



Africa-EU Renewable Energy Research and Innovation Symposium, RERIS 2016, 8-10 March
2016, Tlemcen, Algeria

The Energy Nexus Group – an interdisciplinary research agenda

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Abstract

This paper introduces a new, transformative energy research agenda. A group of researchers has developed a novel approach to tackle the particularities of energy access development in the Global South from a nexus perspective. An interdisciplinary team will use a set of common and specific action-oriented methodologies in order to find sustainable, cross-sector solutions to the pressing issues in energy access with a strong focus on Africa and Asia. Investigating a range of cross-sectoral thematic areas including technology, finance, agriculture, water and policy at decentralized scales, the group draws holistic conclusions from systemic analysis of inherent co-dependencies and causalities.

It is argued that next-generation energy access solutions will need to incorporate the relations to other spheres of influence linked to the energy field. This is required in order to create an understanding of challenges, working mechanisms and best practices to systematically address the complex issue of energy access for long-term, scalable impact. The research will thus create a unique platform for knowledge exchange between experts with diverse backgrounds and origins. Solutions will be adapted to local and regional circumstances by incorporating information exchange between institutions from different countries and regions (South-South learning) as well as the sensitive inclusion of feedback from researched communities.

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Peer-review under responsibility of the organizing committee of RERIS 2016

Keywords: Energy nexus; interdisciplinary research; systems thinking; energy access thinking; energy systems.

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1. Introduction

The energy nexus research group has developed an action-oriented research agenda tackling energy access from a nexus perspective. An interdisciplinary team will use a set of common and specific action-oriented methodologies in order to find sustainable, cross-sector solutions to the pressing issues in energy access with a strong focus on Africa and Asia. Investigating a range of themes including technology, finance, agriculture, water, food and policy at decentralized scales, the group draws holistic conclusions from systemic analysis of inherent co-dependencies and causalities.

Energy access is seen by the group not as an isolated and binary criterion, but rather a process through which energy and energy related services are introduced and improved over time, crucially alongside other key resources, i.e. water, food and finance [1,2,3]. Analysis of energy access impact thus far has lead the group to shift the focus towards anticipating and addressing growing end user needs while ensuring that the socio-technical transformation processes across all nexus areas are stimulated through the electrification processes [4,5].

In order to achieve this, every researcher in the group focuses on one specific nexus based on his/her academic background while incorporating systemic analysis that enables the group to link their approaches and findings, consequently drawing holistic conclusions. This interdisciplinary approach incorporates specific and identifiable foci within every single research project and embeds these projects in the complex field of energy access and financial inclusion at the same time.

The result of the work thus far has been the development of a set of interconnected research themes intended to provide a platform upon which the researchers base their energy access research and engage in dialogue with diverse experts in order to promote nexus-based energy access strategies born in the Global South.

2. Methodology

Each individual researcher within the nexus group conducted literature analysis of energy access literature related to their specific field of expertise. This individual literature analysis was followed by multiple focus group discussions designed to provide a platform for interdisciplinary exchange. The aim was to define key cross-sectoral thematic areas pertinent to the development of sustainable next generation solutions to energy access. In addition to the literature review, a preliminary field study was conducted at a novel KUDURA[†] water+energy mini-grid in Sidonge, Western Kenya in order to understand the impact of water and energy access from a financial and social perspective and include a practitioner perspective in the definition of these broad thematic areas. The field study indicated the production of clean water consumed less than 10 % of the energy generated by the solar-PV mini-grid on site, but provided an additional 25 % in project revenues – despite variations in seasonal demand [6]. The provision of clean water alongside energy has resulted in a marked drop in water-borne diseases in the village over the last 4 years; however, the financial impact of this at the household level requires further research [6]. These preliminary results have provided an empirical insight into the practicalities of combining energy and water for rural energy access and assisted the group in defining the cross-sectoral thematic areas. This field study also supported the need for further research in order to link these initial findings to long-term project sustainability and socio-economic impact. The cross-sectoral thematic areas were defined as technology, finance, agriculture, water and policy.

Definition of these cross-sectoral thematic areas was followed by discussion of common research methodologies, as this was identified as a key enabler of interdisciplinary collaboration. The research methodologies identified include qualitative and quantitative surveys, statistical analysis, financial analysis, complex system analysis, supply chain analysis, GIS analysis, energy systems modelling and empirical case studies. These common research methodologies provide a uniting foundation upon which individual research themes are based. Alongside these research methodologies the implementation of a transparent intra-group knowledge-sharing framework enables members to analyse and contribute to research conducted, opening up opportunities for collaborative field work and multi-faceted research projects.

