SMART VILLAGES
New thinking for off-grid communities worldwide

GLOBAL YOUNG ACADEMY

Concluding workshop for the Smart Villages Initiative's engagement programmes in South and Southeast Asia

Workshop Report 33

BANGKOK, THAILAND

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Smart Villages

We aim to provide policymakers, donors, and development agencies concerned with rural energy access with new insights on the real barriers to energy access in villages in developing countries—technological, financial and political—and how they can be overcome. We have chosen to focus on remote off-grid villages, where local solutions (home- or institution-based systems and mini-grids) are both more realistic and cheaper than national grid extension. Our concern is to ensure that energy access results in development and the creation of "smart villages" in which many of the benefits of life in modern societies are available to rural communities.

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The Global Young Academy

The Global Young Academy aims to become the voice of young scientists around the world. To realise our vision we develop, connect, and mobilize new talent from six continents. Moreover we empower young researchers to lead international, interdisciplinary, and intergenerational dialogue with the goal to make global decision making evidence-based and inclusive.

The GYA provides a rallying point for outstanding young scientists from around the world to come together to address topics of global importance. As of 2014, the GYA has reached its full capacity with 200 members, leading young scientists (defined as an average age of 35 years and at the beginning of their independent academic career). 2016 GYA has in addition to its 200 members 134 alumni. Altogether 70 countries from all continents are represented. Members are selected for the excellence of their science and their commitment to service and are serving five-year terms. The vibrancy of the GYA results from the energy of its members who are passionate about the role of science in creating a better world. The GYA is governed by an Executive Committee that reflects the diversity of its membership and is supported by a Senior Advisory Board composed of outstanding senior scientists and science managers, respectively.

Publishing

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Summary

The Smart Villages/GYA Bangkok workshop addressed overall challenges of off-grid energy access in Asia as well as focussing particularly on the nexus issues of energy and health, and energy and education in off-grid rural communities. The link between energy and two important issues, health and education, became apparent during the first two days of the workshop. This workshop emphasised that development must take a bottom-up approach to come up with solutions that are rooted in local requirements and opportunities, and avoid imposing interventions that are not wanted or needed. Pertinent issues included the quality of training for teachers and health workers, as there are often shortages of skilled workers. When technology for health or education is added to the equation, it also means that workers have to know even more and be comfortable with new ways of doing their work.

It was noted that energy access and technology are not cure-alls, but they do offer some extra tools with significant leverage. While a top-down approach is not advisable, there must still be engagement with policy makers at a high level to ensure necessary changes and to provide funding for health and education. There must also be engagement with the scientific community, which is key to fostering an interdisciplinary approach to off-grid energy-centred development solutions. It was felt that the Global Young Academy members and their peers were well placed to promote such an engagement in order to create developing world applications for cutting-edge research products and innovation.

Many off-grid energy solutions require technological innovation, entrepreneurial solutions, and nuanced community engagement so that energy or technology is not a panacea. Rather, their application potentially opens innovative avenues for addressing issues such as inclusiveness and women's or girls' rights.

Homes near Thailand's KhiriLom Border Patrol School have solar home systems thanks to the Integrated ICT and Renewable Energy Project for Off-Grid Area under the Royal Initiative of Her Royal Princess Sirindhorn.

Introduction

The Smart Villages Initiative concluded its regional engagement in South and Southeast Asia with a workshop in Bangkok, Thailand, in March 2017. The workshop was jointly organised with the Global Young Academy (GYA), the National Science and Technology Development Agency (NSTDA), and the National Science Museum (NSM) of Thailand.

From 7 to 9 March, the workshop brought together 43 key stakeholders representing the public sector, private companies, academia, civil society organisations, and entrepreneurs who are engaged in the off-grid energy sector across South and Southeast Asia. The first day of the workshop provided an extremely useful forum to develop a better understanding of the interaction between energy access and the two important issues of education and healthcare in off-grid communities. The second day, spearheaded by the Global Young Academy, focused on the role of early- to mid-career scientists and academics in developing smart villages. The meeting concluded on the third day with wrap-up discussions on Smart Villages Initiative's engagement programmes in South and Southeast Asia. A day before the start of the workshop, NSTDA organised a field trip in Bang-Sa-Pan-Noi District, about 400km south of Bangkok, for the Smart Villages Initiative and GYA teams to see first-hand how NSTDA scientists are working to address energy access in off-grid communities.

This report summarises key points arising from the presentations and discussions over the three days of the workshop and is accompanied by a policy brief that distils the main messages for the policy and development communities. Copies of the presentations are available on the Smart Villages website (www.e4sv.org). This report can also be accessed on the website. The workshop agenda and the list of participants, along with their organisational affiliations, are provided in Annexes 1 and 2 of this report respectively.

Over 40 participants from across Southeast Asia gathered in Bangkok for three days to discuss off-grid energy, health, and education.

Session 1: How energy access in off-grid villages can enable improvements in education and healthcare at the village level

Opening remarks

Dr Bernie Jones, Smart Villages Initiative, Dr Moritz Riede, Global Young Academy (GYA) and Dr Orakanoke Phanraksa, National Science and Technology Development Agency, Thailand

Bernie Jones introduced the workshop and explained how it fits with the Smart Villages Initiative engagement programmes of learning from those working on the ground to harness and deliver innovative solutions for energy supply in off-grid communities. Key conclusions and recommendations are distilled for delivery to funders, policy makers, and practitioners.

The first session of the Bangkok workshop sought to learn from the participants how energy could be used as a catalyst to deliver innovative solutions for health and education provision in remote communities in South and Southeast Asia. The second session would look at how young scientists, innovators, and entrepreneurs from around the world are working to address these issues. Session three brought together all the learning from South and Southeast Asia to share experiences within the region and beyond.

Moritz Riede introduced the Global Young Academy (GYA, https://globalyoungacademy.net) as a network of early- and mid-career researchers and scholars from around the world looking to engage in international, interdisciplinary, and intergenerational dialogue and to use excellent science and research to deliver solutions to societal challenges. Examples of their activities are: (1) Science Leadership Programmes in Africa, initiated by former GYA Co-Chair Prof Bernhard Slippers, and in Asia, (2) Report on the Global State of Young Scientists (GloSYS), looking at common challenges and solutions for young scientists around the world, and (3) providing input to international organisations such as UNESCO, the WEF, and the recently formed UN Secretary-General's Scientific Advisory Board.

Orakanoke Phanraksa welcomed everyone to Thailand and introduced the National Science and Technology Development Agency (NSTDA) and the National Science Museum (NSM), the two local co-hosts for the workshop. NSTDA is the leading Science and Technology research organisation in Thailand, with four national research centres and about 3000 employees. NSM is the national agency mandated with science communication in Thailand. They are planning a science exhibition and expo in August 2017 and have invited the Smart Villages Initiative and GYA to work with them on a themed exhibition on renewable energy.

Orakanoke Phanraksa also mentioned the field trip NSTDA organised on Monday 6 March for the Smart Villages Initiative and GYA teams to see, first hand, how NSTDA scientists are working to address energy access in off-grid communities. For the trip, the teams visited the Baan Khiri Lom Border Patrol Police School and Learning Center in Bang-Sa-Pan-Noi District, Prachuap Khiri Khan Province, about 400km south of Bangkok. The school is located in Khiri Lom Forest Preservation Unit and has 105 students in primary grades 1 to 6. It is one of 20 pilot centres that will be established as part of the 'ICT and renewable energy integrated system project for communities along borders' being implemented by the Project for Youth and Children in Remote Areas under the Royal patronage of HRH Princess Maha Chakri Sirindhorn. The project aims to improve telecommunication infrastructure and pave the way for further developments in learning and access to information in remote communities. It is being implemented by a partnership involving an ICT-focused foundation initiated

by HRH Princess Maha Chakri Sirindhorn, the Border Patrol Police Bureau, National Electronics and Computer Technology Center (NECTEC), Wildlife Sanctuary authorities, mobile telephone company AIS, and other government agencies.

Welcome address

Dr Yongyuth Yuthavong, NSTDA, Thailand

Yongyuth Yuthavong welcomed all participants to Thailand and commended the choice of Bangkok as host city for the South and Southeast Asia wrap-up workshop. His address was centred on his belief that young scientists, as well as other scientists, technologists, and practitioners, are at the centre of the attempt to address key societal challenges. These challenges are more pronounced for off-grid communities who are not as connected to the rest of society in many ways beyond energy and communication. Off-grid societies are detached from the provision of various essential products and services for a comfortable life, e.g. health care, water, food, education, and information.

Yongyuth Yuthavong suggested that off-grid communities require solutions, in the form of products and services, from science and technology. Unfortunately, conventional markets have failed to deliver these products and services to remote areas so that there is need for targeted policy direction, research and development, and implementation support to enable their delivery. These enabling mechanisms are a necessary foundation to achieving sustainable development for those at the bottom of what he called 'the innovation and service/product delivery pyramid'. In his view, scientists have achieved a lot in other fields, such as genetic engineering and robotics, so they should be able to contribute to delivering sustainable development as set out in the UN Sustainable Development Goals (SDGs). As science and technologies seek to address the needs of the marginalised, there is a need to answer key questions—how, why, when, where, who, and what—concerning the innovation and development they seek to deliver.

Yongyuth Yuthavong's presentation was based on his upcoming book called 'Sparks from the Spirit' which discusses how the fruits of science and technology research can lead to innovation and, if the environment is right, ultimately deliver development, ideally sustainable development. Dr Yuthavong wrote the book for the Thai Academy of Science and Technology. It will be published in 2018.

Introduction: Smart Villages Initiative: reflections on energy, education, and health interaction

Dr John Holmes, Smart Villages Initiative, UK

John Holmes introduced the Smart Villages Initiative and outlined its current thinking about energy and its role in education and health.

The inspiration for the Initiative stems from the poor energy access rates that prevail in the developing world and the far-reaching negative consequences this has on quality of life. For example, more than 1 billion people have no access to electricity worldwide, while over 3 billion still use highly polluting cooking facilities—the fumes of which lead to 4.3 million premature deaths annually, with women and children being most vulnerable. The situation is unacceptable and requires urgent attention. The importance of energy access is reflected in the SDGs: SDG 7 focuses on energy access, renewable energy, and energy efficiency. It is also important to recognise that energy access is important for the achievement of other SDGs as it is a catalyst for development, e.g. for food security, welfare, incomes, health, and education.

Why Smart Villages?

Smart cities have been the focus for development worldwide, yet 47% of the total world population and 70% of the world's poor live in rural villages. Despite rural-urban migrations, these numbers are unlikely to change, with projections of 3.4

billion people still living in villages in 2040. The Smart Villages Initiative is therefore responding to the need for a rural analogue to smart cities that addresses development issues affecting the rural poor.

While the ideal smart village will vary from place to place, there are some key features that will be common for most—all enabled by energy access and improved connectivity. Smart villages will: (1) provide better access to key services, e.g. education, health, clean water, and sanitation; (2) foster entrepreneurship in the provision and use of energy products and services, creating new ways of generating income in rural communities; (3) provide connectivity with other communities and opportunities to participate in governance processes, at local, regional, national, and international levels; and (4) host more resilient communities that are better able to resist and respond to shocks and natural disasters.

Smart villages therefore harness technological advances to change the balance between cities and villages to present new possibilities and opportunities that would not otherwise be available to rural communities. The Smart Villages Initiative seeks to explore what these new possibilities are and how they can be delivered. It focuses on local energy solutions for rural communities: the International Energy Agency (IEA) estimates that for 70% of unconnected rural communities, electricity can be best delivered through local solutions, rather than extending the national grid.

The nature of the Smart Villages Initiative

The Smart Villages Initiative is a collaboration of researchers (in the UK and internationally, e.g. science academies throughout the world and Practical Action), made up of six regional engagement programmes (East and West Africa, South and Central America, and South and Southeast Asia), funded by the Cambridge Malaysia Education Development Trust (CMEDT) and Templeton World Charity Foundation (TWCF).

