Matthew Matimbwi**, *Executive Secretary, Tanzania Renewable Energy Association (TAREA)* - **Ineke Malsch,** *MalschTechnoValuation* - **Noela Invernizzi**, *Universidade Federal do Paraná Curitiba, Brasil*	**Niklas Hayek**, project manager, EUEI PDF
	Moderator: Eva Kagiri	
16.30-16.40	Review of Solar Powered Pumping System as a Sustainable Solution for Decentralized Water Supply in Nigeria	**Vivian Ogechi**, *PAUWES, Tlemcen Algeria*
16.40-16.50	Mobile Solar Pumps for Low-Income Farmers	**Ahmed Abbas,** *Sun City Energy + The American University in Cairo, Cairo, Egypt*
16.50-17.00	Transforming Waste Plastics to Plastic Lumbers while promoting energy efficiency	**Christian Mwijage** EcoAct Tanzania
17.00-17.10	Potential of wind energy development for rural area water pumping in Ngaoundere	**Myrin Kazet Ymele,** *ENSAI, University of Ngaoundere, Cameroon*
17.10-17.20	Solar-aided anaerobic digester system for small scale application in tropics. Case study: Kiruhura district Uganda	**Nicholas Mukisa**, *PAUWES, Tlemcen, Algeria*
17.20-17.30	Solar Energy and Drip Irrigation	**Papa Antoine L Faye**, *Compagnie Horticole du Sine-Saloum (CHSS), Senegal*
17.30-18.00	Rating of YSEs by slam committee and by audience applause	
18.30	Departure to hotels and NM-AIST hostel	All participants
19.30-22.30	Conference Dinner in Arusha City	All participants
23.40	Back to NM-AIST hostel and hotels	All participants

TUESDAY 13 DECEMBER 2016

Session on Energy Solutions		
Chair: Reinhold Lang		
8.30-9.00	**Keynote 3** Photovoltaic solar energy: spectacular technology developments and global breakthrough in applications	**Wim C. Sinke**, *ECN Solar Energy, The Netherlands*
9.00-9.20	Sustainable Communities Project, integral development based on Low External Dependence Distributed Models	**Angeles López Agüera** *University of Santiago de Compostela, Spain*
9.20-9.40	Solar Energy as a Viable Energy Source to Address Water Crisis in Namibia: Solar Energy for Water Pumping as viable alternative!	**Damas Mashauri** *University of Science and Technology, Windhoek, Namibia*
9.40-10.00	The role of renewable energy in the supply of energy for rural areas in Tanzania	**Peter Mashingo**, *Arusha Technical College, Arusha Tanzania*
10.00-10.20	Solution processable kesterite solar cells	**Elif Arici**, *Energy Institute, Istanbul Technical University, Maslak Istanbul, Turkey*
10.20-10.40	Reference Distributions and Beta Probability Density Functions of Daily Relative Sunshine Duration and Clearness Index Data from Some Burundian Stations	**M. Bashahu** *Institute of Applied Pedagogy, Bujumbura, Burundi*
10.40-11.00	**Coffee Break**	
Chair: Wim C. Sinke		
11.00-11.30	**Keynote 4** Fabrication of DSSC and Electrochromic Window Using Nano Particle Deposition System	**Sung-Hoon Ahn,** *Seoul National University, Seoul, Korea*
11.30-11.50	Exploring measures to promote sustainable energy-efficient building – A case for Africa	**Tonny Kukeera,** *PAUWES, Tlemcen, Algeria*
11.50-12.10	Eco-Efficiency of Polymer-Based Solar-Thermal Collectors	**Markus Gall,** *IPMT, Johannes Kepler University Linz, Austria*
12.10-12.30	Investigation of charge photogeneration and **r**ecombination processes in organic solar cells	**Samir Romdhane** et al., *University of Carthago, Tunisia*
12.30-12.50	Anthracene-based polymers with dissymmetric side chain arrangements for solar cells applications	**Daniel A. M. Egbe** *et al, IPMT, Johannes Kepler University, Linz, Austria*
12.50-13.10	The prospect of solar thermal energy technologies in Tanzania	**Sameer Hameer** *et al., NM-AIST, Arusha Tanzania*

13.10-14.10	**Lunch Break**	

International initiatives and programmes

Chair: Noela Invernizzi		
14.10-14.20	UniPiD activities	Kajsa Ekroos
14.20-14.30	EUEI-PDF activities Niklas Hayek	Niklas Hayek
14.30-14.40	TAREA Private Sector –Academia Cooperation	Matthew Matimbwi
14.40-15.40	Erasmus + Call and group discussions on 2-3 projects	Ineke Malsch
15.40-16.00	**Coffee break**	
16.00-17.00	Plenary discussion on BALEWARE mission	Ineke Malsch
17.00-18.00	Closing session-Signing of letter of intent by participant present+ award of certificate of participation	Daniel Egbe/ Ineke Malsch

Abstracts for Oral Presentations

Renewable Energy and Water for the World

A Challenge and Opportunity for Polymer Science and the Polymer Industry

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To identify some of the key technological challenges from a global perspective, reference is made to the Sustainable Development Goals 2030 (SDGs), adopted by the UN General Assembly in September 2015. Among the total of 17 SDGs, two core themes are meeting the needs of the growing global population for affordable, clean energy and clean water, as addressed explicitly in SDG 7 and SDG 6, respectively (but also pervading numerous other SDGs). As to the case of energy, it is now increasingly acknowledged that the transformation of the current fossil fuel and nuclear based energy system to an energy system substantially-to-fully based on renewable resources within the next decades is at the core of any future Sustainable Development path. However, numerous questions remain regarding the required future energy technology mix along with the underlying material technologies driving needed innovations. And yet, it is quite obvious that the selection of adequate materials is of prime importance for the entire energy transformation chain in general, and for the primary conversion of solar energy into electricity or heat in particular. Similar arguments may be brought up for the case of meeting future global water needs (fresh/potable water, sanitation, agriculture & food production, etc.) along with the issue of water management (supply, disposal, waste water treatment) in a sustainable manner by appropriate technologies and materials.

In his lecture, Professor Lang will argue that any advanced or accelerated deployment of renewable energy and sustainable water technologies will depend on substantial contributions from polymer science and the polymer industry. To accelerate the penetration of polymers in such technologies, at least four innovation goals must be met: *improved functionality and performance, enhanced cost effectiveness*, *guaranteed quality and durability*, and *robust/multifunctional and attractive design.* By exemplifying these innovation goals with case studies, the presentation will explore the current status and the prospects of such technologies based on plastics in the context of the global goals (SDGs).

Nanotechnology for social challenges: Latin American Research in the areas of energy and water

Invernizzi, Noela,[a*] Foladori, Guillermo,[b] and Robles-Belmont, Eduardo[c]; Zayago-Lau, Edgar[d]; Arteaga, Edgar[e]; Bagattolli, Carolina[f]; Carrozza, Tomás[g]; Chiancone, Adriana[h]; Urquijo, William[i]

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This presentation reviews, based on data from scientific publications and research groups, the state of the art of nanotechnology research applied to the areas of energy and water in Latin America. Such areas have been considered relevant in order to meet the social needs of the developing countries. A map of current research activities on nanoenergy and nanowater was elaborated based on two different sources of information. On the one hand, bibliometric data from the Web of Science were used for Latin America and the Caribbean in an aggregated manner, and individually for the following countries: Argentina, Brazil, Chile, Colombia, Mexico and Uruguay. Publication data covered since the first publication in each area up to year 2012. On the other hand, a search in databases available in the World Wide Web on research groups and funded research projects in the three areas in the six mentioned countries was conducted during 2013-14. The main results of the study showed that nanotechnology research applied to water and energy has been developing since the last decade in several Latin American countries. Growth of publications in both areas since mid -2000 and the organization of a significant number of research groups reveal the construction of domestic capacities. However, the research exposed large regional disparities, with a very strong concentration of activities in Brazil, and then Mexico, the largest countries and with the more systematic scientific trajectories. In Argentina, Chile and Colombia we found an intermediate situation tending to strengthen their capacities, and several other countries exhibit much more fragmented research conditions. On the other hand, the data show a weak regional collaboration, characterized most by two-sided collaborations than by research networks. In some cases, collaborations outside the region are more intense than within the region. Publication themes as well as research groups´ topics indicate that much of the current investigations on nanoenergy and nanowater are aligned with domestic needs. However, the ongoing investigations are still in quite basic phases, which make it difficult to predict their impact in products and processes. Given the low innovation profile that characterizes the countries in the region, active public policies are needed to ensure that some of this promising research can be further developed and inserted in the local productive chains.

Key-words: nanotechnology; social needs; nano-energy; nano-water.

Do-It-Yourself Ethics in International Cooperation on Water and Renewable Energy

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Responsible Research and Innovation is increasingly mandatory in publicly funded research. For example, it is a horizontal priority in the Horizon 2020 programme funded by the European Union. The onus is increasingly on researchers and companies to behave ethically sound. In addition to traditional research integrity (e.g. anti-plagiarism and anti-fraud), this includes efforts to contribute to a common responsibility for potential future impacts on society due to today's scientific and technological developments. [1] Research intended for deployment in emerging economies and developing countries is extra sensitive, as this is likely to impact the life world of disadvantaged populations.

The presentation will take the form of a short course training the participants in BALEWARE 2016 in "Do-It-Yourself Ethics of Research on Water and Renewable Energy". It starts with a brief introduction of some key concepts and methods for putting research ethics and responsible innovation into practice, [2] targeting the UN Sustainable Development Goals on water and energy. [3] Then the participants will be split into two groups, developing project proposals incorporating Do-It-Yourself Ethics. Group 1 will develop a proposal for a case where innovative water purification technologies are introduced as a solution to ongoing violent conflicts over mining ('water or gold'). Group 2 will develop a proposal for a case where renewable energy solutions are introduced in a remote region in the countryside in a least developed country, in close consultation with the local population. [4] Both groups will present their proposal to a jury of senior lecturers, who will select the winner. The selection criteria include: research integrity, lawfulness, inclusiveness, public acceptance, relevance to the UN Sustainable Development Goals, feasibility under the local circumstances.

The total short course will take 1 hour, including 20 minutes for the introductory presentation, 30 minutes for the group work and 2x5 minutes group presentations. The jury will need some time to deliberate and motivate its choice of the winning proposal during the next break.

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Remanufacturing as a sustainable strategy for water purification and renewable energy equipment and distribution network maintenance and upgrading.

Kim Jansson,[a] * and Tapani Ryynänen,[a]
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Energy production and distribution in Africa is changing. Oil, natural gas, geothermal, power grid, coal and gas fired power-stations, and refineries etc. are in the hands of large, often foreign, companies capable of doing long term investments and having risk management capabilities. There is a strong social call and need for smaller and more suitable energy solutions, which are manageable by local communities and stakeholders. Renewable energy technologies present a viable alternative for local solutions.

Despite all these, as well technical as socio-economical advancements, the access to reliable grid based power remains low. Extending and reinforcing the electricity grid is very costly and progresses slowly due to lack of resources. For example, in Tanzania and Kenya only half of the urban population has access to grid-based electricity. In rural areas the figure is less than 10%. Countries with underperforming energy systems may lose up to 1-2 per cent of growth potential annually as a result of electric power outages, lack of backup electricity generators, energy subsidies and losses, and inefficient use of scarce energy resources.

Using renewable energy for local independent grids and for small user communities is a feasible alternative in many developing countries and, especially, in East Africa. However access to energy alone is not enough. Energy needs to be used to create value. Renewable energy offers opportunities to improve the living standards of a huge share of Africa's current and future population. These local solutions are vulnerable to disturbances and technical malfunctions. All equipment needs continuous maintenance and also upgrading. Remanufacturing is a sustainable alternative to maintain reliable local energy and water supply solutions.

Circular economy is a generic term for an economy that produces neither waste nor pollution. Circular economy is restorative and aiming to keep products, components, and materials at their highest utility and value at all times. It replaces an 'end-of-life' concept with shifts towards the use of renewable energy, and aims for the elimination of waste. Remanufacturing is a key strategy within the circular economy. Remanufacturing is the process of "*returning a used product to at least its original performance with a warranty that is equivalent to or better than that of the newly manufactured product*". From a customer viewpoint, the remanufactured product can be considered the same as a new product.

The proposed presentation will highlight the sustainable aspects of remanufacturing in an African and Latin American context. Furthermore the presentation will emphasize the manifold benefits of remanufacturing, such as for;

Society. Remanufacturing creates a large number of local employments and job positions, requiring skilled personnel.

Customers. Remanufactured parts and components provide same as original performance and reliability at costs typically only 50-80% of a new. Instant availability gives customers more options at repair and overhaul time. The results are reliable productivity and lower costs.

Business. Remanufacturing is based on an exchange system where used components in exchange for our remanufactured products. Remanufacturing is an additional option to support customers and help lower owning and operating costs. Profit margins are often bigger for remanufactured products than for new products.

Environment. The business of returning end of life components to same as original condition, reduce waste and minimize the need for raw material to produce new parts, keeping non-renewable resources in circulation for multiple lifetimes, and reduces energy consumption and greenhouse gas emissions. Material and energy savings are up to 90%.

The proposed approach supports the Base of the Pyramid business model in particular for people at the bottom of the wealth pyramid or the bottom of the income pyramid, developing new models of doing business.

Comprehensive energy planning for sustainable energy solutions in developing countries

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Nowadays, in developing countries, about 1.3 billion people do not have access to electric energy and more than 2.7 billion are still relying on traditional biomass (firewood) for their domestic needs. The complexity of the problem is recognized at the international level, as well as the persistency in time [1] [2].
Energy and sustainable development are closely linked. Energy plays a fundamental role in shaping the human condition, and has many interconnections with environment and society challenges. The unsustainable way in which most of the energy is currently produced and consumed threatens the environment at both local and global scales [3].
In the next future a transition to sustainable energy systems through low-carbon energy innovation will play a big role even in poverty reduction [4]. Energy is essential to ensure the socio-economic development, and other key issues such as people's quality of life, global security (natural resources and materials, food, water), and environmental protection.
For these reasons, in the last decades, the interest on the energy challenge and the link with sustainability has progressively increased, as energy has started to be considered as a key means to provide several services essential for local development [1].
Recently the SDGs, launched in September 2015 as one of the main asset of the UN Agenda 2030, are intended to introduce a new comprehensive paradigm of development, where the essential principle is the integration of environmental, social, and economic concerns into all aspects of decision making, directed to the future to preserve the social and cultural diversity and excellence. And among them, Goal 7, is fully dedicated to energy [5].
In this framework, many studies and research work have been developed, focusing on the different aspects and steps of the process to ensure and extend energy access in developing countries (DCs), such as: (i) needs assessment & resources assessment; (ii) strategic planning; (iii) systems analysis, optimization and implementation; (iv) impact evaluation. However, from the literature a gap is evidenced, regarding the integration of the different aspects in a holistic approach [6].

Based on the previous considerations, the proposed research set up as a first objective the development of proper and comprehensive guidelines to decision-makers that help to plan for the integration of distributed energy solutions in the specific context of DCs, with particular reference to the last-mile solutions and to rural and/or remote regions. The overall work will contribute to define a clear and comprehensive procedure for scientists, practitioners, and energy planners looking at boosting a new inclusive path toward sustainable energy access in Africa, and more in general, in DCs, from the assessment of the needs, to the implementation of projects, to impact evaluation. The holistic nature of the guidelines will also help to track the success of the actions and to better understand the key elements and characteristics, which make energy access projects successful and effective.
Looking at the overall problem of sustainable energy solutions for DCs, the guidelines will consider two overall dimensions of the problem: (i) a *timeline* of energy projects in the field, and (ii) a *needs and technology* dimension, which allows to consider all the different combinations in terms of resources availability and possible technological solutions for energy access.

As per the *timeline*, the lifespan of an energy access project is split into four main steps, namely: (i) Context and needs analysis; (ii) Selection of a proper strategy; (iii) Systems analysis, optimization and implementation, and (iv) Short to long-term impact evaluation.
As per the *needs and technology* dimension, a classification of sustainable energy solutions is proposed, based on the type of supply (electrical or thermal) and the corresponding available resources. Moreover, within both the electrical and thermal category, the different technologies are classified based on a combination of the primary resources they are based on, and the main need to which they respond.

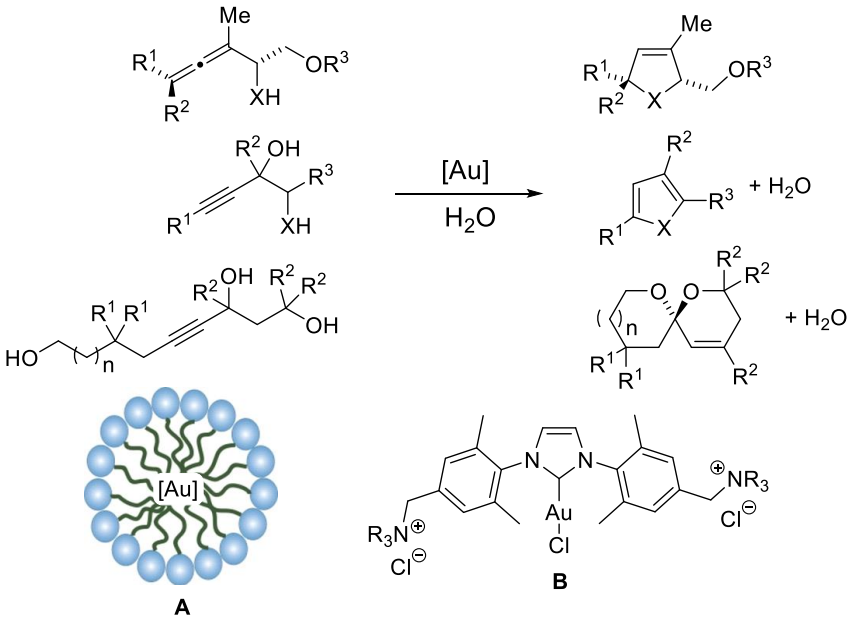
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Sustainable Gold Catalysis in Water

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The development of sustainable transformations is an important task in modern organic synthesis and involves the recycling of precious catalysts and the use of environmentally benign reaction conditions. In homogeneous gold catalysis,[1] catalyst recycling is challenging since reduction to metallic gold prevails in organic solvents. Recently, we have reported the first example of gold catalysis in nanomicelles **A** using vitamin-E-derived designer amphiphiles,[2,3] as well as, poly(2-oxazolines).[4] These recyclable, air- and water-stable gold catalysts allow the smooth and efficient transformation of various unsaturated substrates (including dehydrative reactions) in bulk water.[3,4] Alternatively, these reactions can also be carried with water-soluble and recyclable ammonium-salt-tagged NHC-gold complexes of the type **B**.[5]



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Constructed Wetlands for Drinking Water Treatment

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A study conducted to examine the spatial and temporal variations of physicochemical and microbial water quality of different surface water sources used for drinking in Monduli, Arumeru and Arusha districts in Arusha region revealed that faecal coliform, turbidity, total suspended solids, dissolved organic matter and nitrate contributed to poor water quality for human use. The use of earthen dams for water harvesting is predominant in this semi-arid region and dam waters were found to have highly elevated turbidity above 1000 NTU. The feasibility of constructed wetland integrated with sand filters (CW-SF) for treating high turbid and contaminated water for drinking was investigated. Removal of faecal coliform (FC), chemical oxygen demand (COD), total suspended solids (TSS) and nitrate removal were also investigated. Two types of sand filters were tested namely Bio sand filter (BSF) and Slow sand filter (SSF). Results showed that Horizontal Sub surface flow constructed wetland (HSSF-CW) produced effluent turbidity of <10-50 NTU at retention time of 3 days. Moreover, integrated CW-BSF needed a total retention time of 5 days to produce effluent of turbidity (0 NTU), FC (0 CFU/100ml), COD (6.25 mg/L), TSS (0.5

mg/L) and nitrate (4.2 mg/L) whereas, CW-SSF needed 7 days to produce effluent of turbidity (0.6 NTU), FC (0 CFU/100ml), COD (6.5 mg/L), TSS (1 mg/L) and nitrate (1.79 mg/L), which met drinking water standards of Tanzania Bureau of Standards (TBS) and World Health Organization (WHO). It was thus concluded that integrating Constructed wetlands with simple sand filters can produce safe drinking water in rural areas.