[†] Patent Pending PCT/EP2015/059149

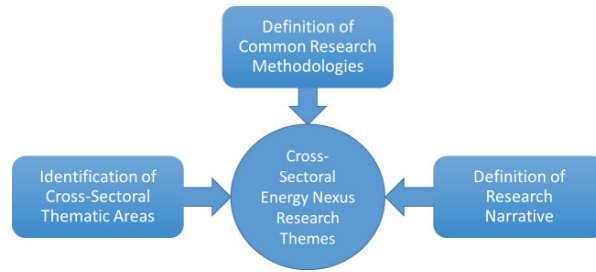


Fig. 1. Energy Nexus Research Group Development Methodology.

The scale of proposed research was then discussed in order to develop a common research narrative, further linking each individual research topic into the common research goal. This was helpful in identifying how to set-up individual research topics such that they draw from, and feed in to each other and promote the development of sustainable next generation solutions to energy access, driven by the base of the pyramid. The group decided to predominantly focus its efforts on energy access at decentralized scales in rural and peri-urban areas in the Global South. Consequently, the research scale ranges from individual persons or households to villages and communities and the structures in which these entities are embedded.

Based on the defined cross-sectoral thematic areas, common research methodologies and the proposed scale of research, specific research objectives considering individual research goals could then be defined. These research themes were submitted by each individual researcher to the group and discussed in detail in order to identify where they fit in the overall research narrative.

3. Results and discussion

The research group has identified key cross-sectoral thematic areas pertinent to the development of sustainable next generation solutions to energy access. These are defined as Technology, Finance, Agriculture, Water and Policy. Based on these broad thematic areas, the research group defined common research methodologies and an overarching research narrative that provides a uniting foundation for interdisciplinary collaboration towards the common research goal. The research narrative is complemented by an action-oriented research approach, putting a large emphasis on in-field exposure, empirical analysis and incorporating researched communities as vital stakeholders in knowledge creation and exchange [7]. This ensures sustainable and direct empowerment of local communities through participation.

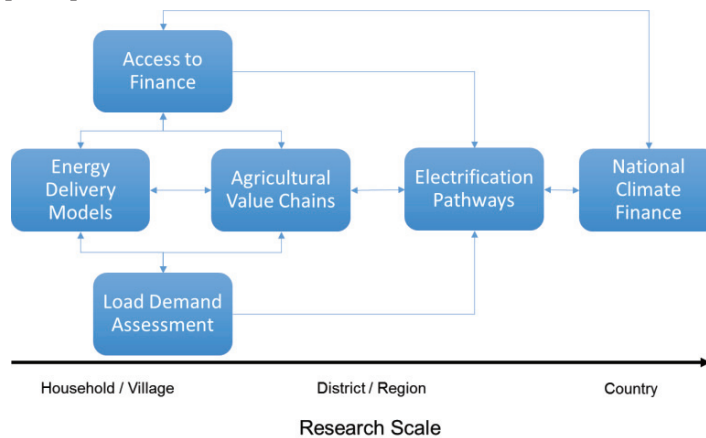


Fig. 2. The six interdisciplinary research themes related to the Energy Nexus.

Each researcher has developed a cross-sectoral energy nexus research theme specific to their area of expertise which also forms part of the overall research narrative. The resulting six cross-sectoral energy nexus research themes (Fig. 2) form a pathway to defining a next-generation energy access strategy. The research themes are outlined in detail below. This is by no means an exhaustive list and the researchers look forward to expanding this scope as new research associates incorporate their disciplinary perspectives in the future.

3.1. The role of people-centred energy delivery models considering the water-food-energy nexus for sustainable decentralised energy access

This research theme will study the implementation of a bottom-up approach to energy delivery model design. Technical analysis of system availability, reliability and sustainability will be combined with analysis of socio-economic theories addressing end-user interaction with energy access projects. An emphasis will be placed on the energy gender bias and the usage of energy for productive usage [8]. This combined socio-technical analysis will form the foundation of a novel holistic nexus-based analysis methodology identifying the quantitative and qualitative impact of improvement in water, energy and food access at the village and household scale. Empirical analysis of existing energy access projects using this methodology will lead to a better understanding of best-practices and development of innovative energy delivery models focussed on the end user, which will ultimately drive commercially sustainable and scalable decentralised energy access business models.