The Smart Villages Initiative activities include workshops, capacity-building events for frontline practitioners (e.g. community leaders in East Africa), media workshops to help improve coverage of the key issues, entrepreneurial competitions for energy microenterprises (to stimulate new ideas, particularly among young people in universities), communication and outreach activities (i.e. newsletter, policy briefs, webinars, website, and social media), and research projects in off-grid villages to better understand the processes and issues at hand. In each of the six regions, wrap-up events are held to consolidate regional insights, while project concluding events will be held in Europe (Brussels) and the USA. Most of the 12- to 18-month regional engagement programmes are now completed; around thirty workshops have been held so far.

The Smart Villages Initiative workshops are designed to capture views from those working at the frontline of delivering energy to rural communities, exploring the opportunities and challenges and what needs to be done to ensure success, i.e. capturing key messages for funders, policy makers and implementers. The Initiative facilitates dialogue between the key players: frontline practitioners, policy makers, entrepreneurs, academics, financiers, development communities, etc. The findings are then communicated to others to enable better progress with energy provision, particularly with SDGs in mind. The intended outcome is more effective policy and interventions, to deliver energy in rural communities and generate the accelerated rate of progress necessary to achieve the SDGs by 2030.

The Smart Villages Initiative wants to identify the framework conditions necessary for fostering entrepreneurial activities for delivering and using energy in villages to maximise the leverage of public sector funding. There is need for an integrated funding approach and for increasing funding for rural energy by a factor of 5-10, together with combining energy access with other development activities to improve livelihoods. There is also a

need to catalyse rapid progression through the levels of energy access.

The Smart Villages Initiative views on energy for education and healthcare

Background: Worldwide, one in three children go to primary schools without electricity, and only one in four health facilities in sub-Saharan Africa have access to electricity. Health clinics need energy for surgical operations, refrigeration, diagnostic equipment, water pumping and purification, ICT and improved connectivity, sterilisation, heating, cooling, cooking, etc. For schools, electricity is necessary for lighting, water pumping and purification, food preparation, heating, cooling, ICT and connectivity.

The Smart Villages Initiative has carried out two literature reviews on these topics, and gathered that there is need for: (1) an integrated approach, i.e. access to energy together with access to allied equipment and services, (2) considering shortfalls in other resource, e.g. getting good quality staff to work in rural schools and clinics, (3) thinking about the intended outcomes from improved energy access, e.g. addressing sources of ill health (like dirty water) and packaging solutions with energy, e.g. providing lighting together with innovative ways for educational activities at home, and (4) recognising linkage between healthcare and education and how progress in one enables the other.

Common issues include: (1) Finance—costs for energy access, connectivity and equipment have reduced; there are strategies for coping with intermittent supply, and anchoring interventions (e.g. using educational or health centres to deliver other services) enable the sharing of costs; (2) System sustainability—there is a need for improved scheme design, e.g. considering needs, not just technology and long-term monitoring and maintenance; and (3) Maximising the value of energy access—e.g. access of expertise in world knowledge banks, distance learning, improved training for practitioners, increased efficiency of healthcare and educational systems, and improved disease diagnostics and surveillance.

John Holmes identified key questions for the workshop as being: (1) What are the lessons from previous experiences? (2) What key developments are needed in financing, technology, infrastructure, etc.? (3) How can energy access in schools and clinics be integrated with other village-level development activities and initiatives? (4) What else needs to happen in the village and outside the village to help achieve health and education outcomes? (5) What are the challenges and opportunities for health and education workers arising from energy access? (6) How can access to other services help education and healthcare in off-grid communities?

Keynote presentation 1: Opportunities and challenges to enhance village level healthcare in South and Southeast Asia through energy access and ICT

Jay Evans, Medic Mobile, Nepal

Medic Mobile is a San Francisco-based, non-profit technology company operating in 23 countries in Asia and Africa, serving 13,000 frontline health workers who deliver care to over 1 million families. The company was established in 2009 to exploit the improved access to mobile telephone signals to deliver rural healthcare. Their focus is currently on disease surveillance, drug stock monitoring, service reporting, child immunisation, and antenatal care. Medic Mobile's model relies on understanding the "last mile healthcare worker" (e.g. community health workers) and how they interact with the wider system, and using this information for human-centred solutions design. The process takes time and relies on employing local actors. The solutions, tools, and technology are designed to fit the needs and conditions so that they are accessible to the healthcare workers, household caregivers, and the patients, and they can be used with basic phones or smartphones.

As with other technology solutions, the path to scale requires other enabling factors, such as energy, infrastructure, financial sustainability, human resources, impact assessment, etc. Mr Evans discussed a few of the enabling factors for e-health.

Energy: Energy access is the most important factor and there is a need for improved coordination between e-health practitioners and those working on energy access. For example, in Nepal, the electrical grid has not extended as widely as the mobile signal: about 96% of people in Nepal have access to a mobile phone signal while only 76% of the population has access to electricity (which is limited to about two to six hours a day, usually at unsocial hours). Even when the electricity is in place, hardware choice for technology solutions is often misguided and servicing, maintenance, and replacement is not always factored in; for example, it is estimated that 5-10% of equipment fails in most projects.

Human resources: While it sounds obvious that just because people have access to technology it does not mean that they know how to use it, the consequences of poor training can be far-reaching. For example, an e-health mobile phone application that Medic Mobile deployed in Nepal failed to achieve its objectives because the healthcare workers using it did not know how to operate basic phone functions, like regularly clearing their message inbox. In addition to adequate training, refresher training is also necessary. To increase the chances of success, the health workers have to find benefit in the supplied tool or solution in their regular workflow, i.e. something beyond the narrow benefit defined in the intervention. To do this, there is the need to understand the tasks that healthcare workers are involved in and incorporate this knowledge into the design of the solution.

Financial sustainability: Poor design leads to projects going over budget and failing to move beyond the pilot. There is a need to involve the end users and beneficiaries in the design of the solution so they can decide if it is worth their while and even commit their own resources where possible, such as local authorities allocating their budget to supporting the projects.

Impact: Impact assessment should focus on real-life health outcomes—that is, go beyond the temptation to use e-health tools as data-gathering gadgets without considering tangible changes in community health (such as better rates of child immunisation or reduced maternal mortality). Greater impact can be achieved when there is better coordination among health practitioners, and between health practitioners and allied service providers, especially those working on energy provision. This way, there will also be better coordination in data collection and evidence gathering to minimise the duplication of efforts and ensure that existing knowledge is fully exploited.

To improve impact, Jay Evans suggested that there is need for the industry to realise that to use ICT in improving rural health care does not always require another app. Rural healthcare organisations should start implementing digital principles and best practices, scaling what is known to work, and developing protocols for ensuring this.

One key outstanding challenge for ICT in health care is coming up with ways of managing non-communicable diseases, which are becoming more prevalent in developing countries.

Keynote presentation 2: Opportunities and challenges to enhance village-level education in South and Southeast Asia through energy access

Sowirin Chuanprapun, UNESCO, Thailand and Dil Bahadur Shrestha, NRC-NFE, Nepal

UNESCO Bangkok serves as the Asia-Pacific Regional Bureau for Education, covering 46 member states. It promotes the SDGs in the region, in particular SDG4: to ensure inclusive and equitable

quality education and promote lifelong learning opportunities for all. There are still 18 million children out of school in the region. UNESCO tries to promote their education and to ensure that those who are in school stay in school.

Sowirin Chuanprapun spoke about two UNESCO initiatives: (1) Mobile Learning for Out-of-school Children, a mobile learning project for remote and under-resourced schools along the Thailand-Myanmar border, and (2) Thai Literacy through Edutainment for Disadvantaged People in the Highlands of Tak Province, a literacy project targeting ethnic minorities in the remote mountainous regions of Tak Province in Thailand.

Mobile Learning for Out-of-school Children supports learning centres in remote areas. There are about 400,000 migrant (non-Thai) children in Thailand, nearly 76,000 of them integrated in the formal Thai education system, with an additional 17,000 attending Migrant Learning Centres (MLCs) established for minority and immigrant communities in remote areas along the Thailand-Myanmar border. The children in MLCs have poor quality education, which is characterised by poor educational outcomes and lack of recognition within the Thai and Burmese systems. The schools and MLCs in the border regions have low teacher/pupil ratios, are run by poorly trained teachers, lack modern learning facilities and teaching materials, are poorly connected (in terms of roads, communication, electricity, etc.) to the communities they serve and the rest of the country, and have insufficient educational material available in local languages.

The project, which is implemented by UNESCO Bangkok, Microsoft, True Corporation, and the Thai Ministry of Education's Office of Non-formal and Informal Education (ONIE), seeks to harness the potential of ICT to benefit migrant, ethnic minority, and stateless children in MLCs along the Thailand-Myanmar border. It aims to enhance the basic literacy and numeracy skills of the school children in the border areas through the use of ICT devices and mobile learning. As part of this project, UNESCO designed a comprehensive offline learning application that features a range of educational resources; Microsoft funded the provision of tablets (which come pre-loaded with the mobile learning app and other mobile learning material provided in local languages for the border area, i.e. Thai, Burmese and Karen) and relevant training; True provided Wi-Fi internet and TV packages with educational satellite channels and tablet-to-TV connectivity, while ONIE plays a key role in implementing the project (e.g. curriculum development and teacher training) and ensuring its long-term sustainability. About 60 other organisations from Thailand and Myanmar are also involved in the development of online learning content. In addition to training for teachers in the use of ICT for teaching and their own continuous professional development, the project also introduces parents and community members to ICT and the possibilities it offers for their day-to-day activities.

The ICT equipment in schools allows for real-time measurement of the project's impact by tracking data usage, access rates for educational material, etc. As a result of the project, more than 50% of the students have achieved better scores in Maths, Thai and Burmese.

Sustainability is a key issue for the project, both in terms of replacement and maintenance of the equipment (especially tablets—the tablets have had to be made more rugged following the initial pilot and the supplier currently has spare tablets on standby) and security from fire (the buildings' structures are mainly wooden) and theft. There is a need to look at ways of re-integrating the migrant children into the Myanmar educational system. The MLCs therefore ensure that they are educated in both Thai and Burmese and that the curriculum meets the requirements of both countries.

The Thai Literacy through Edutainment for Disadvantaged People project seeks to improve literacy in the remote highlands of Tak Province, Thailand, through energy access and ICT. The illiteracy rate among those aged 15 years or older in Tak province is 2%, which is about 10,000 people, with the majority (>6,000) being Karen people living in five highland districts. These districts are characterised by remote mountain villages, which are isolated from the rest of the community due to poor roads, poor access to electricity, and the villagers' naturally reserved disposition and limited confidence communicating in Thai. These challenges limit their access to services and participation in community engagement processes. As part of the project, UNESCO and the Tak Provincial Office of Non-Formal and Informal Education provide mobile learning equipment (scooter, laptop, projector, public address system, etc.) to non-formal education teachers. The teachers then visit remote villages and screen Thai-language (or Thai-dubbed) films and hold Thai karaoke sessions, with the aim of engaging members of the community aged 15 or over in learning the language. The teachers are provided with relevant training and involved in the choice of films and songs to be used in the lessons.

The 'edutainment' initiative also delivers lessons on community development issues, e.g. preventing veld fires, improving agricultural processes. The project has recorded significant success in raising literacy rates and educational engagement among its target group of learners, with about 50% of the leaners obtaining completion certificates, and significant changes in community behaviour and quality of life, e.g. better communication in Thai and participation in environmental conservation initiatives. Key success factors have been motivation of the teachers and leaners, use of (more reliable) solar energy, and community ownership of the systems.

Employing CLCs for sustainable development in Nepal: Dil Bahadur Shrestha

Dil Bahadur Shrestha gave an outline of the non-formal Community Learning Centres (CLC) operated by the National Resource Center for Non Formal Education (NRC-NFE). NRC-NFE is an NGO focused on addressing illiteracy and limited community development in Nepal. Nepal is faced with high rates of illiteracy and primary school dropout, and limited socio-economic development, particularly in remote mountainous communities. CLCs are local educational institutes set up, managed and operated by the community to serve the community. They are multipurpose organisations catering for the educational needs of children, youths, and adults. CLCs combine education with other community development initiatives, such as promoting income-generating activities, health care, environmental stewardship, information/technology dissemination, awareness raising, community development, and women's empowerment activities. Each centre is planned and set up according to local needs and established using local resources and community input. NRC-NFE has implemented 21 CLCs in Nepal to demonstrate to the government and other organisations what these centres can achieve. The government has now set up 2100 CLCs of its own after seeing the impact that NRC-NFE CLCs have had.