Occurrence and and removal of pharmaceutical residues in Sub-Saharan Africa urban hydrological cycles: A case of Nairobi River Basin

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Pharmaceuticals have brought enormous health benefits to the developing countries and reduced the disease burden tremendously. However, the occurrence of pharmaceutical residues in the water cycles has become the focus of worldwide attention in recent years as questions about potential threats to the natural environment and human health have been raised. Pharmaceuticals compounds are not removed entirely during convectional wastewater treatment process and as a result, wastewater plants are a major entry route of pharmaceuticals and personal care products (PPCPs) to the environment[1–3]. More so, significant populations in cities within the Sub-Saharan Africa such as Nairobi-Kenya reside within the informal settlements that are characterized by poor sanitation system. As a result wastewater from these settlements is not subjected to any form of treatment and ends up contaminating the rivers and other water sources within the locality compounding the risks of pharmaceutical contamination. In addition, the rate of disease prevalence especially HIV/AIDS is highest within the informal settlements. Since pharmaceuticals are only partially metabolized by the human body a large proportion is excreted into the environment unchanged or in the form of their components (metabolites and/or conjugated compounds), this implies that the amount of pharmaceuticals released by urban dwellers is significantly high. Much less is known about the occurrence and fate of pharmaceuticals in Sub-Saharan Africa and to date the issue has received limited attention despite the growing concerns. Recent studies on the occurrence of pharmaceuticals in selected urban hydrological cycles in the region have measured concentrations of up to up to 320µg/L and 2 µg/L in river waters and shallow water wells, respectively which is of a great concern with respect to the impact on the environment and the quality of drinking water [4–7].

In this study, we report the latest findings on the occurrence and removal of antibiotics and antiretroviral drugs in urban hydrological cycles using UV/H_2O_2 and UV/Cl_2 oxidation techniques for both centralized and decentralized wastewater treatment systems. These oxidation processes efficiently removed more than 90% of the studied pharmaceuticals that are usually recalcitrant in the convectional wastewater treatment process.

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PAUL Station: achieving universal and equitable access to safe and affordable water in rural areas by using simple and cheap membrane-based decentralized water systems

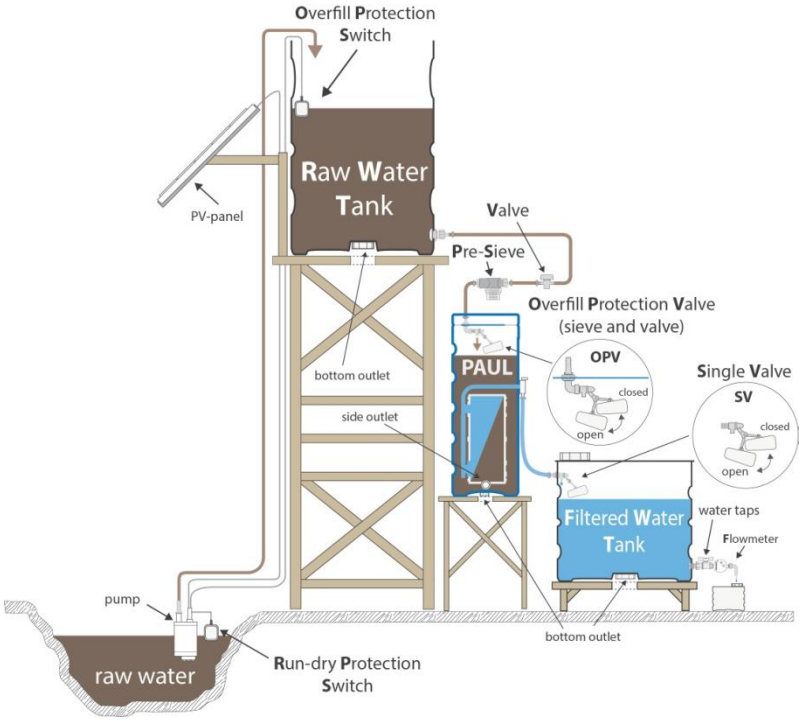
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In 2015, it is estimated that 663 million people worldwide still use unimproved surface water sources. Most of them live in sub-Saharan Africa and Southern Asia [1]. The Sustainable Development Goals – SDGs establishes that by 2030, universal and equitable access to safe and affordable drinking water should be achieved worldwide.
Gravity-driven membrane filtration processes stand as a promising technology to ensure a safe water supply at community and the household levels, since membranes depending upon their properties and especially their pore size or MWCO, are able to retain pathogens and other suspended contaminants.

A small and portable unit based on membrane filtration for water treatment in cases of emergencies was designed 15 years ago at the DESEE. The device, known as the water backpack PAUL is a very simple, robust and small gravity driven membrane unit utilizing the "Ultra Low Pressure Ultra Filtration (ULPUF)" process. The first public report highlighting this special process happened as early as 2002 in a TV broadcast in Germany. Today PAUL is used as decentralized drinking-water treatment in 2,200 different places worldwide.
As the ULPUF process assures a long life of the membrane itself of 10 or even more years, and as the special properties of the process realized in the Waterbackpack lead to a minimum of maintenance requirements, today the base technology is used in an arrangement we call "PAUL Station", which includes a raw water storage tank RWT and a filtered water storage tank FWT, as can be seen from the scheme. The surrounding simple installations assure that none of the tanks nor PAUL itself is overfilled and that filtration can run unattended day and night, whereas water withdrawal can be done in very short time from the FWT, depending only upon tap size and number.
Several projects of PAUL Stations are installed already in Ghana, Nepal and Southern India. Soon, more will be installed in Kenia, too. The experience with PAUL Station shows that the water price per liter of water is below 0.1 €Ct including maintenance and capital cost, which makes this "low-tech" membrane solution is feasible in many situations especially in rural areas, small villages, schools, hospitals etc.
Theoretically, PAUL can deliver 1,200 Liter per day nominal; however, experience of usage since more than 5 years show that in practice water flow is well above 2,000 Liter per day in most circumstances.
The pump, if solar driven, can easily be a DC pump directly connected to the solar panel. This makes the usage of any electronics and a battery backup for energy storage unnecessary, resulting in an utmost economical solution. Nevertheless, energy is stored, just by elevating the water from the source to the RWT during sunlight. This is the perfect wear-free way of energy storage compared with expensive batteries.

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Prevention of Groundwater Contamination from Pit Latrines - Case study of a proposed risk modeling approach

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Pit latrines are the primary sanitation technology in many developing countries. However, if groundwater is not managed carefully, they can severely affect groundwater quality through microbial and chemical contamination [1]. Numerical groundwater flow modeling with wellhead protection area (WHPA) delineation is a powerful tool that helps to prevent groundwater contamination [2]. This technique was applied for the first time to assess the risk to groundwater sources originating from pit latrines in alluvial and sedimentary aquifers in the Mwanza River valley in southern Malawi, Africa.

For the development of a conceptual model and two numerical flow models, 124 water level

measurements and 45 pairs of pump and recovery tests were collected and analysed and relevant literature on the study area was reviewed. Backward particle tracking was used to determine travel distances and to delineate WHPA [3]. Furthermore, 91 water samples were analysed for actual microbial contamination and empirical analysis was carried out to identify possible ways of contamination.

Analysis of the calibration and model results revealed that a great amount of uncertainty is related to the results, as very little information is available on hydrogeological parameters such as the hydraulic conductivity and geological boundaries. Nonetheless, this promising technique could be extended through the collection of a more comprehensive data set over time and the coupling with hydrogeological, geochemical and isotope data.

So far, the risk of groundwater contamination from pit latrines appears small in this particular setting, as rarely pit latrines are found within the critical travel zones. This is supported by empirical analysis, which suggests that localised pathways are the main reason for borehole contamination, especially when many people use a borehole or when no protecting wall is in place. However, higher risk may be present in the wet season or in regions in the north of the study area, where due to fractured flow regimes travel distances may be much higher.

The Karoo sediments in the west of the study area were identified as a possible natural recharge area, as water levels are relatively deep (23–37 m below ground). Clean groundwater probably flows underneath the alluvial valley floor to well up at the Mwanza fault. A large scale regional and a small scale local numerical model were able to reproduce this process and could be a first step to develop and manage this resource sustainably.

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Local activated carbon production for the removal of water pollution by pesticides in Burkina Faso

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The use of phytosanitaries still represents a not well defined risk for health and environment in many sub-sahelian countries. For many of them, lack of technical and financial supports or poor scientific knowledge on pesticides behaviours reduce the effectiveness of integrated water resource management systems. Industrial sorbent remaining relatively expensive, agricultural residues can be valorised to produce specific activated carbon at lower cost. This work attempts to study the issues related to the removal of pesticides from drinking water by adsorption on locally produced activated carbon. Therefore, a summary review on pesticides importations, uses and effects in Burkina Faso is made. Important researches on polluted areas and pesticides adsorption on activated carbon are analysed so to find out different agricultural waste valuable as substrate for sorbents production.

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Impact of Renewable Energy on Development of Alpine Villages in Nepal: Case Study of Photovoltaic-Small Hydro-Wind

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Several remote mountainous villages of Nepal were electrified using micro-grid renewable energy systems-Solar, Wind and Hydro. Implementation of such affordable and reliable power plants in the village has lured entire village to get their share of electricity for lighting and other domestic activities. Most reported article focuses on lighting, education and entertainments that come with village electrifications. However, equally important contribution of village electrification is providing health services and income generation for the local community. This includes extension of vaccine cold chain, up-to-date patient database, electric powder mill etc.
In this presentation, we discuss how 5-20 kW electricity in remote mountainous village has been implemented and changed the overall lives in villages.

Long storage stability of biodiesel made from croton megalocarpus oil with the influence of metal contaminants

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Croton megalocarpus plants are found in the mountains of Tanzania, Kenya and Uganda and have been widely used locally as a shading tree. In the past few years it has been discovered that seeds from croton megalocarpus trees produces oil which is non edible with high potential of biodiesel production. Croton megalocarpus seeds contain 40–45% of oil in mass basis if the seeds are extracted mechanically using a hydraulic press. Therefore, biodiesel from croton megalocarpus oil was produced and tested for fuel related properties. The croton oil methyl ester (COME) was produced by transesterification process. The fresh produced COME without any additives displayed oxidation stability of 2.5 h which did not meet the minimum requirement prescribed in American Society for Testing and Materials (ASTM) D6751 and European biodiesel standards (EN14214) of 3 h and 6 h, respectively. It should be noted that biodiesel undergo oxidation more quickly than mineral diesel because of the presence of unsaturated fatty acids which are susceptible to oxidation. In order to improve the storage stability of the produced COME, two most effective synthetic antioxidants as reported in the author’s previous works (1, 2, 3 tri-hydroxy benzene (Pyrogallol, PY) and 3, 4, 5-tri hydroxy benzoic acid (Propyl Gallate, PG)) were doped to COME. In addition, containers used for storage of biodiesels are made of different metallic materials which quite possible can have significant impact on stability of

biodiesel. Therefore, the impacts of various metals on storage stability of biodiesel (COME) were evaluated in the present study. The samples with and without antioxidants were mixed with different transition metals (Fe, Ni, Mn, Co and Cu) to evaluate the impacts of these metals on storage stability of COME. The samples were stored indoor for 6 months in completely closed and open translucent plastic bottles, the oxidation stability were measured monthly. The results showed that, the antioxidant PY was more effective than PG. Fe displayed least detrimental effect on oxidation stability of COME while Cu had great detrimental impact. In conclusion, COME can only be stored with additional of antioxidants. Also, the stability of biodiesel is dependent on the type of transition metals commonly found on the containers used for storage.

Key words: storage stability, croton methyl ester, metals, antioxidants

Review of Solar Powered Pumping System as a Sustainable Solution for Decentralized Water Supply in Nigeria

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Abstract

The rapid population growth in Nigeria, has not been met with increase and efficient supply of basic amenities. Services such as water and energy are still facing erratic supply and unequitable access. With a rural population water access rate of 47% there is a need to employ sustainable and innovative approaches to the decentralization of water supply in remote locations. The aim of this paper is to assess the current state of water supply in the country, review existing research and solutions on solar powered pumps in Nigeria and to discuss the limitations of its applicability while also proffering solutions to the identified limitations. A review of the water resource in the country indicates an abundance of water resources both surface and ground, that far exceeds the demand. However, erratic power supply was identified as one of the barriers to the access of this resource. Enormous efforts have been made to assess the viability of solar powered pumps and though progress has been made, the rate does not match up to the population growth rate. Hence a deficit still in the access to potable water. Further review of this situation highlighted some limitations to the penetration of this technology. One of such was the low power output associated with intermittency of supply, which is being combated by development of more efficient batteries. The findings of this study indicate that, investment and awareness is required to promote the use of solar pumps and the exploitation of other solar powered innovative approaches to improving access to potable water.

Keywords: Solar pumps; Water supply; Decentralization; Potable water.

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Mobile Solar Pumps for Low-Income Farmers

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In Egypt alone, around 5 million small farmers own less than one acre of agricultural land. These farmers usually use diesel pumps for irrigation. Increasing operating costs of these diesel pumps due to subsidies phasing out has put an increasing economic and social pressure on these poor farmers. Despite Egypt's location at the sun belt, we have not made use of the unlimited resources of clean solar energy. This research and manufacturing project is trying to build an economically and technically viable new product to meet the needs of these small farmers for water pumping using solar energy.



Regular stationary solar systems have many limiting factors against meeting the needs of small farmers. These barriers can be summed up as: very high initial cost, infeasibility for small properties, big foot print of valuable land, and risk of theft.

This innovation is leveraging the unlimited clean solar Energy into an economically viable product at the affordability of low-income farmers, not only in Egypt but also in Africa, Latin America and South Asia.



Our Mobile Solar Pump is basically a complete pumping system that includes solar panels, electric pump and solar pump inverter. The components are mounted on a four-wheel trailer that can be easily towed by a donkey, horse, tractor or pick-up car easily. The solar panels are foldable to ensure they are safe during mobility. The system is user-friendly and can be operated by a single person easily. The pump is capable of pumping up to 60 cubic meters per hour, which means that you can irrigate one acre in 6 to 8 hours, almost the same like a regular diesel pumps. The main comparative advantage of this pump is that it can serve up to 10 acres if the acre needs to be irrigated 3 times a month at no operating cost and a much longer lifespan compared to diesel pumps. Moreover to the operating cost, the Mobile Solar Pump is almost maintenance-free, which saves time, effort and money.

Based on current diesel prices - expected to increase - in Egypt, the unit can payback on average at around 2 and half years. The payback can be as short as 1 year based on the number of acres being served by the Mobile Solar Pump.

Now, we have a fully-working prototype that we are optimizing its performance before piloting in the local market and then moving to mass production and exporting to other countries.

We expect that for each 1000 unit we build and sell we will create 6 to 10 local green jobs, reduce CO2 and GHG emissions by 24 thousand tons a year, reduce reliance on diesel fuel, and save about $ 4.5 million dollar of operating costs to poor farmers.

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Project: Transforming Waste Plastics to Plastic Lumbers while promoting energy efficiency

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Solid waste management is one of the environmental problems that most African cities are struggling to manage. As the number of residents in most cities is increasing so is the production of solid waste. Very unfortunate, effective environmental and sustainable measures to manage the waste are lacking. Tanzania generates about 3,800 tones waste every day of which 38% is plastic waste which end up in the streets, landfills and in oceans. On the other hand, we saw our forests are fast depleting, the growing demand for timber in building and construction activities, as well as charcoal for cooking was putting a lot of pressure on the country's forests (Tanzania loses an average of 400,000 hectares of forest yearly).

This project involves discovering how we use "Plastic extrusion technology" to recycle and transform all these unwanted plastic waste that are dumped and disposed everywhere littering the streets and clogging sewers and encroaching people's homes into a less expensive, durable, good looking and environmentally friendly plastic lumber while promoting energy efficiency. Our project allows the marginalized communities to exchange their plastic garbage with biomass briquettes for domestic cooking. Afterwards, collected plastic waste is recycled and transformed into plastic lumbers (an alternative product to timber) that we sell for building and construction purposes. The generated sells revenue is used to cover the cost for biomass briquettes and profit for the company.

Our three years strategic plan has ensured withdrawal of more than 2.5 million kilograms of waste plastics from the environment and used them to manufacture plastic lumbers hence save an estimated 250 acres of forest that would have been cut, (saved 5,774 Kwh of energy for every tone of plastic recycled), Promoted the domestic energy consumption efficiency by providing 352,000 kg of biomass cooking briquette on exchange to plastic garbage, same time prevented 2,500 Tons of Carbon dioxide gas emissions further mitigating the climate change.

Potential of Wind Energy Development for Rural Area Water Pumping in Ngaoundere

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In sub-Saharan Africa, operation and control of water in both rural and urban areas have become strategic issues for population growth, diversification of economic activities and the current degradation of the environment. Sensitive and complex subject, water should be open to all without any distinction but there is however still in 2016, a severe water crisis in Africa [1]. The modelling of wind energy conversion systems is of great importance if one intends to develop water pumping applications for a sustainable development. This study presents a technical assessment based on the measured wind data in which we investigate the possibility of coupling piston pump, roto-dynamic pump and electric pump with wind rotors for water pumping applications. Weibull distribution was used to model the monthly mean wind speed for a location in a rural area of Ngaoundere. It was found that there is a good agreement between the predicted values of the mean wind speed and those obtained from data suggesting that the Weibull distribution can be used to provide accurate estimation of the mean wind speed [2]. The mean electric power and energy was computed based on the Vestas V25 and V100 power curves. Taking into account the wind regime characteristics of our site, we provide the amount of water which can be expected from each type of wind pumps. The monthly amount of water has minimum and maximum average values of 422 m3 and 674 m3 for the piston pump, 1275 m3 and 1982 m3 for the roto-dynamic pump and 31334 m3 and 100042 m3 for the electric pump. From the results, it is clear that electric pump offers better performances than piston and roto-dynamic pumps. Furthermore, if storage devices like batteries are combined to the system, water could be pumped at any time of the day independently of the wind availability. These systems could be very useful for people living in rural areas far from urban cities.