3.2. The role of agricultural value chains for productive use of energy

This research theme will study the links and structures of global agro-food value chains that can be used to increase sustainable energy access in order to foster productivity and income [9]. Through the development of a suitability matrix that includes academic evidence as well as practitioners' knowledge, it will define which technologies and energy services can be promoted generally or context-specific that utilize the existence of the different nexus and value chain linkages. This includes the usage of new market linkages, improved agricultural practices, enhanced processing and other upgrading strategies. A sustainability assessment framework focusing on energy-interventions in agro-food chains will analyse which outcomes and impacts can be measured from respective projects and whether it is possible to attribute them to the usage of value chain structures. Finally, the research aims at concluding the most promising overall strategies that systemically link energy access and improvements of livelihood of smallholder farmers in the Global South. This will produce key insights for researchers, development practitioners and value chain stakeholders for the design of respective programs.

3.3. The role of load demand assessment for providing energy access

Energy access provided by renewable energy implies positive economic, environmental and social effects [10] and increases the resilience of local communities to global change impacts [11]. Besides economic and technical obstacles for a broad introduction of renewable-based energy access solutions [12] no or insufficient load assessments are considered as one of the main reasons for the failure of innovative systems such as hybrid mini-grids [13]. Therefore, the focus of this thesis project is the development of reliable energy consumption forecasts for the planning of sustainable electrification projects, which make primary use of renewable energy sources. Through field-based research, decisive factors are empirically examined, which are determining the demand of local consumers. The findings serve as a basis for the development of integrated energy systems, taking into account the mutual interactions with the food and water nexus.

3.4. Innovative financing mechanisms for decentralized rural electrification

This research theme will deliver a first insight into end-user financing mechanisms as a tool to enable both energy access and practical implementation of productive energy use technologies. The core research will focus on differentiating between microfinance and digital finance mechanisms (mobile payment, CAYG, PAYG, and others).

Additionally, the concept of “electricity as a currency” will be researched, as part of the swarm electrification concept – can the consumer be a producer at the same time (prosumer)?

3.5. *The role of different electrification pathways within the energy-food-water nexus*

This research theme is focused on the development and assessment of various electrification pathways, for instance with hybrid mini-grids and solar home systems or with grid extension [14]. This is an essential step to reflect the challenges emerging from the nexus, such as electricity for water provision and electricity for productive use in agriculture. In addition, existing power infrastructure and the local potentials of renewable energy are considered.

3.6. *Integrating a nexus approach into national climate finance policy*

This research theme will systematically identify and assess high-impact solutions in the water-energy-food nexus that have the potential to provide combined climate change adaptation and mitigation benefits. Bottom-up and top-down empirical methods will be utilized to identify synergies and trade-offs across the nexus to create scenarios for coordinated and effective mitigation and adaptation finance policy. This will produce key insights for policy makers and development practitioners for the design of climate-compatible policies and implementation programs on national and international level.

4. Conclusions

The methodological development of a research agenda focusing on the energy nexus shows clearly the importance of an interdisciplinary research approach. The creation process of the six research themes involved the inclusion of various dynamics between the single themes which needed thinking outside of one specific “box”. This interdisciplinary approach is required to overcome one-sided problem solving strategies and replace them with new energy access thinking. This allows reaching beyond detached views on energy access tiers on and the mere “on/off” energy access perception still present in some discussions on nexus topics.

The current energy access situation and living conditions in many countries in the Global South clearly show that complex interactions between energy, water, food, finance and policy exist. Therefore, sustainable solutions need to incorporate the relations to other spheres of influence linked to the energy field in order to create an understanding of challenges, working mechanisms and ways to systematically address these with appropriate solutions for long-term, scalable impact.

Many initiatives in the past did not succeed in providing sustainable energy solutions in a long term. As a consequence, the objective of the Energy Nexus Group is to overcome the existing challenges by creating novel holistic approaches. Especially with focus on global change it is important to develop mechanisms which put the Global South in a position of resilience towards climate change, water scarcity and energy poverty.

Knowledge exchange between experts with diverse professional and cultural backgrounds enhances a common understanding of the issues at hand. For this reason, knowledge exchange and partnership of various institutions from different countries and regions, as well as the incorporation of the feedback of the researched communities is a strong benefit.

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