With funding from UNESCO and Japan Funds in Trust, NRC-NFE implemented a project called **'Rural Connectivity for CLCs**'. The project seeks to address the challenges of irregular and intermittent electricity supply from the national grid (with daily blackouts of 10-15 hours) and the limits this imposes on community development. As part of the project, CLCs use solar energy to improve ICT-enabled connectivity and knowledge/technology transfer, support the establishment of community-based biogas plants and associated organic farming activities, and develop a local skills base for community development, such as the construction and operation of biogas systems.

The project activities include installation of a solar power system for the CLC and training of community members in installation and management of solar systems, learning centres, organic farming and biogas systems. The CLC therefore acts as an anchor for other community development activities. For example, it serves as a central charging point for rechargeable desk lamps, distribution centre for water purification products, community resource centre, and library, training, and information centre for establishing (subsidised) community biogas units.

Some of the main achievements have been improvement in literacy, technical skills, women's empowerment, and internet connectivity.

Keynote presentation 3: Experiences of the health-energy interaction at village level

Avishek Malla, SunFarmer, Nepal

Avishek Malla explained that SunFarmer Nepal is a for-profit social enterprise, a subsidiary of a US non-profit called SunFarmer USA. It aims to power critical infrastructure in the developing world with affordable and reliable solar energy, with a focus on health, education, and agriculture. SunFarmer's main selling point is innovative financing and human/need-centred design of solutions.

About 30% of the nearly 30 million people in Nepal have no access to electricity. Of those who have access, 58% are connected to the national grid, while the rest rely on small-scale solar home systems or micro-hydro plants (with a 50% split between the two). Most of the solar systems are small-scale of 10-20 Watts, which cannot supply the 220v needed to run most appliances. A few households have access to diesel/petrol-powered generators, but the coverage is limited due to recurrent fuel shortages and the fact that most off-grid communities are in hilly or mountainous areas that are not easily accessible by road, making it difficult to ferry fuel.

The health sector mainly comprises public facilities: primary health care centres, health posts, and sub-health posts. The sub-health posts are the first institutional contact point for basic healthcare in rural villages. Healthcare facilities require reliable access to energy to extend hours of service, prevent damage to equipment caused by power surges, preserve the cold chain, and deliver basic preventive services.

SunFarmer helps to address the challenges that beset the energy-healthcare intersection: (1) the lack of synchrony between the Ministries responsible for health and energy so that the supply of medical equipment does not always take into account energy availability, (2) the widening infrastructure gap between poor and well-resourced healthcare facilities, and (3) the lack of financial resources for capital investment within most rural healthcare facilities. The state of affairs is demoralising for the health workers; for example, the inadequate lighting facilities for baby deliveries at night, lack of resuscitation facilities, and lack of energy to sterilise equipment.

Energy supply to cold storage facilities is a critical need in Nepal, with 19 of the 75 districts lacking access to reliable facilities. About 70% of vaccine stocks is wasted nationally, mainly due to the irregular power supply to cold storage facilities and the lack of refrigeration facilities in remote off-grid health posts (some posts are 10 hours away from cold store facilities). SunFarmer has supplied solar power systems to health posts depending on their requirements, ranging from 200 W systems to provide lighting, refrigeration, and charging for small pieces of equipment to >100 kW systems to support modern operating theatres and associated diagnostic and lab equipment.

To finance the systems, SunFarmer offers health facilities five- to eight-year 'lease to own' financing arrangements under which the health centre makes monthly repayments and assumes ownership of the solar system at the end of a successful term. SunFarmer monitors and maintains the

system as part of the financing arrangement. The government supplies the funding for the systems and sets aside a percentage of the funding in an investment scheme for use in battery replacement in later years. SunFarmer will hand over the first system financed using the innovative finance model in 2020, thus it is still too early to judge whether the systems will be sustained upon handover to the health posts. Scaling this model to more off-grid health posts requires better coordination between the Ministries responsible for health, energy, finance, and the environment, and clear, long-term forward planning for sustainable energy for the healthcare sector. This is still lacking at the moment.

Keynote presentation 4: Experiences of the education/energy interaction at village level

Farid Khan, IEEE Smart Village, UK/India

The Institute of Electrical and Electronics Engineers (IEEE) is one of the largest professional bodies representing electrical and electronic engineers and allied professionals from 70 countries, with more than 0.5 million members. IEEE started the Smart Village project as part of the humanitarian programmes in Haiti following the 2010 earthquake, focusing mainly on energy provision (unfortunately the effects of Hurricane Matthew in 2016 destroyed most of their achievements).

Farid Khan indicated that IEEE Smart Village started working in India in 2015, undertaking projects mainly in remote, mountainous villages in Northern India. Inspired by the understanding that energy is the basic enabler for development, IEEE Smart Village wants to help achieve the goal of more 'distributed' energy in the world over the next few years as more and more people will generate and consume energy locally. The initiative operates in 18 countries, mainly in Africa but also Ecuador, Papua New Guinea, and Haiti. The focus is energy as an enabler for sanitation and health as well as education and community-level learning. The initiatives prioritise learning from the communities before designing and implementing any intervention.

IEEE Smart Village supports local social enterprises that set up and operate small renewable electricity systems. They achieve this by providing seed funding to local NGOs to set up self-sustaining, community owned and operated micro-utilities. IEEE combines the skills of its members and those of partners in education, business, and technologies to deliver improved livelihoods in off-grid communities.

IEEE Smart Village finds it difficult to reach off-grid communities with the right education models—that is, models that go beyond basic literacy and numeracy to consider aspects like critical thinking. Providing education to remote communities is carried out within the strict guidelines of the national curriculum for religious, social, and political reasons. Internet connectivity, as provided by the IEE Smart Village, can provide ways to get round these restrictions for both the teachers and the students, and supports provision of a relevant and holistic curriculum.

The economic models in most off-grid communities are labour intensive, leading to substantial levels of rural-urban migration as rural dwellers seek a better quality of life. This is further exacerbated by a lack of awareness of how opportunities compare between rural and urban areas and the critical thinking necessary to navigate between the two. To help with this, IEEE Smart Village seeks to provide energy education and microenterprise development through formal training, mentorship programmes, and business coaching. The interventions are seed funded and the returns from the investment are invested in a growth fund, which is reinvested in other enterprises. The model relies on strong community relationships and promotes community empowerment, not just development. In all this, education is key.

IEEE Smart Village aims to address the limitations to education in remote rural areas (e.g. archaic

learning practices, poor quality instructors, lack of feedback, gender bias, etc.) by providing solar energy and ICT equipment to schools. The ICT equipment, which includes desktop computers, networked servers, internet connectivity, online learning material, etc., is used to improve school curricula and provide community computer literacy courses in local languages, with a particular focus on women.

Keynote presentations 5: Integrating energy-health-education: Experience of the interaction at village level

Mike Rosenberg, Aleutia Energy, UK

Mike Rosenberg shared lessons from providing solar energy in African schools and healthcare centres. Three key ideas have influenced the way Aleutia approaches energy supply to schools and health centres; these are:

(1) Affordability and scaling up: for solar systems, these factors are not limited by prices of the solar panels (photovoltaic panels have been commoditised and currently trade at <USD 0.4 per Watt) but rather by the back-end equipment, i.e. the charge controller, inverter, and batteries. Lithium ion technology fundamentally changes the economics of off-grid energy, as it reduces the cost for batteries over time and therefore offers affordable replacement for diesel-powered generators, which is the market segment in which Aleutia sees a lot of potential in the countries they operate in.

(2) Remote monitoring: this is important not just for maintenance but also for generating live views of the health of the battery, power consumption, etc. This has the potential to change the users' behaviour. The fairly basic approach to energy audits carried out for solar systems often leads to over-specification of solutions by suppliers and, for users, poor understanding of energy use and a lack of ways to manage it.

(3) Price and waste: typically, utility scale solar systems are almost always below US$1 per Watt, yet typical systems in off-grid communities cost more than US$10 per Watt. Therefore there is a need to determine the real cost of every project, monitoring it so that it is clear what is being paid for, and determining whether it is needed to achieve the project objectives.

Aleutia Energy was established to provide low-priced, low-energy (7 W), rugged computers to schools, supplied together with an appropriate solar system. The need for customised solutions became more evident when Aleutia started to supply computers to clinics. Some clinics had 2 kW solar panels to power direct solar fridges, yet they were delivering babies with paraffin lanterns because they did not have batteries to power lights using the same panels. Aleutia saw a need for systems that supplied batteries and other back-end equipment to off-grid clinics. This way, properly specified solar systems could be used to power the whole clinic, i.e. replacing diesel generators and numerous specific solar systems for different pieces of equipment.

Aleutia also realised that because of a lack of real-time monitoring of equipment (which can be done via GPRS or GSM), in some cases the equipment had stopped working without the project sponsor's being aware (some fridges were being used as filing cabinets). More importantly, lack of real-time monitoring also meant that there was no information on the power usage of key hospital or clinic devices. As a result, solar systems are often designed to supply the peak power requirements for the equipment (which is rarely used in reality) and when funds are spent on over-specified systems the projects rarely go beyond the pilot phase. A cheaper system could provide baseline power for all appliances over a 24-hour period at a cheaper price. To address this issue, Aleutia is working to benchmark medical devices to generate more data on their power consumption.

As a hardware manufacturer, Aleutia Energy started off as a computer company but soon realised that for each computer and solar system they supplied to a school or clinic, there was the need for power for many other devices. As a result their main focus has been working on how to develop and sell a complete package of back-end components for solar systems and working with manufacturers to put lithium ion batteries, invertors, and charge solutions in a smart package that works reliably in hot, dusty, and remote areas.

The result was the SolarEnabler: a 6 kWh lithium ion battery bank housed in a cabinet together with a charge controller, an inverter, a microcomputer (used for remote monitoring and other sensors), and a simple touchscreen user interface. The innovative power box also has software that can control and monitor the power consumption of up to four AC circuits, allowing better monitoring and management of power consumption by different appliances. The system is designed to be plug-and-play, and high spec enough to compete with diesel generators. It can be serviced in the field, so the cabinet can be opened and the batteries changed in case of malfunction or when cheaper and longer-lasting batteries come to the market. The unit has spare parts built in and can be monitored remotely to know when they need to be serviced, such as through temperature sensors integrated into the cabinet. While it is suitable for dusty, remote areas, the SolarEnabler also has special fans to cool down the system, which heats up when DC is converted to AC.

The SolarEnabler can be used alongside the national grid to prevent power surges and the intermittent supply experienced with most developing world national grids. The objective is to provide baseline power to every clinic for core medical devices as opposed to over-specified solar systems.

To upscale, Aleutia is focusing on replacing diesel generators anywhere in the world as they find partners in different places, like in South and Southeast Asia. The target market for the product is users who are going to buy solar systems, trying to make sure that they buy what they really need. The SolarEnabler has been trialled by Medicins Sans Frontieres and will be installed in a number of rural hospitals in Zimbabwe in 2017.

Panel discussion: Experiences of the energy-education interaction in off-grid communities

Tablet-based education in New Delhi, Clémentine Vignault

Slate2Learn is a tablet-based innovation being implemented in New Delhi's suburban and peri-urban areas, focused on delivering access to quality education to children. It provides low-cost learning via the inexpensive Android tablet platform, which links to a classroom-based, Raspberry Pi-based battery-driven Wi-Fi micro-server, which backs up to the cloud. The servers do not provide internet access to the student tablets.

Clémentine Vignault explained that rather than implementing the system in a traditional school setting (which would raise challenges of national curriculum integration, as well as structural issues of teacher availability, education politics, training, and motivation), they are designed for the ubiquitous private afternoon tuition/cramming settings.

The tablets are loaded with a number of general curriculum-agnostic education applications (e.g. basic numeracy, literacy). Since these are based on general, international standard general pedagogical approaches, rather than a specific curriculum, the system lends itself relatively easily to adaptation to different languages and regions.

The tutors or monitors are able to follow their students' progress and performance on their smartphones via the micro-server, and are easily able to intervene if and when necessary, making their tuition sessions more effective. Tutors are also able

to send updates to parents on the progress and achievements of their children via WhatsApp. Whilst the system is aimed at the five to 12 age range, its use in afternoon tutoring sessions has also opened up the possibility that the same installation could be used to teach similar skills to uneducated parents (often mothers) during the morning, achieving an innovative outcome as well as providing an opportunity for tutors to grow their businesses.