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Solar-Aided Anaerobic Digester System for Small Scale Application in Tropics Case Study: Kiruhura District, Uganda

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Access to reliable and affordable energy is a sustainable development goal whose achievement calls for every stakeholder's input. The drive to combat energy poor in rural communities especially in African countries relies on the utilization of the available energy resources, mainly the renewables. At 6.9% of electrification of rural households, majority of Ugandans cannot use electricity nor liquefied natural gas to cook. 70 % of total energy requirements of households are met by use of paraffin and firewood with over 53% of lighting needs being met by use of paraffin [1]. Uganda's woodland cover declined by 15 % with a forest cover reduction of 27 % in a period of 15 years from 1990 [2]. The country is anticipated to import firewood in the year 2020 if the current rates of deforestation and fuelwood consumption are not regulated [2]. This calls for an urgent venturing into the exploitation of the existing renewable energy resources like solar and biogas to improve energy access in the country.

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A small scale solar-aided anaerobic digester system for household application was designed and simulated in this study to assess the possibility of using solar heating in the tropical regions to supply the heat energy requirements of an anaerobic digester using cattle manure as its feedstock and operating in thermophilic temperatures. The produced biogas was intended to replace the use of firewood for cooking that necessitates 1.56 m^3 of firewood to meet cooking energy demands per year to minimize greenhouse gas emissions and the deforestation rate in the country.

The designed anaerobic digester system was found to operate in temperatures ranging from 50 to 60 °C and only falling to 47 °C when the site receives the worst irradiance-incident between August 10th and 14th. The anaerobic digester temperature on average takes 18 and 20 hours, respectively, for best and worst irradiance-incident periods to vary by 1 °C, rendering favorable conditions for the microorganisms to adjust appropriately with the temperature variation. The digester operates in the thermophilic temperature range (47 – 60 °C) throughout the year.

With biogas replacing firewood use for all the cooking activities, the household would avoid GHG emissions of 5130.53 $kg_{CO_{2eq.}}$ per year, 99.9 % of emissions if firewood had been used for cooking and cattle manure left to digest in open space other than being used in the anaerobic digester.

Key words: Energy access, GHG emissions, Deforestation, Anaerobic digester

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Solar Energy and Drip Irrigation

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Since I realized that sustainable energy and clean water are essential for the development and to reduce poverty, I was pulled towards sustainable agriculture and renewable energy with the aim to create employment and income.
So my initiative focuses on green energy and access to clean water in the service of productive land. With the development of plots from 0.5 hectares to several hectares, the implementation of vegetables and fruit trees the must socio-economic competitive and profitable, with a drip irrigation system and a submersible pump to be powered with solar PV, a standalone system with storage to cope with the fluctuation of the sun and continue to deliver vegetables, the supply of water necessary for their growth.
All of this will be controlled remotely with a communication interface that will allow to manage the programming and management of the irrigation and complete monitoring of the PV system from a smartphone or laptop system. Ensuring saving time and money, to achieve better water management and facilitate quick error detection for better performance of our PV field and our crops.
The turnover is estimated at 120 000 Euros for the first year of operation and for 2 hectares. And with the installation of a solar cold-room for the conservation of fresh product (potatoes, tomatoes...), I expect to reach one million Euros in the 4th year of operation with exportable products such as green beans, melon ... representing in 2013, 700 000 tons so 53 million Euros in the words of Minister of Senegalese Agriculture.
This is accompanied with the creation of a savings and credit mutual between the 2nd and 3rd year of operation, in order to exploit all the potential of productive land, promote socio-economic development of local communities, increase the basic income populations, and so find an alternative for rain-fed and seasonal crop as cash crops (groundnuts, cotton) and food crops (millet, sorghum, maize) based on access to water and renewable energy.
Since my ultimate goal remains to contribute to the development of Senegal.

Photovoltaic solar energy: Spectacular technology developments and global breakthrough in applications

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Photovoltaic solar energy (PV) is a key technology for the transformation towards a sustainable global energy system. PV is modular and reliable, can be used everywhere on earth in the form of small systems for households, communities or enterprises as well as large power plants, and has a huge potential. Importantly, the cost of PV systems and PV electricity has come done dramatically over the past decade, making it competitive and affordable for a growing number of markets and applications. The total installed global capacity is now well over 250 gigawatt and is growing at a high rate. It is expected to enter the terawatt-regime in the first half of the next decade.
The spectacular improvements in the economics of PV have been driven by technology developments, economies of scale, supply-chain efficiency and a number of other factors. Yet,

more is to come. Further enhancement of efficiency, reduction of materials consumption and the introduction of cheaper materials, new system designs and other innovations will bring costs down to levels that were considered beyond reach not even long ago. Moreover, they will enable many new PV applications. Prominent examples are systems integrated into roofs and facades, PV in combination with agriculture, PV on water, bifacial PV, see-through PV, and many more.

This presentation will provide an overview (that may be appreciated by non-experts) of the state-of-the-art and the developments in PV science, technology, applications and economics, from a global perspective. It will also give some insights into the priorities for PV research and innovation in Europe and into the policies and approaches used to promote large-scale use of PV.

Photovoltaic solar energy: prepare for impact!

Sustainable Communities Project, integral development based on Low External Dependence Distributed Models

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The Sustainable Communities Project (SCP) carried out since 2012 by the Special Committee for Local & Regional Leaders Appointment (CLRLA) sponsored by the UNESCO focuses on the assessment of the effects of a Low External Dependence Distributed Model (LEDD) implementation by Development Cooperation in isolated communities, independently on their idiosyncrasies (ethnic, geographic, economic, and others).
SCP is mostly about the design and development of a widely applicable LEDD that will be validated experimentally in a total of 200 SCP carried out in six different regions of the globe (Central America & Caribbean, South America, Central Asia, the Horn of Africa, Southern Africa and Palestine). Each initiative will be implemented in communities smaller than 20,000 inhabitants, constituted by a set of residential structures (villages, nomadic populations, etc.) and characterized mostly by its high poverty and/or inequality levels. The initial working hypothesis, consider that any community, independently of their cultural, climatic and socio-economic context, can ensure the fulfilment of their needs and expectations through responsible and self-managed value of their own resources, ensuring their sustainable development, increasing their resilience and stimulating reproducibility in adjacent communities. As added value, the promotion of local, regional and national impact, it's a positive factor on the eradication of multi-dimensional poverty.
As a distinctive feature to any previous initiative, the SCP handles the concept of integral development in their actions, establishing seven interdependent intervention areas, ranging from socio economic development, to education, the access to clean energy and water.

Solar Energy as a Viable Energy Source to Address Water Crisis in Namibia: Solar Energy for Water Pumping as viable alternative!

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Namibia can be categorised as a Water Scarce country even that it has roughly 2500m^3/a person by 2016. This amount is a drop from about 10 00m^3 per capita per year in 49 years. Namibia finds itself in this predicament due to several factors. Among others low to very low precipitation averaging not more than 300mm/annum coupled with very high potential evaporation which is over 3000mm per year. As a Nation faced with these huge challenges of supplying its population with water (quantity and quality) one must think about and implement plans that are sustainable for the current and future generations.
Currently, Namibia is using all possible sources of water sources e.g. seawater, boreholes (shallow and deep), surface water, condensation of dews, sewage water (treated to drinking water standards) etc. The country shows that most of the boreholes in remote areas are the most used options due to aridity nature of the country as surface waters are NOT abundant. The most challenging aspect to sustainably exploit water resources in the country is the provision and accessibility to sustainable energy supply options. A quick scan of the country shows that most of the energy options used to pump water from boreholes (ranging from 25m and 90m depth) is either diesel prime movers or electricity from the national grid or generators.
However, Namibia is among the countries in the world with significant solar energy resource. Solar water pumping technologies are mature and already widely utilised in the different parts of the world. Indeed with an average insolation of 6kWh/m^2 per day it is a viable and sustainable way to pump the water almost throughout the country with a population of 2.2 million (the most sparsely population in the world!). To increase the amount of water availability in this dry country this inevitably depends on pumping water from deep aquifers one must consider reduction of unaccounted water (UAfW). On average the accounted water is above or more than the IWA recommended values of less than 20% of the total throughput amount of water. In Namibia, the UAfW is ranging from under 10% to over 50% which converts to serious waste of resources in country suffering from acute shorted of water. Developing sustainable infrastructures in the provision of clean and potable waters is well aligned with the Harambee Prosperity Plans (HPPs), Vision 2030 and the Namibian Development Plans (NDP4). This paper is focusing on the investigation of the possible use of solar energy as an energy option to support water pumping in Namibia with abundant solar resource. Considering the range of the borehole depth (25m and 90m) with average pumping system efficiency in the range (50% and 75%) and average efficiency of PV modules of 14% the expected solar energy required per m^3 of water pumped is estimated. The results indicate that solar energy required at system efficiency of 50% is in the range of (0.97kWh/m^3 – 3.50kWh/m^3) and at system efficiency of 75% the range is (0.65kWh/m^3 – 2.34kWh/m^3). Considering average insolation 6kWh/m^2 per day, worst case scenario of boreholes with 90 m depth and system efficiency of 50%, about 3 m^3 of water can be pumped per m^2 of collector per day. There it is concluded that it requires about 2.5m^2 of collector (PV modules) area to pump water consumed by 1 person annually.

Key words: Photovoltaic Pumping, Solar Energy, Insolation, water pumping, UNAfW

The Role of Renewable Energy in the Supply of Energy for the Rural Area in Tanzania

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Renewable energy supply has been very important and necessary in Tanzania due to recent high demand of energy supply, the high cost of supply of fossil fuels, and the increase of environmental impacts caused by frequently use of fossil fuel. At present Tanzania depends on hydro and thermal power supplies as the main sources of energy. On the other hand, many hydropower plants (sources) are mainly erected or placed in the existing natural flow of water in a given specific area, and therefore ensure the economical and viability of using the hydropower in that particular area. Practically, the high cost of transmission from hydro power sources prevent and hinder the grid connected electricity to the widespread populated area in Tanzania. The biomass use account for 89% of the energy consumption and it is estimated that, 90% of the population in the country relies on traditional biomass such as wood fuel and charcoal for cooking, because their majority are rural, poor and cannot afford the cost of modern energy sources such as electricity. The data shows that by 2015, about 24% of the total population in the country was connected to electricity, of which 7% is from rural areas. Only 12% of the hydro potential which is about 561MW has been delivered. The hydroelectric potential in the country is reported to be in excess of 4700MW of the installed capacity. Mini hydros have shown the potential of 187MW but only 4.7MW has been exploited. Tanzania has solar radiation of about 200Wp/m^2, and the estimated potential of solar PV is around 20.2 MW. There are several sites with wind speed ranging from 5-7m/s mostly in central parts of the country. Co – generation and geothermal resources are estimated at 395MW and 5000MW respectively. However, still the utilization of these potential renewable energy resources remains very small especially in rural areas of the Country. Renewable energy resources, excluding large hydro has very little contribution in the generating capacity. This paper focuses on how renewable energy application based on local or decentralized grid on commercial bases will overcome energy deficiencies in rural areas of the country. The Government campaign on exploitation and use of renewable energy in rural areas will reduce rural poverty.

Key words: Renewable Energy, Poverty, Rural

Solution Processable Kesterite Solar Cells

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The main motivation in studies for photovoltaics today is to combine high solar energy conversion efficiencies together with low cost technologies. Thin film PV technologies commercially available are direct band gap materials such as copper indium (gallium) diselenide (CIGS), copper indium diselenide (CIS) and cadmium telluride (CdTe). However, due to toxicity of Cd and Se and availability issues of In and Te, the production of the PV devices based on these absorber layer is limited. There is a recent attention on the absorber materials that are non-toxic, earth abundant and and relatively low cost features for the solar cell production. It has been achieved with forming with Cu_2ZnSnS_4 (CZTS) material by replacing the two In(III) ion with Zn(II) and Sn(IV). Over the last five years $Cu_2ZnSn(S, Se)_4$ (CZTS, CZTSe) based solar cells have demonstrated rapid technological progress with power conversion efficiencies exceeding 11%. By depositing CdS layer electrochemically on wet chemically processed CZTS thin layers, 3 D p-n- junctions with power conversion efficiencies of 5.02 % have been reported, recently [1].

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In this study, we prepared CZTS nanoparticle inks using hot injection method [2]. Kesterite thin films were prepared on different substrates (n-Si and Mo) by spray coating. n-CdS layer was prepared by electochemical deposition. Chemical composition dependence of morphological and optical properties of Cu_2ZnSnS_4 thin films deposited by spray coating have been characterized after annealing at temperatures in the range of 150-400 °C in inert atmosphere using X-Ray diffraction, EDS Analysis, cross-sectional SEM, Raman and UV-Vis-NIR spectroscopy to analyse the growth of crystalline phases and stoichiometric changes on Mo and on Si substrate.
Current/voltage characteristics of Al/ n-Si/p-CZTS/Al and Mo/p-CZTS/n-CdS/ZnO/Al p-n junctions are characterized. Diodes using n-Si/CZTS p/n junctions displayed better diode behaviour in dark and under illumination.

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Reference Distributions and Beta Probability Density Functions of Daily Relative Sunshine Duration and Clearness Index Data from Some Burundian Stations

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A statistical analysis of two kinds of data is presented. The first kind is a 5-years period data of the daily relative sunshine duration (s_r) from six stations in Burundi. The second one is a 6-years period data of the daily clearness index (k_t) from six other stations. The main characteristics of the observed monthly frequency distributions of s_r and k_t have been firstly extracted from those data. Secondly, the beta probability density functions (β-PDFs) fitting those distributions have been constructed for the twelve s_r and k_t data sets of any of the considered stations. The efficiency of the fitting technique has been checked through three complementary statistical tests, namely the MBE, the RMSE and the t-statistics. For any of the previous data sets, the MBE has been found equal or close to zero, the RMSE was very low as expected and t was lower than its critical value (t_c). All the β-PDFs obtained so far are therefore very good fits of the relevant observed s_r and k_t frequency distributions. They should be very useful input data in projects of solar energy conversion and /or storage systems at those stations. Thirdly, another statistical test, i.e the F-test, has been used to check if, for each station, the monthly samples with the same average x_m (x holds for s_r and k_t, respectively) had also the same variance. The null hypothesis has been accepted for all the x_m intervals of interest –excepted one. Those samples belong therefore to the same mother population and have the same statistical distribution referred to as the (s_r and k_t) reference frequency distribution. Such reference distributions have been constructed for all the stations and the x_m intervals of interest. They should also be used as input data in the design and the prediction of a long-term average performance of solar energy conversion systems at the stations under analysis.

Key words: β-PDFs; Clearness index; Reference distributions; Relative sunshine duration; Statistical tests.

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Fabrication of DSSC and Electrochromic Window Using Nano Particle Deposition System

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Nano particle deposition system (NPDS) is a inexpensive, kinetic-energy-based coating method using dry powders mixed with air. Laser and plasma as well as aerodynamic focus enhance deposition properties of various metal and ceramic powders. In this presentation, we discuss fabrication methods and characteristics of two case studies- dye sensitized solar cell (DSSC) using TiO_2 and electrochromic window using WO_3.

Newly developed large area deposition system for 1m x 1m glass substrate showed scalability of NPDS process.

Exploring Measures to Promote Sustainable Energy Efficient Building – A case for Africa

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The building sector continues to be among the highest energy consumption areas accounting for 40% of the total global energy consumption. On the African continent the sector contributes highly to the final energy consumed yet the continent continues to suffer extreme cases of energy poverty mainly in the Sub-Saharan region. This lack of energy has led to continued low productivity and impaired economic growth and has trapped millions of people in the region in abject poverty. Sectors like the building industry, is one of the untapped and cost effective potentials for energy savings in Africa. Owing to the growing rates of urbanization, with Africa having the highest rates of urbanization in the whole world, the industry is expected to grow highly and the repercussions on the side of climate emissions as well as energy availability, particularly in Africa are expected to be rather worse if not mitigated. Notably, there has been more focus on diversification of energy sources through different structures including policies without keenly looking into the different sectors that consume this energy. This has created a gap and to a reasonable extent, it has encouraged poor management and inefficiency in energy use. This paper seeks to shed light on how energy consumption can be made more efficient through a structural integration that supports energy use and energy efficient building as well as pointing out the opportunities that come along.

Key words: Energy efficiency; Urbanization; Sustainable Energy efficient building.

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Eco-Efficiency of Polymer-Based Solar-Thermal Collectors

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Since ca. 50% of the world final energy demand is heat with currently only 25% thereof derived from renewable resources (mainly traditional biomass) and less than 1% being supplied by solar-thermal energy, the relevance of sustainable heating services in view of the overarching goal of a global Sustainable Development strategy cannot be overemphasized. Solar-thermal collectors allow for renewable heat generation without combusting fossil or any other fuels. However, despite employing a renewable energy source, the solar-thermal collector itself should also be considered from a materials performance, eco-efficiency and life-cycle perspective accounting for the limitations and potential within the Sustainable Development nexus.
The present paper examines the eco-efficiency of two solar-thermal collector systems, one being substantially the other entirely based on polymeric materials. By means of a commercial material selection and eco-auditing software the energy and carbon dioxide intensities over the entire life-cycle of both collectors are calculated, discussed and compared to corresponding data of a conventional commercial collector composed of a material mix including metals and glass. Conclusions are drawn as to the eco-efficient and Sustainable Development-oriented material selection for solar-thermal collectors.

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Investigation of charge photogeneration and recombination processes in organic solar cells

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Great efforts have been made to improve the efficiency of the organic solar cells [1-3]. The processes involved in the photo-electron conversion mechanism, can be subdivided into exciton harvesting, exciton transport, exciton transport, exciton dissociation and charge extraction stages. The success of such devises needs a deep understanding of the microscopic mecanisms of each of those steps. Parameters like energetic disorder, relaxation energy, type of recombination, type of aggregation, diffusion time (τ_{diff}) and the diffusion length (L_D) are the key parameters that govern the excitonic motion, relaxation and recombination [4-5].
In the present work, we present our theretical and experimental investigations on a several structures based on the statistical copolymer named (*AnE-PVstat*) [6], varying thicknesses, temperature, type of blend, type of electrode. The experimental emission band shape was theoretically reproduced, for each sample, taking into account the bond stretching vibrational mode leading to an estimation of the Huang-Rhys factor which corresponds to the average number of phonons involved in the emission process. The relaxation energy associated with the geometrical rearrangement after an excitation or de-excitation process is also inferred from the

emission spectra. We also correlate between the spectral diffusion of neutral excitations and morphology and the arrangement of polymer chains. We investigate how aspect of aggregation depends on temperature and how spectral diffusion is controlled by the degree of disorder parameter (the inhomogeneous broadening of the PL spectra) and temperature.