Whilst the system is being trialled in a suburban and peri-urban setting, there is no reason why a similar approach should not work in rural off-grid situations.

Off-grid schools in Nepal,
Dil Bahadur Shrestha

Nepal suffers from a very broadly distributed rural population, who are all off-grid, combined with extreme challenges of terrain and access. Rural education is, in the main, of very low quality. Traditionally schools, where they were present, would use kerosene for lighting, with the concomitant health problems that that would cause. More modern energy systems and access to electricity therefore present immediate benefits to rural education in the country.

The government of Nepal has implemented a subsidy system for solar technology. However, this is not available in sufficient quantity. The question therefore arises of how effectively to electrify all schools in rural off-grid communities.

Since the government also has a commitment to provide quality education to the rural population, it is clear that cross-ministerial collaboration is needed to provide for an effective policy for off-grid power for rural schools. Future innovations, such as the introduction of a feed-in-tariff in Nepal, might make such installations more economic and self-sufficient.

In the meantime it seems necessary to strike a balance between technological capability, a bottom-up needs assessment, and funding availability. Differences between sites also make use of off-the-shelf solutions more challenging.

Discussion

Key points made by participants in the discussion are summarised in the following paragraphs.

Governance, the rule of law, and corruption are all barriers to scaling-up and sustainability. The government of Nepal is investing heavily, but it seems that this is not achieving impact at scale on the ground in rural areas.

The challenge of engaging with the technology-ignorant is also very real, especially when local governments have failed to provide a suitable knowledge-sharing and training system. The need to find individuals in each community to interact with and engage is a considerable resource challenge; for example, for small entrepreneurs providing systems on a self-sustaining basis. It is important to focus on the customers, consider implementation rather than technology, and be aware that implementation will rarely have a short payback period (i.e. take-up and outcomes depend on a much broader range of issues).

In addition, there is the challenge of skills: the sheer scale of countries like India, or remoteness of countries like Nepal, make training challenging when taken to scale. The shortage of rural teachers in most developing countries exacerbates the situation. Challenges for roll-out include the need for superior skills in teaching professionals (to use the new technology) as well as the need to interact with additional classes of non-conventional customers (the children, who use it but don't pay) and parents (who either have a financial or a conceptual stake in the success of the new technology, but will seldom, if ever, use it or even see it being used).

Sustainability for education is often challenging. Subsidies and donations are unlikely to work, so maybe a corporate support model could be explored in poor villages where there is little possibility of community funding to achieve sustainability. Alternatively, there is the possibility of cross-subsidy from medium-income rural communities and urban areas, where families can afford to pay. However, there is often an ineffective use of resources in educational systems. In Delhi, for example, INR 1000 of central funding is allocated each month per pupil. A Slate2Learn tablet can be procured for one quarter of that cost, so it is not always the case that funding is not available. It is important also to consider the use and implementation of systems in private educational establishments—in many developing countries private education is popular due to a perceived failure of the state system.

In terms of pedagogy and group learning, a well-designed system will not result in less interaction among students, or between students and teachers. Indeed, the findings from interactive systems like Slate2Learn are that use of these systems provides new and more innovative situations for students to interact with each other, in a group learning setting.

Some challenges were mentioned with respect to monitoring the function of solutions, in that every system that can assess, monitor, and report on a cohort can therefore equally well report on what teachers are (or are not) doing.

There is a general lack of awareness and information sharing on possible solutions, however. Countries rarely implement mechanisms for learning from individual successful implementations within the country (unless implemented by the government) or indeed for sharing experiences between countries. There can also be a lack of institutional memory, so that countries do not learn from previous mistakes.

For truly "Smart" implementation in rural settings, children and families also have to be satisfied with the value of education, which means (in particular) the creation of suitable innovative employment or entrepreneurial opportunities for graduate students to go into, in order to discourage their migration away from the village. There are also convergence opportunities in smart villages; for example, schools could carry out health screening as well as teach, or deliver life-skills training to adults as well.

Failures are often a good way to learn for future interventions. However, true educational outcomes take time to be demonstrated in the very few cases where there is a system for assessing and measuring impact. Failures in rural energy-education projects have therefore tended to be technological (technology did not work, was vulnerable to the environment, or was rapidly superseded) or political (like if the project is in competition with a private school owned by a local politician).

A general issue is that policy makers, in general, still do not understand rural off-grid power and its possible smart applications in a village setting. There still tends to be a fixation on kilowatts rather than outcomes and applications, which results in systems being poorly designed and/or over-specified. For meaningful rural energy access, and application of that energy to education, decision-makers have to care not only about rural areas, but also education equity and community self-determination, and be open to innovative solutions.

Panel discussion: Experiences of the energy-health interaction in off-grid communities

Enhancing village-level healthcare: a view from the forest sector, Dr Chaw Chaw Sein

Chaw Chaw Sein, from the Myanmar Forest Research Institute (FRI), presented the experiences

of enhancing village-level health in Myanmar through biomass energy access, improved cookstoves (ICS), and ICT.

Myanmar has abundant renewable sources, with almost 80% of primary energy supplied by firewood (the forest cover is 31 million ha throughout the country), charcoal, bamboo, agricultural residue and animal waste. Among these, wood and bamboo are an important source of biomass fuel. The government has been encouraging people to plant new trees to replace those cut down; however, the low cost and convenient access to the nearby natural forests has made it difficult to convince local people to give up logging. Almost 15% of the world's total energy supply comes from the forest to supply cooking and heating. The ratio could be as high as 35% in developing countries like Myanmar.

About 76% of firewood and charcoal are supplied by the forest sector in Myanmar. The annual deforestation rate remained around 0.55% between 1990 and 2010. An important scheme initiated by the Myanmar Forest Department is the National Energy Policy. It included actions for the establishment of village supply plantations, distribution of improved cook stoves, utilisation of agricultural residues, raising local people's awareness of clean energy to reduce the use of traditional firewood stoves, and carrying out further research and development.

The improved cookstove (ICS) development programme (a REDD+ project) is a good example of the R&D. The Myanmar ICS programme started operations in 1986. It sought to encourage people to give up traditional open-fire stoves in rural Myanmar, which consume more firewood (leading to deforestation) and pollute the air (damaging human health and contributing to greenhouse gas emissions) and adopt ICS. The A-1 version of the ICS was developed and tested in 1992. It used 40% less firewood, had higher efficiency (reducing cooking times) and produced less smoke compared to open-fire stoves. Additionally, the ICS is portable so it can be moved anywhere for cooking.

ICS distribution was accompanied by awareness-raising workshops to encourage firewood saving and reduction in cutting down trees for fuel. Despite some success, several challenges still remain: most of the natural forests have been degraded to bushes, and Myanmar has been experiencing higher incidence of drought and higher than normal temperatures due to the lack of monsoon, possibly as a result of climate change impacts.

According to Chaw Chaw Sein, there are some key elements that can be of great benefit in the control of firewood consumption in Myanmar. While using ICS is an important step forward, there is a need to do more, such as encouraging the use of agricultural wastes, improving people's awareness about the issues through public talks, and by establishing a model village for utilisation of firewood substitutes. Myanmar is highly dependent on agriculture: 70% of its population is rural and mainly relies on agricultural activities. Therefore using agricultural waste could be an efficient way to decrease household cooking costs.

To succeed in the ICS project, FRI relies on collaboration with NGOs like the Mercy Corps and GERES (Group for the Environment, Renewable Energy and Solidarity). A project that is jointly implemented with Mercy Corps uses two models for distributing ICS: (1) through project agents who sell the stoves directly to consumers, and (2) reaching consumers through partner organisations (e.g. World Vision). So far, the project has reached nearly 600 villages with a network of 406 vendors, and had sold 19,234 stoves.

FRI is also planning to be involved in other projects that address R&D and training needs for bioenergy and other renewable energy sources in Myanmar.

Clean cookstoves for reduced smoke exposure in Cambodia, Laos and Vietnam, Hong Hanh Nguyen

Hong Hanh Nguyen from SNV presented on their experiences of promoting clean cookstoves to reduce the health risks of smoke exposure from open-fire cooking in the Mekong delta.

SNV believes smart development can end poverty in developing countries around the world, especially in the field of renewable energy. SNV has carried out biogas programmes in 17 countries and clean cookstoves programmes in 25 countries. It also cooperates widely with other partners and donors in the Mekong region, such as USAID and ADB.

A long-ignored health risk is smoke from cooking, which can cause death from pneumonia and other diseases. In the Mekong delta, the traditional way of straw cooking produces much indoor smoke, damaging people's health. However, there are still low levels of awareness of the damage to health from smoke from cooking. Promotion and training are required to raise awareness. As the silent killer in the kitchen, more than 65,000 HAP-related deaths are reported per year. Smoking has become a leading risk factor for diseases in Vietnam. The shocking fact from a Harvard study indicates that typical traditional stoves release 400 cigarettes per hour worth of smoke!

In order to reduce the negative impact of smoke from cooking on health, we need clean cookstoves. The improved cookstoves ACE-1 use gasification to emit less smoke. The SNV project also monitored PM values in the kitchen and on people by using detection devices to collect data to evaluate the effect of ACE-1 on reducing emissions and smoke. Cooperating with the World Bank, LIRE, GeoSys, CSQ, and Berkeley University, the team studied the kitchen air pollution levels and personal exposure.

The case study in Lao PDR of 72 households showed that using ACE-1 improved cookstoves, rather than traditional stoves, reduced personal exposure to PM2.5 from 96 to 66 $\mu g/m^3$. The case study in Cambodia of 48 households showed that using ACE-1 improved cookstoves reduced personal exposure to PM2.5 from 66 to 47 $\mu g/m^3$; while using biogas cookstoves reduced personal exposure to PM2.5 from 73 to 28 $\mu g/m^3$. The WHO guideline is 10 $\mu g/m^3$.

The SNV clean cookstoves programme in the Mekong region (2015-2019) covers Cambodia, Laos and Vietnam. The programme takes a market development approach and provides result-based financial incentives through the stove auction to promote the use of clean cookstoves. A market study carried out by SNV showed that 70% of the rural population in the region still use traditional stoves, so the potential market of 12.8 million households is large. However, many project interventions are initially successful but not sustainable in the long term. The private sector's participation also suffers from many challenges, such as financial constraints and the need for capacity building.

The adoption study of 46 households in two locations indicated that negative health symptoms from cooking smoke included headaches, coughing, stinging and watery eyes, and difficult breathing. Therefore there is a big potential market to promote clean cookstoves in Cambodia, Laos and Vietnam.

Discussion

Points made in discussion on the two presentations are summarised in the following paragraphs.

Forests are important sources of cooking fuel (firewood) in most Southeast Asian countries. This leads to destruction of natural forests, with re-planted forests taking about five to 10 years before they are ready for exploitation. Firewood is easy to access for most rural communities, therefore it is difficult to control deforestation.

Even if ICS are sold cheaply or provided for free, local people still prefer the traditional way of cooking on open-fire stoves, for socio-cultural reasons. There is generally very little awareness about the health impacts of open-fire stoves and the advantages of using ICS, yet cooking is an important factor in indoor air quality and for the rural poor. For these reasons most ICS projects fail to progress beyond the pilot phase.

Electrification rates are very low; for example, in Myanmar's capital, Yangon, the electricity supply is still unstable, and only about 20% of the city has day-long power supply. As a result, most people use firewood for all their cooking, or for cooking certain types of food, in both urban and rural areas.

One key issue to consider when assessing ICS project sustainability is ownership of the project. Ideally, the Ministries responsible for health and the environment would operate the projects. However, in practice, there is often little collaboration between these Ministries in countries in the Southeast Asia region. While strategic plans may be in place for clean cookstoves, there is generally a lack of clear details on how they will be achieved. Although energy saving is sometimes not an attractive motivation for the government, highlighting the health impact of highly polluting cookstoves may influence politicians and public opinion more.

Financing arrangements are also important for project sustainability, not only for the finished improved cook stoves but also for the entrepreneurs who manufacture them. SNV implements a market-oriented auction scheme, in which qualified producers bid for stove production contracts and access to the SNV network of customers. The profits for producers are very small, and SNV only pays the producers when the stoves are sold, in a results-based manner.

Even though air pollution is a big threat to health, it is difficult to observe. If this information could be better communicated to the general public, even the cultural factors that make people continue to use firewood for cooking may be overcome or better managed (perhaps by improving ventilation in cooking areas and kitchens where possible). For example, installing air quality monitors (even temporarily) in cooking places and relaying the results in layman's terms (with reference to WHO limits and indicators) may help. It was suggested that in considering the smoke-related respiratory illnesses such as pneumonia, lung cancer, and chronic obstructive pulmonary disease it might help to highlight research findings, which have shown that an open fire in a kitchen generates pollution equivalent to burning 400 cigarettes per hour.

Mobile phone-enabled healthcare in rural Nepal, Jay Evans

Jay Evans discussed the interaction between healthcare, energy, and ICT, expanding on his earlier keynote presentation. He reinforced three themes:

1. Better coordination is required. The Ministries and departments have overlapped their jurisdictions and responsibilities, which has made project intervention difficult.

2. Promoting evidence-based skills is essential. Evidence, such as how many users and how many villages, is important for scaling up the number of projects and their impacts.

3. The human resources wrapped around the initiative are also crucial. Self-help groups can usefully be formed for long-term diseases.

Chronic diseases such as cardiovascular disease, diabetes, and cancers are increasingly important and pose different challenges compared to accidents and emergency services.

Discussion

With very limited investment in healthcare in South and Southeast Asia, there is the need for new models that require less intensive investment in human resources. For example, patient education to promote self-monitoring and self-care for long-term diseases, including primary self-diagnosis and prevention, could be delivered through ICT-enabled platforms. This way, authorities would make better use of the few nurses who are available to facilitate self-care and self-help groups for community-based information exchange and to offer communal support.

Community support groups can also be used for preventative initiatives, such as community education and screening for diseases. Private pharmacies could also be involved in the initiatives; not necessarily high-end, but dispensing drugs and testing at the contact points and retail shops. People go for different approaches, from Western medication to the traditional ways, to find solutions.

Touchpoints for services like long-term care in rural areas may be a challenge, because it is not always possible for people to travel to the cities. This is especially important for off-grid remote villages that lack suitably qualified professional human resources and medicine supplies. In such cases, there is a need to teach or sensitise the community; but the cost is high, with extremely poor infrastructure and a lack of doctors and nurses. Care pathways supported by mobile phones are an attractive possible solution, but in most cases it takes more than technology for the solution to work and it is not always clear how these self-supporting healthcare systems will be financed. Possible sources of finance are patient fees, collective savings in the villages, or healthcare insurance system. All these sources have problems with collection mechanisms, such as via payrolls for employed subscribers, and rural people are usually short of cash or do not have a natural propensity to pay for healthcare and insurance for future healthcare.

It can be argued that access to energy will not only improve the quality of healthcare services but also the general lifestyle for rural dwellers. For example, energy access may lead to increased family incomes and, therefore, release more resources for use in accessing healthcare, or make cooking a less onerous or polluting exercise so that it will no longer be the sole responsibility of the females in the household.

Usually, the Ministry of Health is so distant from rural clinics that it is not aware of the clinics' operations. Low-cost access to energy and ICT connectivity could help in the sharing of information within the healthcare system, like improving technical and financial reporting or remote-monitoring systems. This improved linkage and information exchange would help in gathering evidence for policy and financial planning, monitoring health outcomes, and resource planning (including developing more tailored specifications for healthcare facilities).

Plenary discussion: Experiences of energy-education and energy-health interactions in off-grid communities

The parallel discussions of the health and education tracks sought to address the key topic of the complex relationships between energy, as a core element of smart villages, and other developmental parameters of healthcare and education.

Energy and healthcare

Three presentations were given in the healthcare track discussion session, covering village-level healthcare, clean cookstoves and in-country experiences. There were a couple of key messages from the discussion. Smoke generated from traditional cooking systems, such as open-fire stoves, is a major cause of health problems and diseases. As mentioned, the typical traditional open-fire stoves release smoke equivalent to burning 400 cigarettes per hour. Therefore, clean cookstoves

can make a major contribution to improving health in villages. Experiences of both the Myanmar forest sector and the SNV programme in the Mekong delta have repeatedly reinforced this point. Meanwhile, there is a need to improve the sharing of evidence and solutions from various sources to progress overall rural development. Sharing good evidence about the impact of traditional cookstoves' pollution on human health could also be useful to persuade people to use clean cookstoves. All presentations mentioned the lack of coordination between ministries and governmental bodies, in this session particularly the Ministry of Health and the Ministry of Energy or the Environment.

There is a new raft of healthcare concerns in the form of chronic and non-communicable diseases, like diabetes, cancer, and heart conditions. These require more intensive and long-term interaction between patients and the healthcare systems, such as pharmacies, rehabilitation centres, and retail shops. Modern technology might help in these interactions. For instance, modern mobile phones can be used for sharing information and running apps that better connect Ministries responsible for health, local clinics, and other allied service providers. Given the limited healthcare resources in the rural areas, there is a need to make the most of what is available. For example, healthcare spending is only US$36 per person per year in Nepal; therefore it is necessary to explore ideas and system solutions that maximise the value without the need for further investment. In all cases, understanding the overall healthcare system and the way it relates to other public service systems in each country (such as the country's overall taxation system) is crucial in order to understand how village healthcare fits into the big picture.

The healthcare discussion concluded that it is useful to explore the best way to spend the next dollar, and collect better data to inform policy and attract further funding.

Energy and education

Two presentations were given in the education track discussion session, addressing the Slate-2Learn technological innovation project and Nepalese experience with off-grid schools. Slate2Learn is a tablet-based innovative education project targeting young age groups. So far, this system has been trialled in suburban and peri-urban areas, and there is great potential to explore the possibility of applying it to rural off-grid communities.

Discussion of the Nepalese experiences with off-grid schools revealed the positive impact of combining education with a quality power supply. A general concern with education is that it should be a public good, whose provision is assured by the government. Involving the private sector in such an environment is not necessarily successful. However, inappropriate participation of the government may also be problematic, such as weak governance capability and mismatched subsidies.

Technology could mainly be used to help support the educational content, which is usually lacking or out-of-date in rural areas. It is also essential for nurturing skills and awareness about technology in school children. Teachers need to teach but also to (continuously) learn, yet ironically the learning and training of teachers is generally lacking. As a result, the quality of teaching in most rural schools is not necessarily good because of the lack of continuous learning about new technology and professional development for teachers. This is a gap that could be plugged through access to energy and ICT connectivity.

To ensure sustainability, projects should value local methods of education while ensuring that education in villages will be good enough for school leavers to obtain the relevant skills to participate in the job market, locally and in the cities. There is no universal approach to solving the education problem, because both the language and approach differ from country to country. Also, curricula are ever-changing and it is costly to rebuild the local

systems to implement changes in remote areas, so the Ministries of Education might not be willing to intervene. However, with access to energy and ICT connectivity, it is possible to generate small changes, such as providing educational tools, developing homework that applies to the specific context, and building teacher skills and knowledge.

In order to raise people's awareness of the importance of education in rural areas, it is important to link education with opportunities in the village, like incorporating some practical or life skills that are attractive to villagers, such as primary banking and marketing for local produce or services. This way, it would be possible to demonstrate the value of education to the community and get their buy-in for specific interventions.

There are other complex issues regarding the relationship between education and energy, such as the shortage of teachers, low quality of educational systems, and limited application of technology, so the link between energy and education is not a simple vertical connection. There is a need to learn from the failures, including technology failures, and to realise that there are other external reasons for project failure, such as social and political issues. Governance, the rule of law, and corruption were cited as common barriers to scaling-up and sustainability of most interventions.

In general, education outcomes are difficult to measure: most of them require long-term observation of the intervention outcome or impact, and consideration of the whole community or system.

Concluding remarks

There was a follow-up discussion after the two parallel sessions. Workshop participants agreed that although ICT intervention is necessary and useful in villages, it might not happen at the needed scale any time soon. Even for those villages with ICT coverage, a lot of work is required in selecting the content and context of using ICT to foster development. This requires government guidance and regulation, e.g. in curriculum development. As for the shortage of teachers, nurses, doctors and other front-line practitioners in rural communities, the general lack of basic infrastructure (including roads, energy, and healthcare facilities) discourages suitably qualified individuals from choosing to work in rural areas. Experiences from the pre-workshop field trip to an off-grid community in rural Thailand indicated that villagers wanted their children to receive proper education and then return back to work in the village, e.g. as local teachers.

Obtaining funding is generally difficult for both healthcare and education solutions, so that in the absence of big funding bodies interventions are not possible when working with governments that lack the necessary fiscal capability. Funding is as important as other policy support mechanisms. Experience indicated that it should be possible for partial funding to come from the village collective funding pool and using local human resource support could bring costs down.

Another concern is the need for an integrated approach that connects all aspects of functional smart villages, rather than having isolated discussions and interventions on each issue. Education and healthcare are deeply linked with the economy, and they are key aspects of improving income and livelihoods in rural communities. Therefore a smart village approach to development should be holistic and take into consideration all aspects of rural life. Energy should be treated as an input, not the end result.

While it is known that top-down technology solutions rarely work, the same mistakes have been repeated several times and the common disconnect between policy-making and the real demand for solutions is persistent.

Session 2: The role and viewpoint of young scientists on science-policy issues related to smart villages

Welcome remarks: Introduction to the Global Young Academy and outline of Session 2

Dr Almas Awan, GYA, Brazil and Dr Moritz Riede, GYA, UK

Almas Awan and Moritz Riede welcomed all participants on behalf of the Global Young Academy (GYA, https://globalyoungacademy.net), and opened the second day with a brief introduction to the GYA.

The Global Young Academy was founded in 2010 by young scientists attending the World Economic Form (WEF) after they saw few opportunities for early and mid-career scientists to engage in international, interdisciplinary, and intergenerational dialogue—with each other and with external stakeholders—and to contribute to science and society internationally. The GYA is rapidly filling these gaps and aims to become the voice of young scientists around the world. The GYA's mission is to empower early-career researchers to engage in and lead such dialogues by developing, connecting and mobilising young talent from around the world and promoting evidence-based approaches and inclusiveness in global decision-making.

As of 2014, the GYA had reached its full capacity of 200 members. GYA members are appointed to five-year terms based on their demonstrated research excellence and commitment to improving the state of science and its links to broader society. After the five-year term, members become GYA alumni and take on advisory and support roles.

GYA activities focus on science and policy, education and outreach, and strengthening international networks of researchers. The GYA Annual General Meeting alternates between the developed and developing world, stimulating transnational

Workshop participants listen to SVI's Dr Bernie Jones.

research, and raising the profile of science in a different host nation every year. GYA also supports the formation of, and cooperation among, National Young Academies, and has organised regional meetings of Young Academies in both Africa and Asia as well as worldwide meetings. GYA members are regularly invited to represent young scientists at external meetings, providing input to international organisations such as UNESCO, the WEF, and the recently formed UN Secretary-General's Scientific Advisory Board.

The GYA also publishes timely reports for policy makers on topics of global importance. Its 2014 report on the Global State of Young Scientists (GloSYS) is an overview of the opportunities and obstacles shaping worldwide research capacity, which is currently focusing on Africa and the ASEAN region. In 2015, the GYA launched joint projects with the InterAcademy Partnership (IAP—the Global Network of Science Academies) on Solid Waste Management and Green Economy, and with the European Commission's Joint Research Centre (JRC), identifying 'Invisible Worlds', i.e. emerging issues of societal relevance that are insufficiently covered in the media and policy agendas.

The GYA head office is based in Germany within the German National Science Academy Leopoldina. The GYA receives its core funding from the German Ministry of Education and Research (BMBF) and additional project funding currently from the IAP, the Leopoldina, the Thai National Science and Technology Development Agency, the Bosch Foundation, and the Volkswagen Foundation.