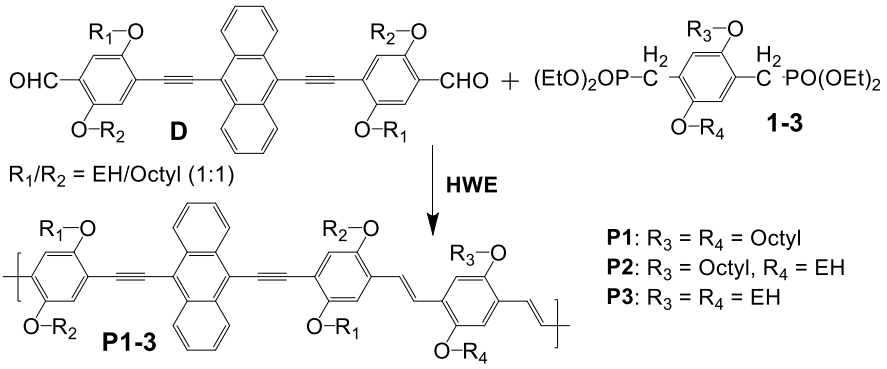
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Anthracene-Based Polymers with Dissymmetric Side Chain Arrangements for Solar Cells Applications

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The influence of side chains on the properties of conjugated backbones is not restricted to the facilitation of solubility. The type and size as well as the arrangement can affect e.g. the photophysical characteristics distinctly. The impact at the performance in organic electronic applications such as organic light-emitting diodes (OLEDs) and organic photovoltaics (OPVs) can be significant. In the work for this contribution we focused on the synthesis and characterization of anthracene-containing poly(p-phenylene-ethynylene)-*alt*-poly(p-phenylene-vinylene)s (AnE-PVs) with dissymmetric arrangement of linear (octyl) and branched (2-ethylhexyl) alkoxy side chains as potential candidates for solar cell applications. The attempt to adept the synthetic protocol, which is well-established for the preparation of AnE-PVs with symmetric side chain arrangements[1], led to isomeric monomer mixtures (**D**) and eventually to polymers with a poorly defined distribution of side chains (see scheme). Seeking for the preparation of well-structured polymers it was necessary to look into another pathway.[2]



*Synthesis of AnE-PVs (**P1-3**) by Horner-Wadsworth-Emmons (HWE) reaction.*

Key words: AnE-PV copolymers; alkoxy side chains; photophysical properties

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Acknowledgement: The authors are grateful for financial support from ANSOLE e.V. and Austrian Science Fund (FWF) with grant No I 1703-N20.

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The Prospect of Solar Thermal Energy Technologies in Tanzania

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This paper presents the challenges involved in the future deployment of solar thermal energy technologies in Tanzania from a strategic framework. There is an inherent need to improve electricity access in the rural reach of Tanzania through solar thermal energy technologies such as concentrating solar power (CSP). However, due to the dilapidated grid and infrastructure required for a CSP plant complimented with lack of industries and tariff structure has made grid scale CSP a challenge to deploy in the energy mix of Tanzania supplemented with the lack of a comprehensive energy policy. The existing information regarding solar thermal deployment in Tanzania is poorly documented, which makes it difficult to gauge the progress in a systematic manner. Feed-in tariff topologies/schemes need to be effectively formulated and optimized based on the type and size of the technology complimented with the incubation of independent power producers in the country. There is potential for micro/mini scale CSP including hybrid systems for decentralized rural electrification in Tanzania. Solar water heating systems up thrust has been at a staggering low due to lack of conformity to structurally sound homes that have proper plumbing in the rural areas. The establishment of energy centre/s in research and academic institutions in Tanzania is pivotal to the successful deployment of renewable energy in the country that is strategically aligned with the energisation plan of the country complimented with collaborative frameworks with stakeholders.

Key words: Tanzania, CSP, tariff, solar thermal, independent power producers, hybrid systems,

rural electrification, solar water heating.

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Poster Presentations

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"Solar Cooking and Gender Entrepreneurship" Women and Solar Restaurant	**Pedro Serrano Rodríguez** *Académic, UTFSM, Director Extreme Architecture Unit, Chile*
Solar Cookers & Public Policy	**Pedro Serrano Rodríguez** *Académic, UTFSM, Chile*
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Effect of Light Soaking on Conversion Efficiency in Solar Cells Based on $In(OH)_xS_y/Pb(OH)_xS_y$	**Robinson Musembi** et al. *University of Nairobi, Kenya*
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Solar Powered Poultry Incubator - Summary of the Product	**Kaledawit Esmelealem** *Kale General Electronics & Machinery Manufacturing plc, Ethiopia*
State of the Art of the Research on Nanotechnology & Water in Brazil	**Guillermo Foladori** et al. *Autonomous University of Zacatecas, México*
Carrier Transport in Conjugated Polymers	**Gustavo H. Santos** et al. *Technological Federal University of Paraná, Brazil*
A Micro-CSP Plant for Micro-Grid Electricity	**N'Tsoukpoe Kokouvi Edem** et al.

Generation in Sub-Saharan Africa	*Institut International d'Ingénierie de l'Eau et de l'Environnement (2iE), Burkina Faso*
Use of Multiferroic Alloy to Enhance the Productivity of Non-Commericial Geothermal Wells Through the Conversion of Waste Heat to Electricity	**Kulundu Levi** et al. *Kenyatta University, Kenya*
Techno-Economic Comparative Analysis of Batteryless Hybrid PV/Diesel Systems for Off-Grid Applications	**Daniel Yamegueu** et al. *International Institute for Water and Environmental Engineering (2iE), Burkina Faso*
Investigating the Effect of Anaerobic Co-Digestion of Cowdung with Common Ugandan Weeds on Biochemical Methane Potential	**Yunus Alokore** et al. *Pan African University Institute of Water and Energy Science (Including Climate Change), Algeria*
Solar Photovoltaic Water Pumping at Mohammedia	**Aimadji Moudarinan** et al. *Hassan II University of Casablanca, Morocco*
Application of Solar Powered Irrigation Systems in Botswana	**N. L. Moumakwa** *Botswana International University of Science and Technology, Botswana*
Side Chain Engineering of Anthracene-Based Polymers: Applications in Photovoltaics	**Suru V. John** et al. *University of Western Cape, South Africa*
Water Monitoring in Colombia by Citizen Science	**Sebastián Arévalo Ribón** et al. *Universidad de los Andes, Colombia*
Web-App for Safety Handling of Nanomaterials at Research and Workplace Scenarios	**Homero F. Pastrana** et al. *Universidad de Los Andes, Colombia*

Abstracts for Poster Presentations

Solar Energy Domestication in Nigeria Prospects and Challenges

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This paper discussed viability and challenges of solar energy domestication in Nigeria. With the geographic positioning of Nigeria and the almost-all-year supply of sunlight, solar photovoltaic energy is a good prospect to end energy crisis in households in Nigeria. The average family Power consumption is about 1.6KWh. Nigeria currently relies on power supply from the National grid with about 70% supply while 60% of the populace is disconnected from the grid. The national grid is fed with thermal and hydro power plants while households use petrol-powered and sometimes diesel-powered generating sets. With the average cost of running the generating sets in average family estimated to be 455,400naira per year (1,366,200naira for 3years) while the initial cost for solar is around 1,226,000naira for a minimum of 3years without any human interference. This shows that solar energy is a better option for Nigerians. However, the major challenge hindering the implementation of it is the fact that Nigeria is home to several individuals living below the poverty line and as such unable to afford the current cost of installing a solar power. This study concluded by making recommendation which include appropriate Public Private Partnership in researching into combining nanotechnology and thin film technology and timely intervention by Africa Union (AU) in order to light up Africa and Nigeria in particular. It also shed light on an emerging technology of producing cheap and efficient solar cell by combining nanotechnology, metals and solar cells.

Key words: solar energy domestication, prospects and challenges, power supply, Nigeria

Educational and Basic Aspects of Solar Power Generation

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Sustainable power is needed for all aspects of modern life, here especially for the very power intensive water desalinization. However, a real understanding of the meaning of “sustainable power”, although used today already in most of the discussions, is rudimentary. The talk starts with explaining the basic concepts of “energy” (“what is energy”; no simple explanation is given in today´s textbooks) and “sustainability” and at the same time discusses University curricula aiming at educating engineers to deal with energy/power problems in a more sustainable way. Proposals for the development of specific curricula for developing countries, here especially Africa and Latin America, will be made.

Start-up and Long Term Performance of a Fullscale UASB-Constructed Wetland for Treatment of Banana Winery Effluent

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Performance of a full scale UASB integrated with a Constructed Wetland for the treatment of winery effluent from Banana Investment Limited (BIL) in Arusha Tanzania was investigated. The integrated wastewater system is aimed at recovering energy in the form of biogas while at the same time treating the BIL wastewater to meet environmental standards and recover nutrients and water for agricultural purposes. The average wastewater flow rate was 62.4m^3/d. During the start-up operation a study conducted 2 months after commissioning indicated that the COD was reduced from 7500±1891mg/l to 720±250mg/l (90%), BOD_5 from 2500±995mg/l to 168.75±85mg/l (93%), TSS from 3850±59mg/l to 150.35±55mg/l (96%) NO_3^--N were reduced from 34±5mg/L to 6.03±5mg/L (82.4%), and PO_4^{3-} from 5±2mg/L to 2.5±0.5mg/L (50%). The steady state conditions of the influent was established using 17 months operation data and it was found that the feed to the UASB had concentrations (mg/L) of COD(4959.3±388.7), BOD_5(1453.7±110.3), TSS(2431.0±190.5), NH_4^+ (7.2±1.1), NO_3^-(23.4±3.2) and PO_4^{3-}(5.12±0.73), VFA(0.60±0.09), and Alkalinity(60.00±8.98). After 19 months of operation the system achieved steady state removal efficiencies (%) of COD (99.0), BOD_5 (98.6), TSS (96.0), NO_3^-(88.7), PO_4^{3-} (50.8).There was a net generation of NH_4^+(387.8%) in the system. The biogas produced in the UASB is collected at a rate of 163m^3/d and is used in the boiler of BIL. The dried sludge and the treated water are used for irrigation. The study concluded that integrating the UASB with constructed wetland for water, nutrient and energy recovery ensures compliance to environmental law and provide incentive to companies to treat their wastewater while also mitigating greenhouse gases.

Key words: Biogas**,** Constructed wetland, industrial wastewater, UASB, wastewater treatment, winery effluent.

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Solar a Sustainable Energy Option to Address of Water Crisis in Namibia: Solar Energy for Desalination as Viable Alternative!

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The demand for fresh water in Namibia is growing because of a number of factors ranging from limited water sources determined by the spatially and temporal variability in rainfall, high rate of evaporation, climatic changes, and industrialisation and population growth. The available fresh water resources are limited by sources that would inherently include seawater, salty/saline springs and brackish water or outright sewage. It is clear knowledge that availability of reliable energy supply is indispensable to the provision of clean and potable water. The role of renewable energy technologies in water processing and supply is proven world over. It can be safely said that in Namibia which is endowed with an average irradiance of between 5 to 7 kWh/m^2.day one can desalinate between 8 and 15 l/m^2 of collector per day at efficiency as low as 40%. The paper discusses the water situation in Namibia with emphasis to address the problem with the use of solar energy for water desalination. Solar energy potential in Namibia is analysed, whereby the country endowed with abundant solar energy. This approach is in line with the political aspiration of the nation as spelt out in VISION 2030, Harambee Prosperity Plans (HHPP), and the NDP4 now being replaced by NDP5.

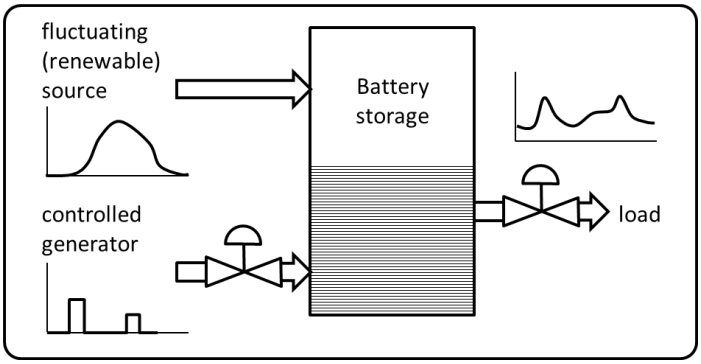
The highest component of solar radiation potential in the country is DNI (Direct Normal Irradiance), which plays a vital role in solar thermal applications. The use of solar energy in water desalination is investigated based on SWOT (Strengths Weaknesses Opportunities and Threats) analysis. The analysis gives the reader a picture about the concept of adopting solar energy to address water crisis in the country. The strengths are dominated by the abundance of solar energy resource and policy support. The willingness of the government to uplift the standard of all Namibians by ensuring accessibility to basic services by all people is part of policy support. The weaknesses range from limitation of the available water resources, sparse of the population and lack of expertise in the technologies and challenges related to infrastructure development. The opportunities are more centred on the availability of technologies (solar for water desalination) proper governance of the resources, the prices of the technologies are decreasing on international scale and financing opportunities is available. Finally the threats are more on the sustainability of the technologies and high evaporation rate in the country.

Key words: Direct Normal Irradiance (DNI), sparse population, very low precipitation and very high potential evaporation, solar desalination, vision 2030, Harambee Prosperity Plans (HPPs) and the National Development Plans (NDP)

A Multi Hybrid Energy Lab for Model Based Training and Applied Research

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A multi hybrid energy system consisting of regenerative sources like photovoltaic (PV), a generator (fuel cell), battery storage and a programmable load provides a versatile base to study the components and a manifold of decentral and autarkic energy systems.



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The didactic approach for advanced training and applied research seamlessly integrates the three essential steps of knowledge gaining; providing a turnkey solution:

- observation and measurement,
- modelling and curve fitting to derive a quantitative description of the components solar cell, battery and fuel cell,
- application of the quantitative description in PV simulation, battery state-of-charge (SoC) calculation and operating point visualization on characteristic curve.

Tailored tools ease the use of advanced data analysis functions like curve fitting.

On system level arbitrary PV, generator and load profiles allow for studies on dimensioning and energy management (e.g. battery cycling) while the operating state (battery, generator or boost) is visualized by a real time energy flow diagram (Sankey).

An application programming interface (API) allows for individual applied research applications, like user defined energy management algorithms (e.g. applying the SoC) or integration into larger systems or control hierarchies (internet of things, IOT).

Problematic to Access to the Safe Drinking Water in Cameroon: Case of Bambui-Bamenda

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Cameroon is one of the few countries in the world where all departments carry the name of a river. This is proof of the existence of this resource in the country. Yet Cameroonians in their majority are thirsty. Statistical studies show that the water deficit in the political capital Yaoundé is over 300 000m^3 of water per day. According to this situation, people turn to digging water wells to supply and unfortunately the quality is not always assured. That is why this population is generally the victim of waterborne diseases. The "rich" households manage to install solar pumps (Fig.1) for pumping water from the wells but the question of the portability remains because one does not have the reflex here to analyze the quality of that water before consumption. The situation is worse among the “poor” households which are also the highest. The Arsenic which is one of slow killers in the water we consume is not often monitored. In a study we are conducting on the situation of water wells generally used at Bambui in the North West region in Cameroon, it appears that the turbidity of the water is to improve. Analysis of heavy metals on samples taken from the field also shows that the Arsenic content was 0.099 out of the value prescribed by OMs which is 0.01. The results of this analysis allow us to design an appropriate filter to help remove the Arsenic from surface water to help providing a potable and clean water to improve the living conditions of populations.

Key words: Solar pumps, water deficit, wells, turbidity, arsenic



Fig. 1: Installation of solar pump

Rain on Methylammonium Lead Iodide Based Perovskites: Possible Environmental Effects of Perovskite Solar Cells

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The great promise of hybrid organic–inorganic lead halide perovskite (HOIP)-based solar cells is being challenged by its Pb content and its sensitivity to water. We investigated the impact of rain on methylammonium lead iodide perovskite films by exposing such films to water of varying pH values, simulating exposure of the films to rain. The amount of Pb loss was determined using both gravimetric and inductively coupled plasma mass spectrometry measurements. The residue on the substrate was characterized by using UV-Visible spectrophotometer and X-ray diffraction spectrometer. Using our results, the extent of Pb loss to the environment, in the case of catastrophic module failure, was evaluated. Although very dependent on module siting, even total destruction of a large solar electrical power generating plant, based on HOIPs, while obviously highly undesirable, is estimated to be far from catastrophic for the environment.

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Crowd-sourcing Energy Poverty Data in South African Informal Settlements: The Opportunity of Mobile Phone Technology

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Biography of Presenting Author: Kimenthrie Pillay is a Masters student at the Energy Research Centre at the University of Cape Town. She has a background in Environmental Science and an interest in energy access and poverty alleviation. She has experience in the renewable energy and energy poverty field while her interests on problems of climate change, globalization and inequality of access to energy resources drive her research interests. She hopes to make a meaningful impact in addressing energy poverty globally.

Abstract: Energy poverty undermines development on a large scale. It is most overtly experienced in informal settlements, where the use of fuels like paraffin, charcoal and wood prove hazardous and harmful to health and wellbeing. The expenditure on and use of energy services in informal settlements are largely undefined, which undermines the success of energy access and safety initiatives. Despite widespread poverty in informal settlements, mobile phone ownership is high in these areas. This research aims to explore the potential and applicability of a digital data collecting systems using a mobile application that is accessible on entry-level mobile phones with basic internet access to collect information about energy access, affordability and multiple fuel use in these areas. As part of this research, a mobile application platform and data collection platform was developed which enables survey design and data collection in real time. The platform allows for creation of weekly surveys that question energy use, expenditure and affordability; it also offers other functions that are designed to increase awareness of fuel safety and efficiency. The application was piloted in Imizamo Yethu in Cape Town. Six weeks of continuous data was extracted from 200 users using airtime incentives. The quality and quantity of data received was high. The results indicate that the potential for using this system and mobile phones as a data-collecting tool in Africa is great.

Study of Czochralski Silicon (CZ-Si) Wafer Optoelectronic Behavior Under Light Exposure

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Semiconductor devices are critical components of solar panels and play a vital role in the energy conversion process. The performance of semiconductor devices maybe limited by electrically active defect centers even if they are present in concentrations below the detection limit of conventional techniques. The development of strategies to reduce or avoid such harmful defects must start with their identification, which becomes increasingly difficult as the electronic quality of the semiconductor material improves. In this study, Czochralski silicon (Cz-Si) p-type wafer was exposed to illumination for 4h using a halogen lamp with an intensity of 0.5 suns. The effective carrier lifetime (τeff) was measured using the quasi-steady-state photoconductance (QSSPC) technique. The carrier lifetime degradation is much slower than the degradation observed during a light induced degradation (LID) process of Cz-Si wafers related to a B-O complex. Moreover, Using a theoretical model the rate of degradation and annihilation of the metastable defect was calculated. In addition, the simulation of lifetime as a function of carrier density was also performed to determine the defect concentration evolution with time of illumination. The results confirm the presence of a second mechanism separate from the B-O complex and was associated with the metallic impurity present in the wafers. Finally, the wafer illumination steps can be a suitable method to confirm the electrical quality of Cz-Si wafer and also contributes to attaining higher efficiencies in solar cells.

Key words: c-Si, Czochralski, QSSPC, Light induced degradation.

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Synthesis and Characterization of Lead Sulphur Selenide (PbS_{1-x} Se_x) Thin Films for Solar Energy Applications by CBD Method

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Semiconducting compounds has attract considerable scientific attention due to their potential applications in the field of solar cells. PbS_{1-x} Se_x thin films can be obtained as polycrystalline thin films by several deposition techniques. PbSe has the least band gap of the lead chalcogenides of 0.27 eV at room temperature but be engineered to up to 1.5 eV and beyond to march the maximum of solar irradiation, by sulphur doping and variation of deposition process. Chemical bath deposition method is considered as a cheap and simple method to produce large area thin films. In this study the PbS_{1-x} Se_x thin films were prepared by chemical bath deposition method using aqueous of lead acetate, thiourea, sodium selenate and sodium hydroxide as a complexing agent. The amount of sulphur was varied ($0 < x > 1$) in order to investigate the solubility. The temperature was kept constant at 80 °C and deposition time was done for 45 min. The films were characterized by X-ray diffraction, scanning electron microscopy and UV-Vis spectrophotometer. The XRD results confirmed the polycrystalline cubic structure of PbS_{1-x} Se_x films. The intensity of diffraction peaks is modified and peaks slightly shift the position with the content of sulphur. Since the ionic radius of the Se^{2-} ion is greater than the S^{2-} ion; addition of Se in PbS gradually expands the cell uniformly. This result is consistent with the well known Vegard's law. The SEM micrograph of all the films shows uniform surface morphology over the entire glass substrates without defects like cracks, peeling or pinholes and nearly all films are composed of well defined cubic shaped grains, with different grain sizes. UV-Vis measurement clearly shows that the optical band gap decreased for pure PbS from 1.32 eV to 1.18 eV ($PbS_{0.5}Se_{0.5}$) due to doping of Se.

Key words: PbS_{1-x} Se_x, semiconductor, chemical bath deposition, thin films

Cultural Attributes to Sustainable Energy Proficiency in Cameroon

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Globally, utmost efforts to energy and water sustainability are enthralled towards technological improvement and innovation; meanwhile the social dimensions, people's practices and perception towards the achievability of these innovations should be at the epicenter of energy policy. In most cases, innovation and energy efficiency technology faces rigid resistance from people's culture, because each culture over the years develops and inherits its own technology and would not easily adhere to alterations. In Cameroon today, 3 out of 4 rural dwellers uses wood as a source of heating, because a study revealed that in most cultures, renewable energy is for the rich (Tim 2016). This partly explains why only 1% of Cameroon's renewable energy potential is used, albeit Cameroon's wide renewable energy resources of 200 mil BBL (2011 est.). The method used in this study is a search in major databases including Open Energy Information (OpenEI), Global Energy Statistics, EUROSTAT and Google scholar; with the search phrase being sustainable energy, energy proficiency and culture. The study also includes a review and clinical analysis of cultural perceptions and the cultural beliefs on the practicability of sustainable energy in Cameroon. To discern cultural attributes to the implementation of renewable energy in most rural dwellings in Cameroon, qualitative and quantitative methods were used, with the administration of 200 questionnaires, semi-structured interviews in more than 22 institutions (including traditional palaces, community based organizations, regulatory agencies, interest groups, energy systems manufacturers, nonprofit organizations, consulting firms, universities, national laboratories, and state institutions) for a period of 1 year. The study revealed that albeit the low utilization of Cameroon's renewable energy and portable water potentials, most local cultures exacerbate the situation as they perceive renewable energy as a holdup and alteration to their traditional practices. This paper thus proposes an in-depth study of the detach between renewable energy production and how it is culturally perceived, before any energy implementation policy. We also proposed that the Long term Energy Sector Development Plan (PDSE 2030), Vision 2035 should be deciphered and popularized for local cultures to see its importance and embrace it.

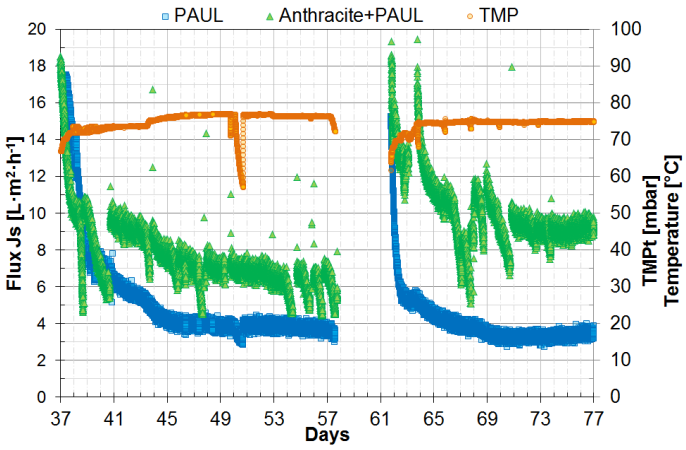
Key words: Renewable energy, cultural beliefs, Cameroon, innovation

Anthracite Filtration as Pre-Treatment for Membrane-Based Decentralized Water Systems; a Chemical Free Small-Scale Systems to Provide Safe and Affordable Water in Rural Areas with Polluted Water

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The ultra-low-pressure ultrafiltration process (ULP-UF) aims to be a suitable and feasible solution to be used as decentralized drinking water treatment plants in remote and rural areas worldwide, since it is easy of handle and requires no chemicals and energy consumption during its operation. When treating water with high content of natural organic matter (NOM, mainly Biopolymer and Humic Acids), ULP-UF modules face operational and maintenance problems due to particulate and organic fouling. Pretreatments for ULP-UF membranes in long term operation and with the identification of the major membrane foulants have been already proposed [1]. A pilot plant based on Anthracite Filtration as pretreatment and ULP-UF as main treatment was operated at the University of Kassel. The results show that Biofiltration by using an anthracite filter is a worthwhile and effective pretreatment process for the reduction of membrane fouling and the decreasing of operational maintenance in the ULP-UF.
During experiments, two PAUL units were put into operation. PAUL is a very simple, robust and small gravity driven membrane unit utilizing the "Ultra Low Pressure Ultra Filtration (ULPUF)" process. PAUL is composed of an ultrafiltration module unit, PES material and MWCO of 150 kDa.
The first PAUL was fed directly with raw water while the second one was fed with pre-treated water. For the second PAUL, the raw water was pre-treated by an anthracite filter
Theoretically, PAUL can deliver 1,200 Liter per day nominal. When using anthracite filter as pre-treatment step, the flow could be increased almost at double. Figure below shows the flux of PAUL without and with anthracite as pre-treatment.



This study shows that the ultrafiltration at very low pressures (ULP-UF) can be installed together with a pre-treatment of easy maintenance to increase the flux. In this way, an ULP-UF can be part of a decentralized small scale system to treat water for remote and rural areas with very polluted raw water sources in terms of organic matter.

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Effect of Annealing and Surface Passivation on Optical and Electrical Properties of Pd-F:SnO_2 Films Prepared by Spray Pyrolysis Technique

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Pd-F:SnO_2 thin films have been prepared by spray pyrolysis technique using an alcoholic precursor solution consisting of stannic chloride ($SnCl_4.5H_20$), ammonium fluoride (NH_4F) and palladium chloride ($PdCl_2$). Optimization on the deposition parameters has been done in order to obtain high quality thin films. The effect of varying the fluorine content on the optoelectronic properties of Pd-F:SnO_2 thin films was studied. Data for transmittance and reflectance in the wavelength range from 300 nm – 2500 nm was measured using the solid spec 3700DUV spectrophotometer. Electrical characterization of the thin films was done using the four point probe method at room temperature. Post deposition treatment of the thin films by annealing in air and then passivating in nitrogen gas environment was done in a tube furnace at 450 °C. Sheet resistivity for Pd- F: SnO_2 was found to be 0.0271Ωcm (at 0 at% F doping in Pd:SnO_2) and 0.000164 Ωcm (at 16.04 at% F doping in Pd:SnO_2) being the highest and lowest sheet resistivity respectively. Optimization on the F dopant concentration in preparation of Pd-F:SnO_2 thin films led to a decrease in the sheet resistivity of Pd-F:SnO_2 thin films which is due to substitutional incorporation of F ions instead of oxygen ions into the crystal lattice of Pd:SnO_2 thin films which increases free carrier concentration. The effect of annealing generally was found to improve on the electrical conductivity of the thin films which is due to increase in carrier mobility and density. Passivation on the other hand had a slight opposite effect. Calculated band gap energy for Pd-F:SnO_2 thin films was 4.2289 eV (at 19.28 at% F doping in Pd:SnO_2) and 4.0143 eV (at 16.04 at% F doping in Pd:SnO_2) being the highest and the lowest calculated band gap energies respectively. Effects resulting from annealing and passivation of Pd-F:SnO_2 thin films calculated band gap energy and their transparency was quite insignificant rendering the doped SnO_2 thin films good choice for making a transparent thin film gas sensors.

Adapting waste mango seed shells for adsorptive water treatment

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In the quest for sustainable water treatment technologies especially in the context of developing nations, the use of waste agricultural products as adsorbents has been widely proposed [1].

However, when applied in their natural state, lignocellulosic adsorbents often exhibit low metal ion sorption capacity and their soluble components tend to leach and raise the chemical oxygen demand of treated water [2]. This study explores the use of waste mango seed shells and adapts them for heavy metal removal by base washing and treatment with ethylene diamine tetraacetic (EDTA) dianhydride. Surface modification was confirmed by Fourier transform infra-red spectroscopy, elemental and thermogravimetric analysis. The mango seed shell adsorbents was tested for removal of Pb^{2+} from synthetic aqueous solutions through batch adsorption experiments. The Langmuir and Freundlich models were used to simulate the adsorption isotherms, the latter providing best fit to the experimental data. Langmuir maximum adsorption capacities of 59.3 $mg.g^{-1}$ and 306.3 $mg.g^{-1}$ for base washed and EDTA treated adsorbents, respectively.

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Electroanalysis of Organo-Chalcogenide Perovskite Nanomaterials

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Organo-lead halide perovskites are one of the most promising candidates for use in the production of next-generation solar cells. The generic perovskite structure, ABX_3, allows the synthesis of a broad range of perovskite materials by the simple modification of the building blocks A, B, and X (A = organic group, B = metal and X = halide). The preparation of solar cell materials based on methylammonium lead halides, $CH_3NH_3PbX_3$ (X = Cl, Br, and I), has been reported. These mixed halide systems are solution-processable and have tuneable optical properties. The optimal bandgap for single-junction solar cell materials is known to be between 1.1 and 1.4 eV. However, the bandgaps of methylammonium lead trihalide ($CH_3NH_3PbI_3$ or MALT) perovskites are beyond this range. In this study the bandgaps of MALT perovskites were modulated by the incorporation of the nanomaterials of chalcogenide (S, Se and Te) ions into the perovskites. The electrochemical, electronic and band-gap properties of the chalcogenic MALT perovskite nanomaterials were studied by electrochemical impedance spectroscopy (EIS), cyclic and square wave voltammetries, ultraviolet/visible spectroscopy and photoluminescence spectroscopy. The microscopic properties of the materials were interrogated by high resolution scanning electron microscopy (HRSEM), high resolution transmission electron microscopy (HRTEM) and atomic force microscopy (AFM); while the composition, particle size and structure of the materials were confirmed with X-ray diffraction (XRD) measurements.

Key words: Bandgap modulation, chalcogenide nanomaterials, methylammonium lead halides, mixed ions perovskites.

Development of Biodegradable Nanocomposites for Water Remediation

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Conventional water treatment methods do not remove dissolved trace levels of pollutants such as heavy metals, microorganisms and halogenated compounds like pesticides. This work describes the use of nanocomposites that employ both photoremediation and adsorption in the removal of selected microbial, inorganic and organic pollutants. The nanocomposites were fabricated by process of electrospinning of selected biopolymers which were mixed with doped titania to generate nanocomposites. The removal of organic polutants was achieved through photooxidation while the removal of heavy metals was achieved through adsorption process. These nanocomposite materials were characterized for structure, morphology and surface area. The removal efficiency of pollutants was characterized using adsorption and desorption kinetics and as well degradation profiles of organic pollutants using HPLC.

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Overview of Nanotechnology Applications for Water Treatment in Mexico

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Nanotechnologies are part of a new industrial platform able to surpass current tech-intensive water treatment alternatives. Accordingly, many countries apply nanotechnology-based processes to solve problems associated with water. The authors of this investigation review the state of nanotech applications for water treatment in Mexico. To this purpose, they follow the trajectory of the nanotech package; from its research and development to its commercialization. They applied a bibliometric analysis (publications), created a database with all the research groups looking at this issue, developed a catalog of all related patents and, finally, located some

Mexican nano-companies in the water sector. The authors provide a general outlook of the nanotechnology water treatment value chain in Mexico. At the same time, they raise some concerns regarding the lack of linkage between R&D and manufacturing; and the prevalence of foreign companies in the patenting process.

Public Engagement with a Nanofiltration Plant

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Although nanotechnologies are widely used in water purification, most of the applications are at a small scale, particularly at household level where only a few litres of water are treated. This paper explores a nanofiltration plant that travelled to a remote village of Madibogo (South Afria) in 2005 and has been operational since then. The plant is used at a community level to produce 10 000 litres of potable water per day. The technology evolved to become an integral part of the Madibogo community, although it generated a lot of controversy when it was installed in the village. It reached the stage of closure and stabilisation as articulated in the Social Construction of Technology (Pinch and Bijker, 1987) after the controversies that characterised its implementation were resolved through public engagement and making adjustments to the technology. This paper uses the lens of public engagement on the case study to show how technologies travel to the users and get entrenched in society. The key question to which this paper is anchored is: What role does public engagement play in the travelling of nanotechnologies? Focusing on the case study of the nanofiltration plant, the paper unravels the mechanisms that were used to engage the community until there were no more grey areas on the technology. Such an analysis of the nanofiltration plant provides an interesting arena for investigating the role of public engagement towards the acceptance of emerging technologies that travel to new sites.

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Structural Modifications/ Defect Creations on Graphene-Metal oxide Surfaces through Microwave Heating and Their Application for Electrochemical Energy Storage

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With the rapid development of the global economy, the depletion of fossil fuels and increasing environmental pollution, there is an urgent need for efficient, clean, and sustainable sources of energy, as well as new technologies associated with energy conversion, storage and also for cheap and simple synthesis route. Graphene based metal oxide hybrids as electrodes have attracted much research interest due to their positive synergistic effects of supercapacitors (SCs) as pseudo-capacitance and electric double-layer capacitance (EDLC) between graphene and metal oxides. The graphene oxide containing dispersed metal oxide nano-particles in the form of anchored, wrapped, encapsulated, layered, sandwich and mixed structures using different metal by adapting microwave irradiation are most useful method for rapid synthesis with minimum requirement of power and energy. From the viewpoint of structure, on one hand, metal oxides anchored, wrapped, encapsulated, layered, sandwich, mixed structures etc. with mechanically confined by graphene oxide not only suppress the agglomeration and re- stacking of graphene nanosheets but also increase the available surface area of the graphene oxide alone, leading to high electrochemical activity and measure their application for energy storage (supercapacitors). Several The syntheses of graphene-based metal oxide hybrids for enhanced capacitance originating from increased electron transport protected restacking of graphene sheets, high surface area, and efficient electrolyte pathways.

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Disinfection of Water for Human Consumption using Solar Radiation

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People living in rural communities are the population sector most affected by hydro-transmissible infectious pathogen agents. The use of solar radiation for water disinfection has proven to be an efficient technique for the inactivation and destruction of pathogenic bacteria [1]. In this study, the efficiency of the solar energy based water disinfection process was determined using water from contaminated sources in rural communities from Mexico [2]. The performed tests consisted in studying the effect of disinfecting water by direct exposure to sunlight during the whole day, with and without solar concentrators, in plastic bottles of commercial beverages. The study shows that, in rural communities from this geographic zone, the available water must be disinfected before consumption. Disinfection efficiency reached 100% efficiency with the use of solar radiation. It was found that, a complete disinfection takes place by simply placing water bottles in the sunlight during the whole day (Fig. 1). However, the use of solar concentrators and bottles partially painted black increases the disinfection efficiency and reduce the solar exposure time to 2 h. Results shows that this technology is very well suited for rural communities of low income, which do not have access to standard water purification systems, do not boil or chlorinate water, and are only interested in treating the water required for their daily consumption.



Fig. 1: Solar Water Disinfection.

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Wastes Valorization and Renewable Energies in Chad

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In this paper, we show, how sugar industry's wastes are valorised in producing biofuel namely Ethanol. These wastes are used in agriculture and road managing.
We show the pertinence of photovoltaic production of electric energy and the use of Photovoltaic devices in rural areas of Chad.
Furthermore, we propose what we call Integrated Energy Production Systems (IEPS). Many researchers in the field were concerned by the accumulation (Batteries) issue. A solution is to combine Photovoltaic, Hydraulic /Eolean (wind) and biomass systems avoiding thus, the problems of energy storage.

Key words: valorisation of industries wastes, Integrated Energy Systems, biomass, photovoltaic.

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Metallic Iron Treatment of Drinking Water

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Metallic iron (Fe^0) is effective in reducing the level of aqueous biological and chemical contamination. Water is passed through a layer containing filamentary or granular Fe^0 to reduce the contamination level. Removed species include harmless taste- and odor producing chemicals. This oral presentation discusses the principles and processes of typical Fe^0 filtration systems.

The water treatment industry is increasingly concerned about chemical contaminants that cannot be removed by water softeners or conventional filtration. Typical sources of contamination include agricultural, domestic, industrial and mining wastes. Undesirable chemicals also originate from water pipes and joints (e.g. iron, lead), natural decay (e.g. Ra from U) and/or the water treatment chain. As an example, the reaction of chlorine with dissolved organic matter during the chlorination of drinking water can produce other compounds such as trihalomethanes (THMs; by-products). THMs have been demonstrated to increase the risk of certain cancers.

Campers, hickers, international travellers, military personnel often face the difficulty for microbially safe drinking water source, This situation is exhaberced in developing nations and during emergency situations (e.g. flood, heartquakes, hurricanes). The difficulty of transporting large quantities of water is obvious. It is thus essential to develop affordable, chemistry-free technologies, using indigeneous materials to provide chemically and microbially safe drinking water. Such technologies would have the unique advantage of deserving both indigeneous population and travallers.

The suitability of Fe^0 filters for safe drinking water provision at several scales (e.g. hospitals, households, schools, small communities) will be presented. The author has being coordonating the efforts for efficient Fe^0 filters during the last decade. The presentation will summarize the state-of-the-art knowledge and discuss some tools currently tested in less equiped laboratories.

The presentation will insist on the importance of water quality assessment by accredited laboratories for public health. If the level of any contaminant exceeds the maximum concentration level (MCL), treatment must be undertaken. Private water systems must be tested at the owner's initiative to determin whether treatment is needed. The efficiency of (new) treatment systems should be analytically assessed as well.