Keynote Address: Challenges and Opportunities for International Cooperation in Green Science, Technology, and Innovation

Prof Mohamed Hassan, TWAS, Italy

Mohamed Hassan began his presentation by outlining the challenges the world currently faces in the area of sustainability. Rio+10 (2002) identified water, energy, health, agriculture, and biodiversity as the main challenges. Ten years later, Rio+20 added cities, disasters, peace, inequalities, education, and jobs as further global sustainability challenges. To address these challenges and transform the world, the UN defined 17 Sustainable Development Goals (SDGs) in 2015.

The goals of eradicating poverty, tackling climate change, obtaining affordable and clean energy, provision of clean water and sanitation, protecting the oceans, and having sustainable cities and communities, decent work, and economic growth highlight how global, complex, and interconnected the sustainability challenges are. For example, climate change has multiple impacts on water, oceans, and disasters, whereas developing countries are most vulnerable—in particular Africa—because of their fragile ecosystems and adaptation capacities.

International collaboration in scientific research and education, based on shared global goals and capacity needs, is critical to addressing sustainability challenges, and there are several areas with significant opportunities and success stories. ICT is key to attaining most SDGs, for example: it allows the real-time monitoring of environmental change and natural resources through ground-based sensors and satellite data, as well as access to education in rural communities. Modern biotechnology, controversial as it may be, has promising new applications in agriculture, medicine, and the environment by, for example, developing pest-resistant, drought-resistant, and higher-yielding crops. Nanotechnology is one of the fastest-growing technologies in the world today, with applications in improving agriculture, new solar cells, and water filtration systems. Finally, renewable energy technologies are growing rapidly, with solar soon to become the dominant source.

China is leading the world in renewable energy investments (in 2015 it invested more than

US$100 billion, which is 36% of the world total). Africa has the greatest potential and need for renewable energy: it has an abundance of sun and wind as well as opportunities for geothermal and hydropower, but 70% of Africans (including 90% of African small-scale farmers) have no access to electricity and their needs would be best served by small-scale renewable energy systems. For those far from the grid—and there are many—rural electrification is the key: it provides food, water, and energy security and improved income for farmers. Scaling up smart villages needs integrated innovations, not only in Science Technology and Innovation (STI) but also in social innovation and business innovation along with governance innovation.

There are several major initiatives around the world trying to address these challenges and harness the potential of STI. The G20 has a special responsibility to lead global partnership in sustainability science and green technologies, and endorsed that 1% of their GDP will be invested in green technologies, which China and South Korea take seriously (having invested 3% of their GDP each, while others still spend below 1%). 2016 was an important year for renewable energy and STI: China pledged US$3 billion to the China South-South Climate Cooperation Fund and the US pledged US$3 billion to the UN Green Climate Fund. Furthermore, over 40 countries, including many least developed countries (LDCs), at COP22 in Marrakesh agreed to strive to shift to using only renewable energy by 2050, while the UN established the Technology Bank for LDCs and a trust fund to support its operation.

Science academies worldwide will play a key role in addressing these challenges. Academies have a reputation for excellence and independence, which they can use to influence change. They can mobilise the best scientific minds and allow networking to act jointly to address regional and global challenges. Academies have joined forces and formed regional and global networks. For example, The InterAcademy Partnership (IAP) includes 111 senior, merit-based academies and its members come together to (among other things) strengthen their advisory capacity and influence policy by producing and disseminating joint consensus statements and reports on regional and global issues. In the Young Academy ecosystem, there is the GYA and about 30 active national young academies. Together, they issue short statements and consensus reports as well as work on science education and literacy.

Mohamed Hassan concluded his presentation with recommendations for the Smart Villages Initiative on their road ahead into a second phase: Continue and strengthen existing collaboration with GYA and National Young Academies as well as with the IAP and regional networks of academies; Adopt the integrated innovation approach to bring the Smart Villages Initiative to scale; Introduce Inquiry-based Science Education and Education for Sustainable Development to school teachers in smart villages; Establish a smart villages forum or alliance; Collaborate with government science advisors and advisory councils to bring the Smart Villages Initiative to the attention of politicians and policy makers, and finally, Develop a partnership with the UN's Technology Bank For Least-Developed Countries.

Discussion

The discussion following Mohamed Hassan's presentation revolved around two main points: (1) China and (2) the role of academics in international cooperation on green science, technology and innovation. The global production of oil and gas will significantly change by 2030. China is seen as being very aware of that, and also of environmental issues associated with fossil fuels. China is trying to completely change its energy structures and has put corresponding commitments into place. For example, they are investing heavily into smart cities (however, there are not many smart villages yet and it is still an open question whether there are any lessons learned that can be transferred from smart cities to smart villages).

The second main discussion point was on how to get science academies and academics involved. The challenge is not only about the actual science and technology, but how to get scientists to engage. This is working well with the GYA, but not with senior academies, where only a few have so far recognised their role in society and actively engaged with societal challenges. For example, the Sudanese Academy is teaming up with the Sudanese government to solve regional challenges. The question about how to bridge the gap between academia, the government and other practitioners can be answered through workshops like this, where science innovators, business innovators and government officials exchange ideas and come up with concrete ideas to carry forward.

Presentation 1: Unlocking the role of women to ensure the success of Smart Villages

Dr Sohasini Sudtharalingam, PWC, UK

On International Women's Day 2017, which happened to coincide with the workshop, Sohasini Sudtharalingam addressed the important role of women in smart villages. At the same time, she stressed that even though her presentation focused on enhancing the role of women, one should think more broadly in terms of inclusiveness for all marginalised groups and the benefits of effective smart villages.

In the next decade, nearly one billion women will enter the global workforce. Increasing female employment would significantly increase the gross domestic product (GDP) in many countries, particularly in countries like Egypt and India where female labour participation rates are below 30%. If female employment rates matched the male rates, the GDP in Egypt and India are forecast to increase by about 35% and 27% by 2020[1]. Even Sweden, which is very progressive in terms of the economic empowerment of women, would see an approximately 2% increase.

Smart villages encompass a range of characteristics, from meeting basic needs like clean energy, water, food, and access to good quality health services and education, through to providing the ICT infrastructure for access to information and markets, high-value-added production and economic activities and job creation. Smart villages would also support collective decisions and actions for well-managed resources; for example, by pooling together production, and better management of the environment for current and future generations. With highly productive villages and the corresponding job opportunities, the standard of living in villages would increase along with a reduced migration to cities. It is crucial to stress that introducing technology alone is not the solution; it needs to be accompanied by the appropriate enabling environment.

Sohasini Sudtharalingam used energy, water, sanitation, and agriculture as examples to highlight the successful role of women in these areas. Energy is a catalyst for the development of multiple sectors, from basic services (education, health, water, etc.) to productive activities (e.g. businesses and industry). Women can act as entrepreneurs and providers of sustainable energy solutions at the community level and as agents of change in other areas, whilst economically empowering themselves. M-KOPA, a "pay-as-you-go" energy business, has demonstrated in East Africa how important the role of women is in the dissemination of sustainable energy solutions given their network across villages.

Clean water and sanitation are basic needs and essential for health and productivity. One estimate suggests that some 40 billion hours a year are spent collecting water in sub-Saharan Africa—equal to a year's labour for the entire workforce of France

1 http://www.economist.com/news/economic-and-financial-indicators/21564857

(UNDP, 2006)[2]. Women can play an important role, as the WaterSHED project in Cambodia has demonstrated. Water, sanitation, and hygiene products can be "marketed by women, to women" and they will adapt marketing tools to be more appealing to female consumers. WaterSHED has already recruited more than 175 rural Cambodian women.

Finally, climate-smart agriculture could drive up productivity. Women—especially in developing countries—are often more exposed to the risks of extreme weather than men, because they can be less mobile and lack access to traditional means of communication according to the UN's World Meteorological Organization (WMO). The Center for Environment and Agricultural Policy Research, Extension and Development (CEAPRED) in Nepal piloted climate-smart villages to educate smallholder farmers, especially women, about climate-smart farming techniques and help them access weather and vegetable price information using mobile phones. Testimonies from female farmers show that they are seeing the benefits; they are already seeing the monetary savings by switching from chemical to homemade pesticide and using wastewater from cleaning on vegetables planted in their backyards. As a result, these women now feel empowered by knowledge.

There are several sectoral innovations that are seen as having the potential to create a positive disruption: new energy models (e.g. rooftop solar), financing and payments (e.g. via mobile phones), improvement in data collection and information transfers (e.g. new mapping approaches to highlight areas with broken streetlights, along with ways to report such issues), and education and skills improvements (e.g. ICT skills). Women and marginalised communities should be brought along the journey to be part of the workforce and voice of the new society that exploits these innovations and puts them to use.

To unleash the positive potential of women in the workforce, several key issues need to change—in particular access to education and knowledge, energy, finances, and mentors. This requires creating an enabling environment, including improving the perception of the role of women in family and society, enacting better laws and legal protection, having fairer hiring procedures, and recognition of unpaid household work. The resulting pathway of change would start with meeting basic needs and addressing vulnerabilities. The next step would be addressing strategic gender and inclusion issues beyond basic needs, so that individuals are empowered to make active choices, and build their assets, capabilities and opportunities. This would finally lead to a structural transformation, getting at the root causes of inequality and may address norms and systems that exacerbate this. Using water as an example, this would resemble getting access to clean water and adequate sanitation as a first step, subsequently getting women actively involved in the workforce (e.g. monitoring water quantity and quality levels for the service provider) and finally, getting everyone involved in decision-making and the chores related to water and sanitation.

Discussion

Following Sohasini Sudtharalingam's presentation, participants shared their observations and comments on the role of women in smart villages. For example, the Smart Villages Initiative has published a report on energy and gender, as it is so fundamentally central to sustainable villages. Energy and education cannot be separated, and it is similarly important to approach energy and gender holistically. Another participant shared results of a study from the Philippines on energy and the agricultural sector, where women play a central role in post-harvest processing. With energy, they can have lighting, and it is then possible for them to extend their working time to after dark. As a result, women can generate

2 United Nations Development Programme (UNDP). 2006. Human Development Report 2006: Beyond Scarcity: Power, Poverty and the Global Water Crisis. New York: Palgrave MacMillan, p. 47.

more income and paying for lighting becomes a non-issue. Similarly, without electricity, women and mothers mainly carry out household chores. With the introduction of electricity and electrical household appliances (e.g. rice cookers), household chores have now become a family activity; one participant said, "With a rice cooker, even men can cook rice now."

Presentation 2: Education and Development in Rural Communities

Dr Aftab Ahmad, National Academy of Young Scientists, Pakistan

Aftab Ahmad, who gave his presentation remotely from Pakistan via Skype, started his presentation with two quotes: "Education is the most powerful weapon which you can use to change the world" (Nelson Mandela) and "Extremists have shown what frightens them most: a girl with a book" (Malala Yousafzai), both stressing the importance of education.

Over the past few years, the rural population in South Asian countries has continuously declined, from about 72% in 2004 to 67% in 2015. In Pakistan, even fewer people lived in rural areas in 2015 (approximately 61%), and there are significant differences in education between rural areas and cities. In Balochistan, in southwest Pakistan, 66% of children are out of school (accounting for 7% of all Pakistani children), whereas in the capital region of Islamabad 16% are out of school (0.2% of all Pakistani children). Overall, around 50% of children are out of school in Pakistan. Furthermore, with the exception of the capital region, more girls are out of school, often by a significant margin, than boys. The two main reasons why girls are out of school are their parents do not allow it (34%) and the children are not willing (20%). The picture is different for boys, where the top two reasons are that the children are not willing (38%) and education is expensive (19%). Only 6% of the boys do not go to school because their parents forbid them! Of the out-of-school children (OOSC), around 70% have never been to a school. In the capital region, 95% of the children can be retained in school up to class five, compared to the national average of 48%. Another main reason for OOSC is poverty: children drop out of school to learn different skills and earn money for the family, so that about 57% of the OOSC are from the lowest income group and only 10% from the rich.

The main challenge is to improve education and reduce OOSC, particularly in the rural areas, and there are several initiatives that try to do this. One such initiative is Science for Youth, which was started in 2011 with the aim of promoting education in schools and colleges. It focuses on rural communities and encourages researchers to visit schools in their areas and participate in different activities. Science for Youth also involves various competitions (e.g. sketches, models and essays) and exciting experiments to get the children involved and improve their interaction with researchers. One of the factors that is considered very important is career counselling. Most of the children think that there are only very limited options (e.g. a medical degree), but counselling exposes them to many other career options and fields of study. This is usually done through lectures, both general and subject-specific ones, to give the children a better understanding of their opportunities and what they can do with their knowledge to help their villages.

The main issues with the educational system are: lack of high quality teachers in schools, obsolete teaching methodologies, poor healthcare and nutrition, lack of checks and balances in the school system, lack of facilities in rural schools (including teaching facilities and equipment), and language or dialect barriers. To solve these issues, several approaches are required in parallel. Food provision in schools would have a major impact and support growth and development by improving the children's physical and mental health. Currently, half of the deaths of those under the age of five are due to malnutrition and 44% of Pakistani children are stunted. Pocket

money would incentivise children and reduce the burden on their families, which should also improve the retention rate at schools. Similarly, providing free books and school uniforms would reduce the burden on poor families and incentivise studying. Methodologies like inquiry-based science education, learning by doing and more interactive elements could update and innovate the educational system and help pupil retention rates. This will require better teacher training, taking into account the latest understanding of how children learn best in the given settings.

To scale up what has worked in other places, ICT could help with disseminating what model modern villages look like, how health and education can be improved and what can be learned from others, which can easily be implemented in the local language, cultures, and so on.

To address the poverty, small local businesses are required. Agriculture and dairy have been identified as the main businesses that can be improved to empower people in rural villages. Doing this also requires the education of farmers, and ICT is increasingly being employed to both answer farmers' questions and distribute information like health education for farmers.

Aftab Ahmad also recommended model villages as a method of intervention. These would set an example for other villages, showcasing good health and education systems, playgrounds for young people, and proper electricity and internet services, providing a reference and a starting point for other villages.

Plenary Discussion on the Role of Education and Women in Smart Villages

Panellists: Dr Uttam Shrestha, Dr Sohasini Sudtharalingam, and Dr Aftab Ahmad

Panel moderator: Dr Almas Awan

Following the previous two presentations, three panellists led workshop participants in a discussion about how important education is to rural communities and the barriers to implementing education initiatives in rural areas. **Uttam Shrestha** started with his background, having being born and raised in Nepal. He went on to talk about how the education provided to rural communities must be relevant to their needs. Education should enable development in rural areas in order to slow down migration to cities or overseas.

For villagers, education is a double-edged sword: educated individuals are exposed to various opportunities and if the villages do not provide opportunities, the individuals emigrate, making villages "empty" rather than "smart". Currently, about 55% of the households in Nepal have at least a single member abroad. The situation is worse in the villages and among the educated individuals. It is human nature to look for better living standards. If the education provided makes the village residents more aware about how good life appears overseas without providing solutions to improve or develop the local community, more people will emigrate. Uttam also highlighted the role of basic infrastructure (e.g. water and sanitation, transport and healthcare) in rural development and how, compared with the 'high-tech' solutions like using ICT for education, it may be more important to begin with. For example, in Nepal, many girls do not go to school because there are no female toilets available on site.

Aftab Ahmad suggested that a model village should be constructed and set as an example for the rest, to promote education effectively in the village. There are many similarities between south Asian countries (e.g. Sri Lanka and Pakistan) so they can learn from each other. The key issue in most countries is still government policy. In Pakistan, a huge part of the population has never participated in school education, yet only 2% of the country's GDP is allocated for education. Hence, the first step is to influence the policy-makers to increase this investment.

Discussion

In south Asia (e.g. in India and Pakistan), one of the key barriers to promoting education is related to the fact that the community is multicultural. The number of teachers who are willing to work in villages is low and the multicultural community exacerbates this shortage, as teachers who do not know the language and culture of a particular village may not be able to live or work there. Teachers need to be trained so that they are fit to teach in the village. Perhaps top-down methods are needed to some extent. Privileged people who have the opportunity to obtain a good education abroad or in the city should reach out to the community and encourage the villagers to learn, and tell them not to come to the cities—even though most privileged people have stayed in the city, so telling others not to move there is a contradiction.

South or southeast Asian individuals who are first in their family or community, in particular women, to go to university, or go to study and work abroad, sometimes feel that it is their responsibility to return and work in their countries. However, an alternative view was offered: scientists, no matter where they come from, should consider working wherever they felt they could do good science, even if that means leaving their countries of origin.

The government of Pakistan has taken steps to bring education and health initiatives to villages. A previous project that sought to improve more than 4,000 village schools, focusing on Punjab Province, recently started work on improving energy access in villages. The project works with university academics to train rural teachers in using more relevant teaching methods, such as carrying out experiments during science lessons. This capacity-building programme has led to significant changes in attitudes and the new generation of teachers and scientists are keen to participate in it. However, one major problem with the capacity building is that some practitioners choose to leave the villages or Pakistan , and the authorities have not been able to address the root cause behind this emigration. While there are many possible causes, bringing change in the government's mindset appears to be the most important. For example, the Pakistani education system has many types of schools, which is the major problem in capacity building—more problematic than the language barrier. A policy to standardise the system to harmonise all schools may be a major first step.

Education goes beyond simply setting up a school. Other elements such as good quality teachers, books, and facilities are necessary for a school to function. Energy supply is an important ingredient for improving the quality of education delivered. With a reliable electricity supply, a school can actually act as the education centre. Besides allowing students to do homework and reading at night, the school can also be the centre for community gathering, including community training. Therefore, if it is not possible to supply energy to the whole village, it is better to at least electrify the village school; then it will be the hub of development in the village. Other developments will gradually follow with time.

On the other hand, there is a case from Myanmar, where villagers opted to install solar energy in their homes, leaving the school without electricity. The teachers in that case said that, while it would be good to have a solar energy system in the school, they did not really need it for teaching because the school only opened during the day and they did not have any electrical appliances to use in their teaching. Instead, they needed solar power to desalinate water and to supply clean water in their homes, which was more important to them.

Conclusion: Uttam Shrestha brought up the idea that in considering smart villages, there is a need to bear in mind the issue of resilience. A smart village should be resilient to various shocks and natural disasters. For example, many schools were destroyed in Nepal during the 2015 earthquake.

Sohasini Sudtharalingam suggested that to foster resilience schools should act hubs or assets shared by many people; in other words, there is a need for innovative solutions that integrate various socio-economic activities into the school so that the whole community owns and uses it. Aftab Ahmad reiterated the need for lobbying governments to allocate more funds to education, including electrifying rural schools and for programmes that improve the link between universities and schools.

Presentation 3: Energy Innovations as a Major Factor for Transition to Smart Villages

Dr Bartlomiej (Bart) Kolodziejczyk, H2sg Energy and Scientists-in-Residence, Australia

Bart Kolodziejczyk introduced H2sg Energy as an energy company that works mainly in Asian and Pacific regions. Its main technology platform aims to produce solar hydrogen for industrial, energy storage, and automotive applications. He went on to give a presentation on the role of energy innovations in the development of off-grid communities.

Globally, energy systems are currently centralised in large power plants; however, the evolving energy landscape should focus on smart grids and smaller, renewable energy-based production nodes—in other words, making future power generation and distribution systems decentralised. These decentralised systems tend to be more efficient and more robust.

Small off-grid village communities will require innovative renewable energy solutions for power generation and storage. Bart Kolodziejczyk introduced one example from rural Guyana. Solar energy plays a crucial role in hinterland areas of Guyana as they are remote and do not have access to national-grid electricity. A few years ago, a project jointly managed and sponsored by UNDP and the Guyana Energy Agency (GEA) was introduced. The project relied on a number of simple hybrid solar systems and battery storage for single households. The simplicity and cost-effectiveness of this solution allowed its application in mountainous off-grid areas of southern Guyana. This solution became a life-changing experience for South Guyanese farmers, providing electricity to power devices such as water pumps, light bulbs, electrical stoves, and more; improving the water supply, sanitation, cooking, irrigation, and education.

Bart Kolodziejczyk also spoke about the Wecoolu wind-powered cooling system, which is based on the well-established Joule-Thomson effect commonly used in traditional refrigeration systems. It is a new and simple invention that can potentially be applied in a variety of settings, including off-grid air conditioning and refrigeration. It can be used as an off-grid wind-powered refrigerator, and is currently being trialled in prototype refrigeration systems for food and medicine preservation in remote areas.

The presentation also covered various solar developments across the Pacific region. For example, Vanuatu's remote Mangalilu village received a solar power system to charge electrical devices, such as phones. However, it seems that this development was introduced too early and the solar power system is unused, due to lack of devices that could benefit from this free-of-charge energy. Lack of support and guidance on how to use the solar systems is a major issue preventing villagers from utilising them fully. Mangalilu is a striking illustration of how projects providing energy access can quickly fail without support, lack of governance, and applicability. A similar project in Kiribati, a small island nation in the South Pacific, suffered the same fate: lack of support, governance, and applications brought this initiative into question.

Bart Kolodziejczyk presented one success story, also from the South Pacific region. Tokelau, a country made up of three atolls whose highest

point is only five meters above sea level, with an area of 10 km^2 and a population of 1,502, is considered the world's first solar nation. It received the support of $7 million from the government of New Zealand to build a solar power plant. The plant was finished in 2012, making this small island state 100% renewable.

Presentation 4: Building Smart Villages through Human-Centred Design and Innovation

Dr David Ireland, ThinkPlace, Australia

David Ireland is a strategic design consultant and believes in a designer's philosophy of learning, visualisation, empowerment, inquiry and constant questioning, dealing with uncertainty, recasting knowns and reassembling unknowns. Design thinking looks at complex things from the perspective of the people who will use or be affected by them.

David Ireland started his presentation with a quote by Albert Einstein: "We cannot solve our problems with the same thinking we used when we created them". Many of our traditional approaches to problem-solving do not have the capacity to affect the changes. Many of these approaches are often risk-averse, linear in their methodology, and cautious; they tend to invest significantly early on, working behind closed doors, only to potentially fail in front of millions of people. Design thinking differs in that by listening, learning, and working with the people at the centre of the problem; the solutions developed are more grounded in a deeper understanding of the situation. This depth of understanding, together with the collaborative design approach, also leads to higher levels of solution uptake and adoption.

The design process draws on a range of theories and tools, including from chaos and complexity theory, to understand the dynamic systems, human-centred design to empower individuals within the system, behavioural sciences and economics to grasp the motivations and behaviours of individuals in systems, and innovation to ideate and prototype. The flexibility to draw on different methodologies is powerful and enables highly-tailored solutions to be developed and implemented.

Prototyping, a fundamental component of design thinking, enables the transformation of vision into reality through an iterative approach of solution development and refinement. With a focus on testing functionality, prototyping can start with paper mock-ups and story boards and progress only when certain confidence levels are met that justify the increased expenses of higher fidelity versions. Through prototyping, design thinking provides the opportunity to progressively improve the quality of the idea prior to implementation, thereby significantly reducing the risks of failure.

David Ireland provided two case studies that highlighted the power of the design thinking approach. The first was a programme that sought to amplify a custom within Kenyan culture of donating to support the resilience and strength of the community. The project used several methodologies, including game play and participatory design, to build empathy and a deep understanding of the challenges and opportunities. By recognising that users are the best designers, the approach helped to appreciate how rural Kenyans make decisions about spending and community contributions, and developed a solution that not only met their needs, but that was culturally sensitive and appropriate.

Another project entitled "CHN on the Go" was presented. The main intention of this project was to develop a more motivated frontline health workforce in rural Ghana, resulting in better quality of maternal and child healthcare, through mobile technology. The approach used was based on provoking empathy within the design team, building trust with the health workforce, and co-creating a solution together. The research included 100 participants, including 60 community health nurses, 18 pregnant or nursing women, 12 frontline supervisors, and 10 Ghana Health

Services stakeholders. Through extensive participatory design, including living and working with the nurses and other stakeholders, a mobile application for CHN on the Go was designed, tested, and launched. The app has gone on to have tremendous impact in not only the productivity of the healthcare service in rural Ghana, but also satisfaction of the healthcare workers who now feel supported and connected.

Plenary discussion on the Potential of Technology and Open Science in Smart Villages

Panellists: Dr Christa Hasenkopf, Dr Bartlomiej (Bart) Kolodziejczyk, and Dr David Ireland

Panel moderator: Dr Moritz Riede

Christa Hasenkopf started the afternoon panel discussion by giving a brief presentation on an initiative called OpenAQ, which she co-founded. OpenAQ seeks to influence science, policy, and public action to understand and combat air pollution through open data, open-source tools, and cooperation. According to a recent (2014) WHO report, one out of eight deaths worldwide is due to air pollution. The global community currently faces several issues and one of them is lack of air quality data for monitoring air pollution.