Preliminary Investigation on the Seeds of *Cerathoteca sesamoids (LALO)* and *Corchorus tridens (KALKASHI)* as Coagulants for Water Treatment

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This paper investigates the coagulating activity of some plants (*Corchorus tridens* and *Cerathoteca sesamoides)* for water treatment using Jar-test analysis. Physical analysis showed that the turbidity of the treated water with alum, treated water with alum-*Corchorus tridens,* treated water with alum-*Corchorus tridens- Cerathoteca sesamoides* are 18NTU, 2NTU, 24.2NTU, the pH are 5, 6.8, 5.4 and the conductivity are 186µs, 185µs, 195µs respectively. Chemical analysis showed that the treated water with alum, treated water with alum-*Corchorus tridens*, treated water with alum-*Corchorus tridens- Cerathoteca sesamoides* has calcium content of 1.4mg/L, 1.5mg/L, 1.6mg/L, chlorides contents of 0.3mg/L, 0.37mg/L,0.39mg/L sodium contents of 12mg/L, 13mg/L, 13mg/L and the Bicarbonates contents are 0.8mg/L, 0.5mg/L, 0.8mg/L respectively. From the results, it showed that *Corchorus tridens* at optimum dosage (150mg/L) reduced the turbidity from >1000NTU to 545NTU. While at this concentration *Cerathoteca sesamoides* remains ineffective to turbidity removal. It also showed that *Corchorus tridens* when coupled with alum at optimum dosage of 85mg/L alum and 160mg/L *Corchorustridens* has the tendency of reducing the turbidity from >1000NTU to 2NTU at a pH of 6.8. While the *Cerathoteca sesamoides* does not have any coagulating activity .But instead it hindered the activity of alum when added together.

Effect of NiO/SiO_2 on Thermo-Chemical Conversion of Waste Cooking Oil to Hydrocarbons

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Increase in organic waste generation, dwindling nature of global oil reserves coupled with environmental challenges caused by waste oil disposal and burning of fossil fuels necessitated the need for alternative energy resources. Waste cooking oil obtained from frying fish outlet was analyzed for its physicochemical properties using ASTM D-975 methods. Acid and Iodine values of the oil were 30.43±0.32mgKOH/g and 57.08±0.43mgI_2/100g respectively. Thermo-chemical conversion of the oil using NiO/SiO_2 at different reaction conditions (pressure, temperature, catalyst concentration) at a residence time of 3 hours yielded 33.63% hydrocarbons. Hydro-catalytic pyrolysis of waste cooking oil at 400 °C, H_2 pressure of 15 bar, and catalyst to oil ratio of 0.25g/100cm^3 give the optimum hydrocarbons yield (41.98%). The fuel properties of the product were: cetane number (71.16), high heating value (41.43mj/kg), kinematic viscosity (2.01mm^2/s), density (0.94g/ml), saponification value (185.1±3.96mgKOH/g), and iodine value (20.57±0.20I_2/100g) respectively. These results show that the NiO/SiO_2 could be a suitable catalyst for conversion of waste vegetable oil to hydrocarbons.

Production of Briquettes from Charcoal Fines: A Source of Solid Fuel

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Currently only 41.5% of Zimbabwean population has access to electricity resulting in the balance of the population relies on alternative energy source for cooking, with the use firewood accounting for 63% of the alternative [1]. At the same time Zimbabwe is endowed with wattle trees, whose waste can be carbonized to charcoal [2]. During the packaging and transport, charcoal, fines are generated as waste and these pose a hazard to the environment. This work looked at the feasibility of converting charcoal fines to briquettes for application as cooking fuel. Charcoal fines were first ground and then mixed with a binder in the ratio 10:1. Water was then added to make a pulp which was densified using a pressing machine. The charcoal briquettes produced had a heating value of 22-30 MJ/kg. The briquetting allowed the production of smokeless and dustless charcoal briquettes which can effectively be used as a source of energy for cooking purposes [3]. Potential of utilising the waste charcoal fines into bio-adsorbents for waste water treatment is also being investigated.

Fig 1: Charcoal briquettes from charcoal fines

Key words: Briquettes, charcoal fines, cooking, waste management

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Application of ECO Cook stoves in the Sub-Sahara Africa: A Review

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The use of cook stoves is increasingly becoming popular in the Sub Sahara Africa mainly due to the fact that 50% of the population are living off the grid and also that the users are becoming more energy conscious. Eco friendly cook stoves promote energy conservation due to their robust design. Design parameters such as the heat transfer, material of construction, thermal and combustion efficiency are important when selecting an Eco cook stove. The value chain for the distribution of the cook stoves to commercialization (Figure 1) is also of utmost importance.

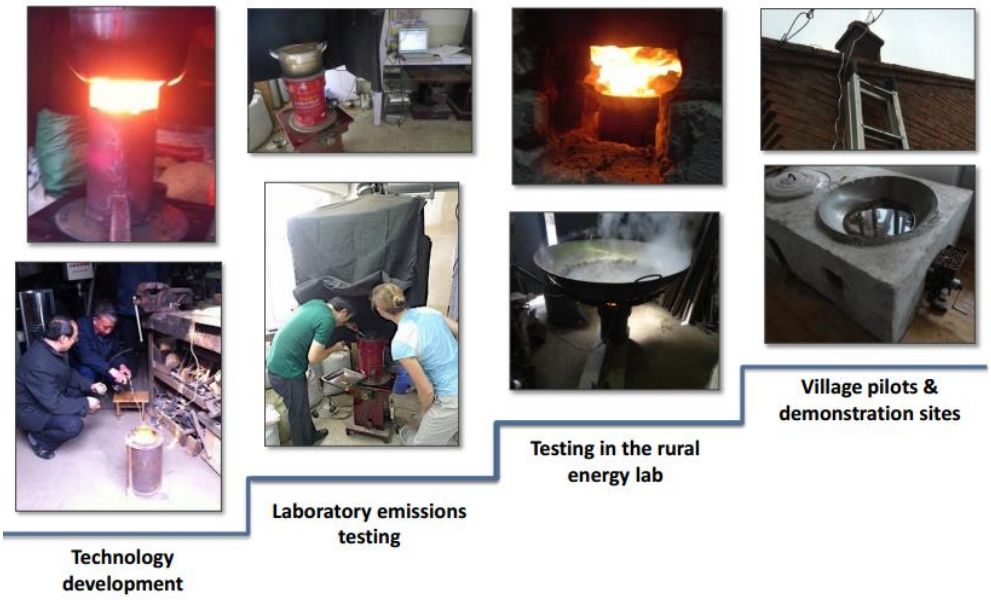


Figure 1: Eco cook stoves stages to commercialization (https://www.epa.gov/sites/production/files/2015-08/documents/baumgartner.pdf)

Keywords: Design parameters, Eco cook stoves, energy management, off-grid communities

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"Solar Cooking and Gender Entrepreneurship"

Women and Solar Restaurant

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I represent a country from South America south cone. The project that I am going to tell you about today, takes place in a little rural town, in the border of Atacama desert, 60 km near city La Serena 29°54 S in latitude and 71°15' W.
One of the world's areas richest in solar power is also found in the northern part of Chile.
In Chile, firewood comes second only to oil in terms of energy use. It makes up 20% of the primary energy in the country.
I will present a story about how solar technology, in particular different prototype and innovative technology on solar cookers, led a group of women from the country-side with few economic means to open the first solar restaurants in Chile. These restaurants originally opened 25 years ago, and have allowed the women to provide for themselves, independently, ever since.

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Solar cookers & public policy

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In development countries projects, solar cookers are artifacts that point to solve problems associated with communities energy access, which are mainly rural .
Solar cookers present continuity of operation problems, night/day, cold weather, rain and cloudy skies. Its applicability is climate and culturally restricted.
However, in high lands, mountains areas, semi – desert, intertropical, they are an interesting tool to replace firewood consumption.
The intensive use of firewood, affects nearly 2,000,000,000 human beings on the planet. Increasing desertification, affecting the water regulation and biological ecosystems sustainability, increases domestic pollution and associated diseases. Of course, it affects the greenhouse effect and global warming.
For all the above situations, countries should develop and implement public policies, especially in developing countries .
According to the above, solar cookers and solar ovens are not the main objective of development programs, the goal is to achieve public policy realization, and within them, in certain territories and cultures, solar cookers and solar ovens have an important role to play.
Therefore, dissemination strategy for solar cookers and solar ovens, must focus on public policies, in which solar cookers and solar ovens can be part of the problems solutions.
It is necessary to consider that, for solar cookers future , beyond projects disseminating them, it is important that these projects are associated with larger public policy context .

Hydrogen Sulfide Removal from Biogas by Manganese Dioxide Octahedral Molecular Sieve

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Biogas is a promising alternative energy though some of its components are harmful including H_2S. H_2S causes health problems including loss of consciousness and death. It causes acid rains and changes soil pH. Since it is acidic it tends to corrode metallic instruments and concrete. For these problems it is therefore necessary to remove H_2S from biogas before its utilization. Single-doped Octahedral Molecular Sieves (OMS-2) waere synthesized using precipitation and reflux methods then part of the samples obtained were calcined at 300°C. $Fe(NO_3)_2$, Na_2MoO_4, and $ZnCl_2$ were sources of Fe, Mo, and Zn dopants to OMS-2, respectively. The doping process was at different ratios ranging 2.5 to 25 % of the doping element weight to Mn total weight. XRD patterns confirmed that the nanomaterials produced are OMS-2 since they follow the patterns of natural occuring OMS-2. SEM micrographs show the deformation of rod shapes of undoped OMS-2 by the doping elements. As the percentage of the dopant increases the rod shapes becomes more deformed. The samples were then used as catalytic oxidants towards H_2S from biogas. Fe doped OMS-2 had best catalytic oxidation for H_2S followed by Mo-OMS-2 and Zn-OMS-2. In 5 min the oxidation was 100, 96.3, and 90.5 % and after 2 h it was 75, 59.3, and 52.4 % respectively for the mentioned samples at 10 % doping percentage. The oxidation also increased as the amount of dopant was decreasing. In case of 2.5% Fe doped OMS-2 had a good catalytic oxidation of 86 % with a SC of 124.8g/100g after 2 h whereas 76, 70, 68, 60, and 45 % removal were obtained with samples doped at 5, 10, 15, 20, and 25 %, respectively. Increase of catalyst mass and decrease of gas flow rate during the process increased the oxidation of H_2S. This indicates that doping of OMS-2 increases its efficiency as a catalytic oxidant but the doping ratio must be kept low. For this case Fe serves as the best choice as a dopant to OMS-2 for H_2S oxidation.

Characterizing the Efficiency of Steel Wool for Water Treatment Using the MB Discoloration Method

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The achievement of the UN SDGs requires new affordable and efficient water treatment technologies applicable at small scale. In the past 15 years, filtration on packed-beds of metallic iron (Fe^0) was been identified as such an appropriate technology. The present work (oral presentation) discuss results of characterizing the suitability of commercially available steel wool (Fe^0) from the market place of Douala (Cameroon) as reactive filler for water filters using a new protocol. Seven steel wool (SW) samples were characterized in preliminary works and three (SW1, SW2 and SW3) were selected for long-term in column studies. In individual experiments, 1 g SW (100 % Fe^0) was sandwiched between 6 cm upper coarse sand and 3.5 cm lower fine sand. A 2.0 mg/L methylene blue (MB) solution was gravity fed through the columns. 80 mL of the MB solution was filtered through individual column on a daily basis for 3 months. The columns were characterized by changes in (i) the hydraulic conductivity (permeability), (ii) the effluent MB level and the Fe concentration. Results clearly showed (i) quantitative MB removal (> 95%), and (ii) limited Fe release for the three columns. The Fe levels were rarely up to 2.0 mg/L after about 2 months. The most significant difference was observed in the hydraulic conductivity evolution and was attributed to the difference in the SWs filaments widths. The finest grade SW2 exhibited the most significant permeability loss and thus was subject to total clogging after 2 months. Results confirmed the reliability of the tested protocol to assess the efficiency of Fe^0-bearing materials in long-term column experiments. Results also confirmed the potential of reactive SW as a low-cost, readily available material for decentralized safe drinking water production. Higher widths (> 50 mm) reactive SWs are recommended for long-term efficient Fe^0 filtration systems. All three tested materials should be chopped and admixed with sand for further tests.

Key words: intrinsic reactivity; methylene blue; steel wool; treatability studies; water treatment; zero-valent iron

Natural Thermal Energy Storage Material from Laterite Stone for Concentrated Solar Thermal Power Plan in West Africa

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Concentrated solar power (CSP) technologies are under extensive development in Africa but still suffer of lack of adapted thermal energy storage materials (TESM). According to today constraints, the storage approaches developed during the eighties do not mach all the current environmental, technical and regulation standards. In this context, only natural or recycled materials could be really considered as a long term sustainable solution without conflict of use for African countries [1]. Under those constrains, local natural material as laterite stone, which is widely available in Burkina Faso and in half of the continent have been identify and select as potential TESM for CSP application in the WAC. In the present paper, the potential of laterite to be used as a thermal storage material in concentrating solar power plants is investigated and experimental results are presented. Changes in phase composition and morphology caused by heat treatment were exanimated using X-ray diffraction (XRD) and scanning electron microscopy (SEM) associated of energy dispersion spectroscopy (EDS) analyses. Thermal behaviours were also study by using coupled thermo-gravimetric (TG) and differential scanning calorimetry (DSC) analyses. The minerals phases detected by XRD in the originals ores include kaolinite, goethite, hematite and quartz. Fe-spinel ($MgAl_{.79}Fe_{1.21}O_4$) with inclusion of repetitive structure of dendrites of magnetite (Fe_3O_4) was observed with EDS for the melt samples (LADA1 and LADA2) after heat treatment at 1100 °C. Mullite ($3Al_2O_3$, $2SiO_2$) and hematite (Fe_2O_3) were found in all the samples (LADA1, LADA2, LADA3, LADA4) sintering at 1200 °C contains. The TG/DSC analysis shows that the materials are very stable under heat treatment up to 900 °C. Transformation of all goethite (FeOOH) to Hematite could help to enhances thermal conductivity the elaborated materials. Mullite and spinel phases have demonstrated elsewhere to lead to refractory ceramics relevant for high temperature thermal energy system applications [2]. A new way for manufacturing a low cost dense ceramic which can compete with industrial ceramic (cost between 4500 and 8000 euro per ton) is performed at small scale. The obtained material can be used as sensible TESM for many kinds of the CSP processes (from low up to high temperature) with properties in the same range than other available materials nevertheless with lower cost and without conflict of use.

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Solar Receiver Design for CSP4Africa

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CSP4Africa is a project that aims to develop a 100 kWth central receiver system in 2iE in Burkina Faso. This paper deals with the design and manufacturing of the solar receiver of the power plant. The receivers of central receiver systems can be classified in three groups [1] : volumetric [2], tubular [3] and particle [4] receivers. The first ones are used for high temperatures CSP (>900°C) and did not demonstrated sustainability in various tests whereas the last ones still in the research phase. Most of the solar receivers used in the world are tubular and can be classified in two groups [3] : external [5] and cavity receivers [6].
In the case of CSP4Africa, a cavity tubular receiver is chosen and a cylindrical geometry is set as shape. Helical coil is used as absorber and located inside the cylindrical cavity.
The modelling method used in this study is based on the use of view factors for radiative exchange. An energy balance is written on every coil which is supposed to receive radiative energy from the incident flux, ambient atmosphere and the inner surfaces of the cavity, and at the same time, coil emits radiation flux towards these inner surfaces and the atmosphere. An energy balance is also written in every volume of the heat transfer fluid of each coil.
It is considered that the receiver operates in stationary mode. The optimization process takes into account the operation temperatures as constraints. Optimization variables considered were the number of the coils (height of the cavity), the inner diameter of the coil, the nature and mass flow of the heat transfer fluid. The exergy analysis led to optimal parameters of the receiver. Thereafter, the component was manufactured by a local enterprise.
Laboratory tests were conducted in a closed room (off-wind conditions) to determine the global convective heat losses coefficient, with is later used to extend the design model.
A non-stationary model, which integrates the variation of the solar irradiation, is derived from the previous stationary model. The simulation showed the trend of the temperature of the heat transfer fluid at the receiver's outlet according to incident flux.

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The Phytochemical Compositions and Characterization of Anthocleistavogelii Cell and Nymphaea Flower (Osibata) Dye Sensitized Solar cell

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The Phytochemical compositions and characterization of Anthocleistavogelii was determined and compared. Standard methods of analyses were employed. The phytochemical analysis reveals the presence of phytoconstituents such as flavonoids, volatile oil, tannins, saponins, thus suggesting presence of compounds that could be useful as dye for smart windows. These dyes were mordanted with Alum, potash and sodium chloride for fastening of the colours. The exhibited low absorbance and high reflectance at transmittance set at 400 nm when studied using UV/VIS spectruphotometer between 400 nm and 1000 nm wavelength i.e. within the visible range of light in the electromagnetic spectrum. These indicated suitability of the leaf-extracts from the studied plants for growing environmentally friendly dye compounds that could be used for smart windows.

Key words: Natural Dyes, Anthocleistavogelii, Phytochemical Analysis

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Fabrication of $TiO_2/Cu_2ZnSnS_4/Al_2O_3$ /Ag for thin Film PV Applications

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Due to the challenges posed by silicon, CdTe and CIGS cells, new emerging materials have been discovered. The kesterite compound, Cu_2ZnSnS_4 (CZTS) has been the centre of interest to many scientists. CZTS is an earth abundant, cheaper, nontoxic alternative to the other chalcogenide compounds such as CdTe and $CuInGa(S,Se)_2$ (CIGS). In addition its direct and tunable band gap energy, high optical absorption coefficient make it a good candidate for its application as an absorber. CZTS has been prepared using vacuum and non-vacuum solution deposition methods. Highest recorded efficiencies for vacuum deposition is 8.4% and via solution route 10.1% (Ramasamy et al., 2012). In a recent report a CZTSSe cell was fabricated with an efficiency of 12.6% using hydrazine pure solution (wang et al., 2013)

In this current research CZTS will be deposited by SILAR route i.e Successive ionic layer adsorption and reaction method. SILAR is one of the chemical methods for making uniform and large area thin films, which is based on immersion of the substrate into separately placed cations and anions. Al_2O_3 layer will be used as a back surface field (BSF). Al_2o_3 is found to have a high negative fixed charge of the order 10^{12} A band gap gradient is formed in the absorber near the back contact by increasing the conduction band edge towards the back. This creates a BSF that help reflect minority charge carriers (electrons) away from the back interface.

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Design and Development of Rice Husk and Charcoal Dust Gasifier Stoves in Uganda

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Today about three billion people still depend on fuel wood, charcoal, agricultural waste and animal dung to satisfy their daily needs for cooking and heating (Ekouevi and Tuntivate, 2012; WHO, 2014). Ninety percent (90%) of Uganda's energy needs is derived from biomass and it is estimated that a forest surface of about 115 football fields is used for cooking every day either in form of firewood or charcoal (Adeyemi and Asere, 2014). As such, there is a continued threat to plant life and resulting climate change. There is also the problem of indoor air pollution (IAP) due to inefficient burning of the biomass in open air and primitive stoves. In Uganda and estimated 19,700 die annually due to household air pollution caused by inefficient burning of solid fuels. To fight these situations, there is need to find a technical cooking solution that: (1) renders useful alternative and sustainable sources of energy for cooking apart from trees, (2) provides clean and efficient burning for IAP control, (3) is low-cost and affordable to the locals. In this work we are developing two improved cook stoves that use crop residue waste (rice husk) and charcoal dust respectively. The cook stoves are top-lit updraft (TLUD) that use gasification technique to release syngas that is completely combusted at the burner with blue flames and zero smoke. Gasification is aided by 0.32 A, 12 V electric fans installed on the cook stoves. Results of prototype tests for the rice husk gasifier stove show fuel consumption rate of 2.22 kg hr^{-1}, specific gasification rate of 125.75 kg/m^2hr, combustion zone rate of 1 m hr^{-1}, water boiling time of 480 s and thermal efficiency of 10%. Our next step in the research is to improve the thermal efficiency, maximize insulation and minimize carbon monoxide (CO) and particulate matter (PM) emissions of the cook stoves. This will require use computational fluid dynamics (CFD) for material property tests and selection and also simulation of air flow regime, heat transfer, pyrolysis and combustion in the stove reactor will be carried out.

Key words: cook stove, rice husk, charcoal dust, gasification, sustainable energy

The Effect ofAaccumulated Dust on the Performance of Photovoltaic Modules

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Photovoltaic (PV) systems are one of the most promising renewable energy sources in the world, and hence it is important to explore the factors that affect the working /operational efficiency of this source. Accumulation of dust on the panels of solar photovoltaic (PV) system is natural and this accumulated dust can reduce the performance of solar panels, the objective of this research was to study the effects of dust accumulation on the performance of solar PV panels. Experiments were conducted using dust particles on solar panels with a constant-power light source indoor to determine the resulting electrical resistant, voltage and power generated. It was found from the study that the accumulated dust on the surface of photovoltaic solar panel can reduce the system's performance for about 20% with time.

Key words: Dust, Solar photovoltaic panel, photovoltaic effect, halogen lamp

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The Utilization of Solar Energy as Cooking Option in Rural Area

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The high consumption of wood fuel is lead to environmental degradation due to deforestation and scarcity of firewood. The use of fossil fuels such as kerosene and LPG for cooking is very expensive according to Tanzanian life standards. Solar energy is non-consumptive and non-polluting fuel it can help to alleviate the problem of insecurity of cooking energy, which is the major domestic energy requirement. The study shows that solar cooking leads to an improvement of women's perception of their own heath and a considerable time gain which is mainly used for income generating activities and domestic works. There are critical issues yet needed to be addressed in order to make this technology acceptable to our society. They are including getting the appropriate type of solar cookers for specific uses, type of material to be used, optimal design and affordable cost. In order to obtain the results for the mentioned issue a comprehensive study through theoretical review, development work and evolution of solar cookers was conducted. This paper present the results of the study indicate that many of cookers could be used to cook food for household in areas with medium and high insulation with appropriate selection of the type and specification of the cookers. As a guiding tool, reflector cookers offer best comparative performance in areas with longest duration of clear sky, panel and collector cooker under moderate cloudy condition.

Key words: Tanzania, Solar, Rural Electrification and Cooker

Computational Chemistry for a Sustainable Future

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The world is facing challenges in developing an affordable, sustainable and plentiful supply of energy. Tackling the energy crisis issue requires multidisciplinary input from across the scientific landscape; however, the role of chemistry as a central science is important in seeking innovative solutions. We are in an exciting era where computers are becoming more powerful and are widely available. This has led to the development of influential quantum methods that are aiding computational chemists in their quest to develop solutions to the energy challenge. Computational chemistry is playing a significant role in accelerating the required research. Solar cells, one of the most favourable ways to convert solar energy into electricity, were demonstrated for the first time by Bell Laboratory in 1954 with an efficiency of 6%. Since then, major advances have been made in solar cell technology. One of the crucial concerns for the improvement of photovoltaic performance is to enhance light-absorbing capability and to slow the degradation process. In order to design a more efficient solar cell, there is a critical need to understand the different steps in solar cell operation and experimentally it may take years to realise one particular solar cell design. This is where computational techniques come in. Different computational strategies have been used to study the optical and electronic properties of sensitisers, but the *ab initio* method – that is from first principle – has become the method of choice. Computations are currently being used to simulate UV spectra and to predict absorption wavelength and oscillator strength, which aid in determining organic molecules that are active material in the solar spectrum [1]. These theoretical results can also eliminate unfit candidates and provide information for promising structural molecules. Consequently, these data are helpful to experimentalists in their attempts to synthesise these molecules. The HOMO-LUMO gap, an important parameter, can be evaluated so that an efficient charge separated state can be tuned by substituting electron donating and withdrawing groups to the dye-sensitizers. In addition, to overcome the degradation process induced by sunlight, it is essential to gain insight into the chemical reactions in the excited state. This is difficult to study by experiment but the mechanism can be elucidated with the help of quantum chemical computations. From a synthetic point of view, the geometric and electronic structures have a central role in the optimisation of dye-sensitized solar cells. Thanks to Computational chemistry, these parameters can be determined with well-established methods and, therefore, are helpful in the design and improvement of dye-sensitizers that satisfy the needs of solar cell technology.

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Optimal Operation of Hybrid Photovoltaic/Diesel System for Cost Effective Rural Electrification: Case of Bilgo Located in Burkina Faso

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Rural areas in sub-Saharan Africa are regions where only 14 % of the population have access to electricity. Despite many efforts to extend the existing grids to rural areas, most remote areas will not be reached within a foreseeable future. Hybrid PV/Diesel without battery system can be a clean and cost-effective solution for the electrification in those areas[1,2]. However an optimal and smart energy management strategy (EMS) is one of the main key that could guarantee reliability to the whole hybrid energy system with the lowest cost of energy.
This paper presents an optimization and exp called ''Bilgo'' located at Burkina Faso with 135 kW peak load It aims to minimize the operation cost of th erimental analysis for energy management in hybrid photovoltaic/Diesel without battery system using dynamic programming (DP). This approach applied to a rural sub-Saharan Africa village e system which could lead to minimize the levelized cost of energy (LCOE) produced over the system's lifetime (20 years). The results obtained with energy management with DP proposed have been compared to Diesel generator (DG) in standalone. It highlights a reduction in the operation cost, the fuel consumption, the carbon emission and the cost of energy as shown in Table 1.

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Table 1 ***: Comparative results***

	Characteristics of the energy systems	
	Diesel generators standalone : **DG: 150 kW**	Hybrid PV/Diesel system with DP: **PV array : 67.5 kWp DG1 : 100 kW and DG2 : 50 kW**
Operation Cost (k€)	3186	2120
LCOE (€/kWh)	0.43	0.29
Fuel consumption (L/year)	414,655	158,775
Carbon emission (kg/year)	8778.25	6803.6
Solar coverage (%)	0	23

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Photo-Catalytic Water Splitting Using ABX Compound From Computational Approach For Hydrogen Energy System

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Photo catalytic water splitting is an artificial photosynthesis process with photo-catalysis in a photo-electrochemical cell used for the dissociation of water into its constituent parts, hydrogen (H_2) which is a a clean and affordable burning fuel and oxygen (O_2), using either artificial or natural light. Hydrogen fuel production has gained increased attention as oil and other non-renewable fuels become increasingly depleted and expensive. Water splitting holds particular promise since it utilizes water, an inexpensive renewable resource. Photo-voltaics can provide energy directly from sunlight, the inefficiency of fuel production from photovoltaic electricity (indirect process) and given that sunshine is not constant throughout the day sets a limit to its use.[1][2] *Artificial photosynthesis aims to produce a fuel from sunlight that can be conveniently stored and used when sunlight is not available*. With the development of catalysts able to reproduce the key steps of photosynthesis, *water and sunlight* would ultimately be the only needed sources for clean energy production.

This method of sustainable hydrogen production is a key objective in the development of alternative energy systems.[3] It is also predicted to be one of the most efficient ways of obtaining hydrogen from water.[4] The conversion of solar energy into hydrogen via a water-splitting process assisted by *photo-semiconductor catalysts is one of the most promising technologies in development*.[5] There is an increased quantum efficiency of approximately 14% in the hydrogen energy produced when the newly predicted ABX compounds of TaIrGe is used in a photo-electrocemical cell. The water splits under visible light illumination (365–700 nm) for TaIrGe ABX compound predicted by computational technique. This corresponds to the energy band gap range of 3.39eV to 255eV (citation) and is a *p*-type semiconductor. The transparent films of TaIrGe are deposited at room temperature by spray pyrolysis giving a Hall mobility of ~+2730 cm^2/V, which is much higher and hence high water splitting rate. This suggests its potential use for large-scale solar-fuel conversion.

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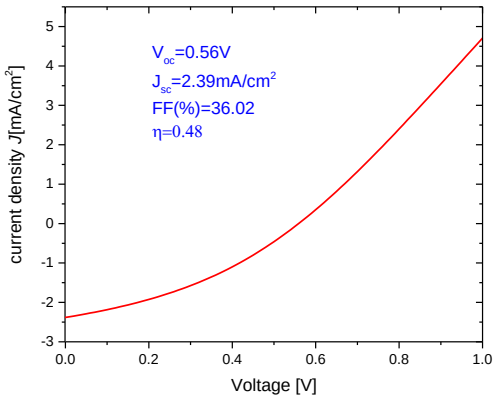
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Characterization of Antimony Sulphide for Photovoltaic Application

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Few types of thin film solar cells have made it to commercial stage due to low conversion efficiency, the variety has been limited by suitable availability of absorber layer. In this work, antimony suphide has been characterized by various techniques for photovoltaic application. This paper reports on optical, structural and morphological properties as well as photovoltaic performance of antimony sulphide by chemical bath deposition technique. The preliminary results shows that the Sb_2S_3 films have a PL peak at 1.65eV and a bandgap of 2.15eV. PDS results indicate that there is a reduction in the density of deep trap states for films deposited with 0.6g $SbCl_3$ and it increases with increase in the bath concentration. Raman spectra indicate that the films have better crystallinity based on the number of peaks. The morphological properties of the films suggest that Sb_2S_3 film growth is by simple ion-by-ion mechanism as seen from the images. The IV characteristics for the solar cell structure has a conversion efficiency of about 0.5% with a potential of achieving better results.

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Effect of Light Soaking on Conversion Efficiency in Solar Cells Based on $In(OH)_xS_y/Pb(OH)_xS_y$

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Light soaking characterization on complete SnO_2:F/TiO_2/$In(OH)_xS_y$/$Pb(OH)_xS_y$/PEDOT:PSS/Au, eta solar cell structure as well as on devices which do not include one or both TiO_2 and/or PEDOT:PSS layers has been conducted. Addition ally, studies of SnO_2:F/$In(OH)_xS_y$/$Pb(OH)_xS_y$/PEDOT:PSS/Au solar cell have been performed. The power conversion efficiency and the short circuit current density have been found to increase with light soaking duration by a factor of about 1.6 - 2.7 and 2.1 - 3, respectively. The increase in these two parameters has been attributed to the filling up of trap states and/or charge-discharge of deep levels found in $In(OH)_xS_y$. These effects take place at almost fill factor and open circuit voltage being unaffected by the light soaking effects.

Key words: Eta Solar Cell; Light Soaking; Conversion Efficiency; TiO_2; $In(OH)_xS_y$; $Pb(OH)_xS_y$

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CdSe Quantum Dots Passivation and Application to Hybrid Solar Cell

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Colloidal quantum dots (CQDs) present several attributes, they combine the solution processability and photon harvesting by matching the band gap to the solar spectrum. In our work we applied the hot injection method to yield CdSe stabilized with tri-n-octylphosphine oxide (TOPO) and hexadecylamine (HDA) with an excitonic absorption at 2.1 eV. Although these ligands are essential during synthesis to preserve the quantum confinement of the nanoparticles, it greatly affects their performance and act as a barrier for charge carrier transport. Tetrabutylammonium iodide (TBAI) is used to replace the original ligands by a liquid–liquid extraction process. An in-depth optical description for the colloidal nanoparticles is outlined to elucidate the particles attitude. The iodide treated CdSe CQDs is then used to improve the performance of P3HT:PCBM solar cell with final power conversion efficiency of 1.7%.

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On the Acceptance of Solar Cooking: The Funnel Concrete Cooker Case

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Solar applications are useful in sunny parts of the world. Despite this fact, the potential for solar cooking is not yet well understood and the technology has not yet been implemented in regions of the world where it could be very useful. The author was “seriously infected with the solar cooking virus” in 2006, when he attended the Solar Cookers International Conference in Granada-Spain. He learned to solar cook using the simple cardboard solar Cookit. He has since built and used a number of solar cookers and has also organized solar cooking workshops and courses on solar cooking technology for schoolteachers. This author has also made presentations on the technique of slow cooking with simple solar cookers at seminars and conferences in several countries. Solar meals are routinely prepared on most sunny days at his home in Algarve-Portugal. Sometimes he prepares solar meals for groups of friends at his home, at restaurants and for colleagues and students at his university campus. He has organized birthday parties in which most of the food served was solar cooked. His dissemination of information and his demonstrations of solar food processing over the past eight years have contributed to the development and the spread of solar cooking technology. Despite the enormous and continuous efforts in promoting solar cooking, solar cooking is not yet a reality in sunny regions of Portugal. Unfortunately just very few fellows are using solar cooking.

A concrete funnel solar cooker, using glass mirrors or appropriate aluminum sheet as a reflective surface, was developed by the author and has been in use since 2010. Some of the main advantages of this slow solar cooker are: its ease of construction in any part of the world, its low cost, the need for only locally available building materials, its ease of use, its practicality and finally the fact that it is water and wind resistant and poses no fire hazard since it cannot reach combustion temperature. Actually there are only three molds in the world, two in Portugal and one in India, for making this cooker. Instructions are available at http://solarcooking.wikia.com/wiki/Celestino_Solar_Funnel_Cooker.

Around ten friends of the author have received a funnel concrete cooker as a gift. According to the feedback only one family is using intensively this cooker and other types of solar cookers. Based on the experiences of the author over the past five years, it is indeed possible to use the potential of the sun to solar cook more than 300 days per year in the southern Iberian Peninsula. Some barriers still exist and need to overcome. Is the human attitude the biggest barrier regarding success of solar cooking?

The main goal of the paper is to present the feedback of users of concrete funnel cooker in South of Iberian Peninsula and pointed out a successful case where important barriers exist and some unsuccessful cases without any apparent major barrier.

Algeria Renewable Energy Program: Obstacles and Solutions

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It is well known that different types of fossil fuels have limited sources in the world. Indeed, our country has a greatest renewable energy potential especialy solar and wind energy. This is the most reasons which led our country to a significant launch program to develop renewable energy over the period of 2011-2030, which aims to produce 40% of the electrical energy consumption in Algeria, with an estimated capacity of 22,000 Megawatts (MW) dedicating 12,000 MW to domestic use and 10,000MW to exports at a cost of $60 US billion [1-3]. In this work, we illustrate the reality of the national program of the development of renewable energies and energy efficiency, by giving somme obstacles that prevent access to the goals, especialy after the oil prices crisis and the weak financial income. Finally we propose solutions to remedy the problem and achieve the objectives.

Key words: renewable energies, the national program.

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Modeling and Sizing of Photovoltaic / Battery Hybrid Power Systems for a Typical Remote Village: A Case Study in Burkina Faso

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In this paper, a modeling and sizing approach of an autonomous photovoltaic (PV) system with battery storage is proposed for a case study situated in Burkina Faso. Photovoltaic and battery hybrid system have been modeled for the electrification of typical rural households and other activities in a remote area of Burkina. The PV systems utilize solar energy to produce electrical energy to meet load demands. A battery device supplies transient power for the selected area when the PV-generated power is not sufficient to cover the load demands. The system is designed to supply power for a village of 10000 inhabitants. Based on socio-economic data and households sample survey, a practical and simple algorithm for load estimation is proposed. A total of 1600 households were interviewed and several infrastructures such as: schools, Health centers, police station etc, were visited during the survey. In order to display the system

effectiveness, simulation studies have been carried out using a global systemic method based on a practical load demand profile and real weather data. The size of the PV array and battery is varied to achieve the optimum configuration for the proposed system. The life cycle cost (LCC) is implemented to evaluate the economic feasibility of the optimized PV system. Based on the current prices of PV modules, the proposed system is found to be economically viable compared to conventional diesel generator system. The potential of mitigating carbon dioxide (CO_2) emissions in the total lifetime of the PV system is also examined.

Key words: Energy management; Life cycle cost; Optimum configuration; Rural electrification; Survey

Characterization of Sn_xSe_y / SnO_2-Ni Prepared by Spray Pyrolysis for Photovoltaic Application

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Nickel doped tin oxide and tin monoselenide thin films were coated using spray pyrolysis. Nickel doped tin oxide Precursor solution was prepared using a 0.05M Tin (II) Chloride ($SnCl_4.2H_2O$) and 0.05M Nickel chloride 6-hydrate ($NiCl_2.6H_2O$) in de-ionized water and then being added in ethanol in the ratio 1:1 to get equal proportions, followed by about 2-3 drops of hydrochloric acid. Doping tin oxide was done using uniform concentration of ($NiCl_2.6H_2O$) of 0-10 %. Precursor solution of tin selenide S_xSe_y was prepared using alcoholic solution consisting of tin chloride $SnCl_2.2H_2O$ and 1,1-dimethl-2-selenourea ($C_3H_8N_2Se$) and then heated while stirring and left for about a week. Samples of (Sn_xSe_y) were made in ratios of 1:0.4 to 1:1.4. Thin films of SnO_2, SnO_2: Ni, Sn_xSe_y and Sn_xSe_y-SnO_2:Ni were deposited on glass substrate using Spray pyrolysis at deposition temperature of 375^{o}C. The samples of tin selenide were characterized by measuring their optical properties using UV-VIS-NIR spectrophotometer 3700 DUV in the range 280nm to 1200nm and were used to calculate solid state and optical properties namely band gap (E_g), refractive index (n) and absorbance (α). The optical band gap of deposited tin selenide ranged between 1.39-2.23eV. The sample of $Sn:Se_{1.0}$ had the highest absorbance of over 46.26% and lowest transmittance of about 44.3% in the VIS-NIR region. The optical band gap of deposited Nickel doped tin oxide ranged between 3.65-3.75eV. The sample of Nickel doped tin oxide of 2% concentration had the highest transmittance of 86.2% and lowest absorbance of about 5.05% in the VIS-NIR region. These properties are suitable for window and absorber layers for application in photovoltaic cell. The diode characteristics such as short circuit current (I_{sc}) = 1.118mA, open circuit voltage (V_{oc}) = 0.607V, fill factor (FF) = 0.6792 and conversion coefficient (η) = 0.4609 % was obtained for Tin selenide (Sn_xSe_y) and nickel doped tin oxide (SnO_2:Ni) solar cell.

Solar Powered Poultry Incubator - Summary of the Product

Kaledawit Esmelealem
ቃል አጠቃላይ ኤሌክትሮኒክስ እና ማሽነሪ ማምረቻ ፓ.የተ.የግ.ኩ
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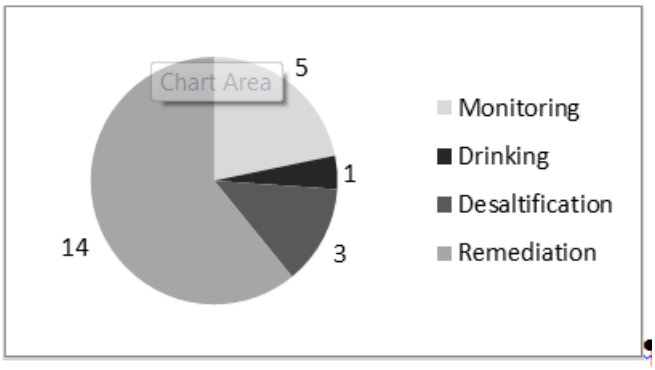
Chicken farming is an important agricultural activity in almost all rural communities of Africa which makes the best use of locally available resource. Though neglected in the development themes for a long time, now a day's many researchers and development agents are coming into consensuses that the smallholder chicken production plays a major role in poverty alleviation and food security at household level.
Correspondingly we found that the needs of chicken raise from day to day in Ethiopia and easy way for food security at household level and generate monthly income sold out Day old chicks. So with this, we settled on an idea to create an affordable, good hatchable rate, environmental friendly, and innovative product named Solar Powered Poultry Incubator uniquely including Home Lighting and Mobile Charging Unit in a single package. Which is able to warm up eggs and parallel the device can give home lighting and mobile charging system.
The normal incubator which is available from local market is maximum power consuming product, temperature and Humidity not stable, ventilation and air circulation is centralized, egg rotation is manually, and operated all technical by manual and also the incubator heat source either kerosene or charcoal powered incubator runs in rural area as well as urban. You need to have diesel Generator if power fails. Otherwise the entire eggs kept for hatching will gets damaged.
Where as in our solar based Poultry incubator there will not be any power shortage or breakdown, cause source of power is solar, heating system distributed, hatching rate is convenient, have digital temperature and humidity sensor, LCD interfacing for controlling, market boundary is not limited and user friendly device.

State of the Art of the Research on Nanotechnology & Water in Brazil

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We analyzed the stage of nanotechnology research and development applied to water treatment (nano-water), for drinking water, desaltification, and decontamination of water courses in Brazil. We review data offered by the Ministry of Science, Technology and Innovation on research with public funding during 2004 to 2012, and data from the research groups listed by the National Council on Science and Technology Development.
Most of the research on nano-water came out to be on water remediation, which shows the potentiality for decontamination of important water courses, a significant Brazilian health problem. There is also an important account of research infrastructure and human resources capable of fostering public policy oriented towards resolving problems of water access. Nevertheless, there is a lack of a solid public policy accompanying the development of new technologies with studies of the potential risks associated, which raises uncertainties on the

sustainability of applying nanotechnologies.
The following chart summarizes the research groups on nanotechnology and water in Brazil with data up to 2015.



Carrier Transport in Conjugated Polymers

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Polymer solar cells have been widely studied mainly to reduce costs of processing and energy conversion, weight and in order to achieve energy conversion efficiency comparable to inorganic based devices. One import parameter to enhance the photovoltaic conversion is the charge transport which is governed especially by the molecular structure and the intermolecular interactions [1]. In this work we studied the charge transport of PEDOT:PSS thin films prepared using organic addictives, for instance isopropyl alcohol, and subsequent thermal treatment[2]. In other copolymers used as active layer in organic solar cells, the charge mobility characterization is made by using three main techniques: Space-charge-limited current (SCLC) which uses Mott-Gurney equation; Photo-Carrier extraction by linearly increasing voltage (Photo - CELIV) and Field-Effect Transistor[3]. The results of these methods will be compared for the PCDTBT copolymer and a modified fullerene.

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A Micro-CSP Plant for Micro-Grid Electricity Generation in Sub-Saharan Africa

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Concentrating solar power technology is one of the emerging sustainable technologies for electricity generation. The currently installed plants worldwide have capacities in the order of hundreds of megawatts and are not suitable to small communities' electrification, where the required capacities are in the range of a few hundred or even a few tens of kilowatts. The initial capital cost, combined to the technology is considered as the two main barriers to CSP development in developing countries. The objective of the CSPAfrica project is therefore the development of a cost effective micro-CSP plant for mini-grid electricity generation by designing and experimenting their components using local low cost materials [1]. The project is specifically designed to address energy access challenges in rural areas in the Sub-Saharan region. A solar tower technology has been retained in order to use locally available mirrors for the heliostats and gain experience with small scale solar tower technology. The solar field is made of 20 small scale multifaceted heliostats. We have designed and built "human scale heliostats", which are easy to be handled and do not necessitate work at high, as it is the case with common heliostats. The power block is an ORC generating 8.6 kWe, coupled with a dry-cooler. Jatropha curcas vegetable oil, a locally produced oil, has been demonstrated as a promising heat transfer fluid and storage medium. It offers significant environmental benefits, biodegradability, and economy and has excellent thermal storage properties, compared to the current most cost-effective and practical commonly used organic oils in CSP plants. The solar receiver is a coil heat exchanger, made of galvanised steel. These design simplifications have made possible the manufacturing of most of the components by local mankind using locally available materials and, therefore, have increased local contents.



Figure 1: Overview of the CSP4Africa power plant on the campus of 2iE in Ouagadougou (construction is on-going).

Acknowledgments: We thank the European Union Commission and the African Union Commission for their financial support of the project "CSP4Africa" in the framework of the African Union Research Grant Programme (Grant Contract n° AURG/163/2012-CRSI n° 2012/289-007).

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Use of Multiferroic Alloy to Enhance the Productivity of Non-Commericial Geothermal Wells Through the Conversion of Waste Heat to Electricity

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The goal of this research is to come up with a design of a multiferroic ($Ni_{45}Co_5Mn_{40}Sn_{10}$) alloy that utilizes waste heat from non-commercial geothermal power plants to develop green energy. The alloy is surrounded by suitably placed coils and then placed adjacent to a permanent magnet. In the design, the steam coming from the well is used to heat a multiferroic alloy. The alloy then undergoes a reversible first order martensitic phase transformation from martensite at low temperature to austenite at high temperature. The martensitic phase is non-ferromagnetic while the austenite phase is highly ferromagnetic. The magnetic field momentum of the alloy increases rapidly when heated. Extreme fluctuation in the magnetic field momentum that cuts through the coil as the alloy transforms from non-ferromagnetic to ferromagnetic phase induces electromotive force into the coil (Faradays law).
Cooling the alloy in the air through natural convection and conduction induces an electromotive force of opposite polarity in the coil. Successive heating and cooling of the alloy result in continuous power generation. The martensitic transformation is extremely fast due to low magnetic hysteresis, absence of diffusion and presence of low energy mode of transformation between the martensitic phase and austenite phase. The speed of interface transformation in the alloy tends to the speed of light in a material. The rapid martensitic phase transformation results in production of electricity at high frequency. The frequency of power generation is further increased by having several turns of coil around the magnet. The magnet is placed such that their fields produce multiple phases of current in the coils.
The heating process is achieved through the transfer of heat by convection from the steam to the alloy. The cooling process is accomplished through heat transfer from the alloy to the atmosphere by natural convection and conduction. Periodic heating and cooling of the alloy induces an alternating current in the coil. The temperature of the alloy will vary between the upper critical and lower critical temperatures to achieve continuous power generation. An optimized model for heating and air-cooling the alloy at a predetermined frequency results into a steady and continuous power production through controlled steam flow into the alloy.
The project aims to generate 15MW of electricity from non-commercial geothermal wells in the first phase of the project implementation. This will broaden the economic drivers in both developing and industrialized countries through increased and steady power production from geothermal wells which are currently unproductive.

Key words: Multiferroic alloy, martensitic phase, austenite phase

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Techno-Economic Comparative Analysis of Batteryless Hybrid PV/Diesel Systems for Off-Grid Applications

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Access to energy is known as a key issue for poverty reduction. Electrification rate of sub-Saharan Africa countries is one of the lowest among the developing countries (less than 18% in rural areas). However solar resource is abundant in Sub-Saharan countries. Their mean daily solar irradiation exceeds 5.5 kWh/m^2/day. There is then a great possibility to widen the rural electrification in this region by using photovoltaic systems.
PV/Diesel hybrid systems seem to be more suitable for rural areas in sub-Saharan Africa and for any other remote area with higher solar irradiation. As dealt by many authors, PV/Diesel hybrid systems can be certainly more reliable and more cost effective than standalone PV systems or stand-alone Diesel generators if and only if they are well designed and well managed during their operation [1,2]. In this sense an original ‘‘flexy-energy’’ concept of hybrid PV/Diesel energy system was developed [3] and tested [4]. The “flexy energy” concept consists in decentralized electricity generation through hybrid PV/Diesel systems without battery storage and with an optimal management of the energy production and loads to be supplied.

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This paper aims to compare and analyze from technical and economic viewpoints hybrid PV/Diesel ‘’flexy energy” system and hybrid PV/Diesel ‘’classical’’ energy system without battery storage. The comparative analysis has been applied using data of 2iE campus at Kamboinsé-Ouagadougou (solar radiation, the ambient temperature profile and the typical working day load profile). The specific fuel consumption (SFC) and the levelized cost of energy (LCOE) are selected as respectively the technical and the economic decision variables.
The results obtained show that the SFC of the Diesel generators running under the hybrid “flexy energy” energy system is at all the time lower than the one of the classical hybrid system. The daily specific fuel consumption reduction ranges from 4% to 26%. From economic analysis based on Levelized Cost Of Energy (LCOE), hybrid “flexy energy” energy system provide the lowest values of LCOE. Indeed, a reduction of LCOE from 10 % to 25% compared to the hybrid “classical” systems has been achieved.
The present study shows that the hybrid “flexy energy” system could make the electrification of remote areas more cost effective than the hybrid PV/Diesel classical system.

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Investigating the Effect of Anaerobic Co-Digestion of Cowdung with Common Ugandan Weeds on Biochemical Methane Potential

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Biogas technology has existed in Uganda since 1950s. However, its adoption has majorly been hindered by inadequate feedstock, with cowdung being the most commonly employed feedstock in biogas production. Anaerobic digestion of single feedstock is normally unreliable due to the resulting low quantities and quality of biogas. Besides, the bio-digesters are often left non-operational when feedstocks get depleted. Alternative substrates such as water lily and *Lantana camara* offer an opportunity for co-digestion with cowdung. These feedstocks are fast growing, and readily available. This paper therefore aims at investigating the effect of anaerobic co-digestion of cowdung with water lily and Lantana camara on biochemical methane potential. The water lily and *Lantana camara* were separately co-digested with cowdung at 25, 50 and 75%. The findings of the research revealed that a ratio of 1:1 of *Lantana camara* to cow dung could obtain on average 37.60% methane (CH_4) and 71.8 L/day of biogas. It was also observed that a ratio of 1:3 of water lily to cow dung could averagely produce 31.1% CH_4 and 47L/day of biogas. These amounts were higherthan those obtained from anaerobic digestion of cowdung which yielded an average of 24.2% CH_4 and 38.9L/day biogas. The findings of the research therefore suggest that co-digestion could enhance both the quality and quantity of biogas.

Solar Photovoltaic Water Pumping at Mohammedia

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Through this note, we presented the sizing study of solar system for the water pumping at mohammedia by three methods. We started our sizing by the analytical method; after we continued by the graphical method and we end by the third method, which is the simulation through the software PV system and meteonorm 7, considering solar irradiations, daily needs in water, the water flow and the depth. The results showed that it will be very profitable to highlight such projects in this region.

Key words: Solar, photovoltaïc, water, pumping, PVsystem, Meteonorm 7.

Application of Solar Powered Irrigation Systems in Botswana

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Solar powered irrigation technology in Botswana remains highly under-utilised and unexplored. The application of this technology is far beyond the expense of local farmers as well as commercial farmers. There is lack of demand due to lack of awareness in clean renewable energy and shortage of service providers. The low penetration of solar powered irrigation system in the country makes it challenging especially in terms of the high costs. Farmers usually suffer greatly to water crops and feed their livestock in times of low rainfall. The costs of fuels to pump water using generators are extremely difficult as well as maintenance and repair of the equipment.
This paper seeks to explore a solution to the cost of solar powered irrigation systems which can be used to harness solar power to pump underground water providing farmers with flexible options that will contribute to reduce greenhouse effect, depleting fossil fuels, low labour intensive and low maintenance irrigation system.
We therefore have a proposed system to solve the current issues posed by using diesel engines. With the availability of the sun, solar technology can be applied to pump water for farm lands, livestock and even store in large reservoirs. This study looks at the designed of solar PV panels and the use of pumps. The cells on the solar modules are made of materials that conduct direct current (DC) produce by the exposure of the panel to light. The current is then use to power the pumps. However instead of consumers having to install a whole irrigation system again, the solar-powered engine will be installed to already existing system to cut installation costs.

Applying solar powered irrigation system creates enormous benefit for the local people. It also provides a sustainable means for energy security in the rural areas. Farmers are able to have a year-round supply of water for their crops, livestock and homes. The system can be adopted to assist in resource management especially in energy because of the insufficient power supply in this country. Additionally, this process can be automated and creates a green economic with reduction in carbon dioxide emissions. It will also provide a net creation employment in rural agricultural workforce and solar industry sector service providers for farmers in Botswana and the neighbouring Southern Africa countries transition to a system which provides them a year-round commercial irrigated agriculture.

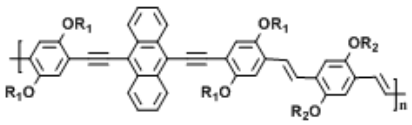
Key words: Irrigation, solar power, electricity, pumps, PV cells, sustainable resource.

Side Chain Engineering of Anthracene-Based Polymers: Applications in Photovoltaics

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Anthracene is very appealing as building unit possessing high thermal and device stability.[1] The rigid structure can be easily functionalized at the positions 9 and 10. Anthracene-based polymers possess high fluorescence quantum yields and the emission can be tuned by the introduction of other arylene-building blocks in the polymerization process.[2] Good photoconductive behaviour, high fluorescence quantum yields in thin film and high absorption coefficients (~ 100 000 M^{-1} cm^{-1}) make them attractive candidates for organic electronic applications.[3]

We have synthesized a series of anthracene-containing polymers with identical constructed backbones but with a steady increase in side chain length (see figure below) to investigate how this variation may affect the polymer morphology and the performance in bulk heterojunction solar cells (ITO/PEDOT:PSS/*SV*:PCBM/LiF/Al). The preliminary photovoltaic results show a steady increase in efficiency from SV1 (R_2 = octyl) to SV3 (R_2 = decyl), and afterwards (SV4 – 6) a downward slope. While all polymers of the series show a rather high V_{OC} (> 900 mV) in the fabricated solar cells, the before-mentioned trend is reflected in the J_{SC} values. These results could indicate that light absorption and/or charge mobility in polymers with longer side chain are possibly hindered, leading to lowered efficiencies.



R_1 =

SV1 R_2 =

SV2 R_2 =

SV3 R_2 =

SV4 R_2 =

SV5 R_2 =

SV6 R_2 =

Acknowledgements: V. S. John acknowledges the financial support from UWC and from ICTP-ANSOLE ANEX fellowship. D. A: M. Egbe is grateful to FWF for grant No: I 1703-N20.

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Water Monitoring in Colombia by Citizen Science

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Colombia has one of the largest number of ecosystems with drinking water production [1]. The expanding mining industries in Latin America have increased the pollution in river, underground and surface water sources. Some of these industries use highly toxic substances to extract precious metals, such as Gold, Silver and Platinum. Added to this, the illegal mining in the country, which accounts for the 63% of the total mining activity, distributed in 233 municipalities, pollutes around 19 rivers [2]. Those areas are involved in the civil conflict, that contribute to the water pollutant, according to this take importance the Colombian peace process to protect the environment. In the post conflict process, the environmental quality as resource take importance and how the government can determine it. Furthermore, the government limited monitoring and sanctioning policies, makes the implementation of sensing and control systems a big priority for the assurance of water quality in communities.
In this project we introduce the probe SensoAgua4 that monitor 4 water quality parameters: temperature, pH, disolved oxygen and conductivity. It integrates 3 comercial sensor (for T,pH,OD) and the conductivity sensor, designed and fabricated at Universidad de los Andes. For the mesurement vizualization, we design friendly mobilie app that can send the measurements to a web plataform. In web plataform we can vizualice the mesurements with each geographical location. Our project is aimed at building and evaluating the impact of the information portal using crowdsourcing and social network that generates rapid early alerts on potential problems regarding mining projects and their possible inefficiencies or negative social impact. The project was tested in Santurbán, Colombia a region that was affected by the mining activities.

Acknowledgement: This project was possible thanks to the collaboration of Juan Camilo Cárdenas, Juan Felipe Ortiz Riomalo and Johan Manual de Aguas Perez, School of Economics; John Hurtado, Department of Chemistry, Faculty of Science; Johana Husserl, Department of Civil and Environmental Engineering; Felipe Muñoz, Department of Chemical Engineering

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Web-App for Safety Handling of Nanomaterials at Research and Workplace Scenarios

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Nanomaterials have been incorporated from research to manufacturing chain. Currently, it is estimated that more than 10 million tons of engineering nanomaterials (ENM) are produced yearly around the world[1]. During their life cycle, ENMs interact with biological entities and environment, creating new exposure scenarios at workplace or research laboratories where the potential toxicological effects are not well understood. Urging for the implementation of the precautionary principle[2]. Due to the wide variety of ENM's properties identify and establishes exposure limits to each one of the ENM results in an unviable approach. Therefore, strategies that allow the hazard identification from nanomaterials properties and the exposure level to establish the risk associated with the handling and disposal of these ENM are highly needed[3]. We face this challenge developing a web-app to assess the risk to suggest engineering and personal protective equipment strategies.

The NanoRisk App provides risk assessment information from the inherent hazard of the ENM and the exposure probability based on the activities to be performed and the time of exposure. The ENM's hazard is defined from the ENM's physical and chemical characteristics, the knowledge of cytotoxic and adverse effects of ENM and the safety data of bulk counterpart. The measurement of each parameter defines the weight on a hazard/exposure matrix (see figure 1). The result will define the strategies measures required to handle the nanomaterial and reduce the risk. The relevance and weights of the parameters were defined by the currently available literature on cytotoxicity and health effects of nanomaterials in the literature.

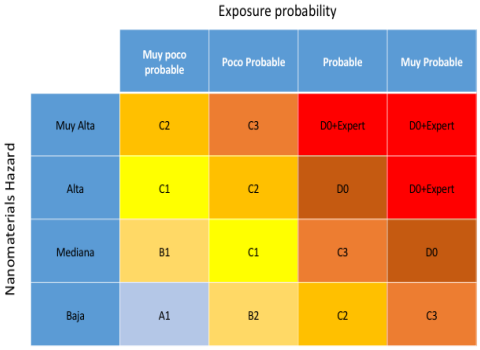


Figure 1: Hazard/exposure

This web-app has been incorporated into the institutional occupational health program at the Universidad de Los Andes, Bogota D.C., Colombia since 2015. The NanoRisk App provides safety information for the handling of ENM in 10 research projects across the university labs. Also, the app can be freely accessed from the web platform and has been used around the world in more than 60 countries. In conclusion, NanoRisk App results in a powerful tool to guide safe handling of ENMs at research laboratories as well as in workplaces scenarios, preventing the potential effects on health and environment at low cost. Further work is required to incorporate additional recommendations related to ENMs' waste management.

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