Christa Hasenkopf stated that there are some websites where small amounts of data are provided, but it is often removed too soon so that it is difficult to evaluate long-term air quality monitoring by government, or for private agencies to inform further policy analyses.

The OpenAQ team has worked extensively on assembling air quality data on one website: www.openaq.org. The website gives real-time air quality data for everyone to access and contains a significant amount of data linked to different types of pollutants in a universal format.

Panel discussion

After Christa Hasenkopf's presentation, the panel discussion started on the topic of Intellectual Property (IP). Bart Kolodziejczyk shared his thoughts, starting by saying that the modern IP framework was developed in the early 18th century and has become inefficient in this age. Due to the rapidly growing global population, climate change, and other emerging issues, there is an urgent need to shift towards open innovation and replace the traditional IP system. Many organisations and leading thinkers around the world recognise this fact and urge the R&D community to consider accepting the rapidly growing movement of open science and open innovation. The current IP laws are challenging as they go against the idea that innovation is truly based on sharing. David Ireland agreed with the view that IP laws need to be reviewed.

Bart Kolodziejczyk emphasised that patenting traditional knowledge is not ethical and simply against the rules of patentability. However, such knowledge continues to be patented due to flaws in the current patent system. This is an important issue to work on. Technology is developing too fast for the current IP system to adapt; the systems can no longer cater for current science and technology needs. One recommendation was for the IP frameworks to be revised and adapted to current socio-technological needs so that they can better deal with the current and emerging challenges. The current IP system is, however, very conservative and large enterprises benefit the most, and so they lobby against its change. Bart believes that open innovation and IP law can coexist and be simultaneously applied to maximise the output. To reach this goal, good practices have to be developed to prove that application of both methods is possible. Several large international companies, including Honda and Tesla Motors, have taken steps to determine the viability of open innovation and have made numerous patents they own freely accessible to everyone. We continually face new challenges so, apart from data sharing and adapting IP policies, new innovation models

need to be formulated to facilitate and provide solutions to some of the most urgent issues.

A participant shared her experience with measuring air quality in Vietnam. Previously, people in Vietnam did not consider low air quality a risk, but then many began to notice health problems which brought their attention to the issue. However, hardly any reliable data on air quality existed. Once data had been collected, it became apparent that air pollution was at high-risk levels according to the WHO criteria. She suggested that government agencies should be asked to take action—for example, against the burning of agricultural residues in villages as it contributes to air pollution in big cities. Using devices that measure air quality in Vietnam determined that even the air inside offices is often not healthy for people. Similar measurements were carried out in villages to demonstrate how polluting indoor open-fire cook stoves can be. She further suggested that governments should also look into investing in similar devices to measure air quality in more areas, which would be a valuable source of data to better understand and fight air pollution.

Regarding access to data and information about development in general, a participant from Nepal suggested that when science and technology projects are implemented the corresponding data and information should be made open. Many times, governments implement projects but, once the projects are finished, it is difficult to sustain them due to lack of information on how to maintain them. Christa Hasenkopf agreed with the suggestion that opening up access to data sets is important. She added that it is equally important to let people know about the available information through suitable websites and social media awareness programmes. Sometimes the data are available but people are not aware of them. Ideally, governments or NGOs should carry out such data management duties, instead of individuals, who may harbour their own personal interests.

Bart Kolodziejczyk emphasized that besides opening access to data, respective data collection protocols should also be disclosed, as having data without knowing how it was collected makes it less useful.

During the discussion, it was noted that additional funding sources are needed for the management and sharing of open data. It would be consuming in terms of both time and money to manage those sources, which means that investment is required in the management of such data.

Mohamed Hassan shared his views about open science. He mentioned that in 2015 the four science organisations: the International Council for Science (ICSU, www.icsu.org), the Inter Academy Partnership (IAP, www.interacademies.net), the International Social Science Council (ISSC, www.worldsocialscience.org), and The World Academy of Sciences (TWAS, www.twas.org) started supporting a call for addressing the values of open data. Strong policies for science at the global level to enforce the principles of open data are important. That call culminated in an accord, entitled "Open Data in a Big Data World", which has been signed by more than 120 organisations around the world, and can be viewed on the Science International website (www.science-international.org).

In considering patents and open data, it is important to consider indigenous knowledge. Patenting of indigenous knowledge by private companies was considered a serious issue, as it can result in the knowledge not being used at all. Indigenous knowledge is passive knowledge that prevails within the communities and it needs to be safeguarded and shared rather than be exploited by outsiders. A few years ago India and China started a drive to document indigenous knowledge. This practice should be adopted in other countries as well, especially for Africa.

Although open data and sources have many benefits, they also have some limitations. Some data is highly confidential and has strategic importance

so that it cannot be made a public good. Therefore there should be clear guidelines concerning the difference between private property and public goods. Striking this balance also extends to privacy issues: not all data can be defined as a public good as some data is private.

Regarding energy access, open data and energy access to smart villages are linked; for instance, when designing solar power systems for a particular village, data about the local solar energy radiation is really important. There is some satellite measurement data available openly, but more comprehensive data currently still needs to be purchased.

Concerning how open data can make a difference at village level, and how it can be used to encourage the uptake of technology, Bart Kolodziejczyk said hydrogen production is a good example of technology that provides a great opportunity for villages to grow. Villagers can use this technology and become harvesters and sellers of hydrogen. This way, they could switch from agriculture to the technology industry.

Wrap-up and key messages for policy makers, development organisations, entrepreneurs and other stakeholders

Energy-Education-Gender Nexus

Making a village "smart" cannot be separated into energy, education and gender. All the issues need to be considered holistically, as they significantly influence each other. Many studies have shown the paramount importance of girls and women making a village smart and sustaining it. Education should not be limited to children, but schools should serve as centres for life-long learning for every member of the community.

Open Data and Knowledge

Rural communities often hold significant amounts of traditional knowledge and can benefit from tapping into solutions developed elsewhere. Making this knowledge available to other communities without stripping the originators of the ownership of their knowledge is important, as is the ability to make use of data and technology generated elsewhere in the world, e.g. air-quality data and efficient cooking stoves. Achieving these goals requires current IP laws to be revised and adapted to current socio-technological needs and to allow for emerging trends like Open Data and, more generally, open science and innovation.

Engagement of Scientists

To solve global challenges like climate change and social inequalities requires the engagement of more scientists and scholars, current as well as future generations. This requires changes to school education, such as in the area of methods that enable students to realise their potential, and the existing science and research systems—for example, improving the current performance evaluation systems for researchers, and funding incentives to increase the engagement of scientists across disciplines and cultures.

Session 3: Synthesis of what the Smart Villages Initiative has learned from its engagement programmes in South and Southeast Asia

Opening remarks: Summary of Days 1 and 2

Dr Bernie Jones

Bernie Jones summarised some of the key points of discussion during the first two days of the workshop: on the Energy, Health and Education nexuses, and the workshop with the Global Young Academy on engagement of the world's early and mid-career scientific community on these technical development challenges.

For the Health-Energy and Education-Energy nexuses, it was noted how outcomes and results were unlikely to be achieved quickly; the challenge of measuring the specific outcome that could be attributed to energy-enabled innovations and services, as opposed to more traditional engagement, was emphasised. The importance of working in a bottom-up manner was highlighted: for approaches to work in these community-level service areas, engagement and specification by the community, and a sense of ownership and control by the community, is critical. And whilst one of the lowest hanging fruits is in terms of automated assessment and collection of records for both health and education, these are benefits that are particularly felt by regional and national-level organisations as opposed to the frontline actors in the rural areas. The importance for technologies to also deliver a tangible benefit to village-level practitioners and users is also critical to ensure sustainability and indeed inspiration and enthusiasm to use the new technology.

Remote rural communities in the developing world tend to suffer from structural problems in both the health and education sectors, with challenges in adequate resourcing, manpower and training. Off-grid energy-catalysed innovations cannot be dissociated from these more general structural problems. And while it is true that access to more modern remote services through technology might serve as an encouragement to rural users and practitioners (e.g. teachers), it also presents a training challenge. In a sense, health practitioners and teachers need to be more qualified to be able learn to use the new technologies in addition to the regular demands of their jobs.

For engagement with the scientific community, one clear opportunity was the fostering of interdisciplinarity. Since off-grid energy-catalysed development solutions require technological innovation, entrepreneurial solutions, and nuanced community engagement, an interdisciplinary approach is the only one that will work sustainably. Yet, encouraging interdisciplinarity is often challenging in the scientific community, and rewards and metrics within the global science base rarely reward it.

It was felt that GYA members and their peers were well placed to promote such an approach, however. Similarly, the GYA peer group is ideal to encourage the creative consideration of developing world applications for cutting-edge industrialised world research products and innovations.

In areas such as gender and education, where there is such a strong, obvious relationship with off-grid energy, it is important not to regard the application of such technologies as a panacea. However, their use does potentially open new opportunities for addressing issues such as education and women's and girls' rights in a more innovative manner.

The workshop also recalled the importance of human-centred design and community engagement approached in product design as well as system implementation, for adoption and long-term sustainability.

Finally, participants considered there was a clear opportunity, potentially through the partnership

with the world's science academies and their networks, to engage with high-level international organisations with key policy messages, rather than just with national and sub-national bodies. And having support and advocacy at these high levels could be highly effective.

Background and scene setting: Review of findings of the Smart Villages Initiative engagement programmes in South and Southeast Asia

John Holmes, Smart Villages Initiative, UK

John Holmes provided attendees with an overview of the findings of the Smart Villages Initiative in South and Southeast Asia. Several cross-cutting issues have emerged, including that of finance. Banks remain nervous about lending, but if the track records of companies and customer payments can be shared, their confidence will increase. Moreover, governments and agencies can help to de-risk bank loans and lower interest rates. The transaction costs for small companies remain high and they chase relatively small amounts of money; that money needs to be more readily available.

Beyond financing, a supportive policy framework is required with high-level political commitment that is backed up with action. National energy access plans need to be clear about which areas will receive access to the grid and by when. In addition, all actors need to take an integrated approach to rural development, which should include energy access, education, health, and water. Support for entrepreneurs is essential; this could include business incubation and advisory services. Governments need to cut red tape for entrepreneurs.

Building capacity is another essential element. This is necessary for those in the banking sector and in governments. Companies and people living in villages also need additional technical and business skills. Creating awareness more broadly of the opportunities that energy access offers is important, including income-generating opportunities. Women and young people need to be closely involved with working in energy, healthcare, education, and livelihoods; and the Smart Villages Initiative has found that building markets and businesses is critical to the success of these aspects of rural development. "Giveaways"—whether of solar lanterns, cookstoves, or other elements—undermine businesses and often do not have a long-term plan for necessary repairs. Villagers need to have a stake in their own future and make the decision to use these technologies.

In terms of the different sources of energy, John Holmes described solar lights and solar home systems, the future for home-based energy supply, and mini-grids. With solar home systems and solar lights, there have been substantial advances over the past five years. Appliances are becoming more efficient, including innovative DC appliances that require less energy. Pay-as-you-go (PAYG) systems have helped villagers to afford to replace kerosene light with solar lights. Third-generation solar home systems are also much lighter and more efficient.

John Holmes cited Bangladesh as an example, where the Infrastructure Development Company Limited (IDCOL) gave a 10% grant for the cost of a solar home system and homeowners paid the other 90%, which they were allowed to repay in instalments over the course of two years. This initiative was also notable because they ensured technical standards of all systems and offered a 24/7 hotline. Looking ahead, improving the quality of the equipment and preventing counterfeiters from entering the market will be crucial.

In future, technological development will also be important, including developing better batteries, creating recycling programmes, and improving solar PV and appliance efficiencies, among other things. DC nano-grids are also being developed, which can connect 20-30 houses and help with load management.

Moving to mini-grids, which typically manage much greater loads than solar home systems, there have been even greater challenges. At the moment, although there have been pilots, the core issue is whether they can be scaled up and become financially sustainable. If they can be replicated, scaling may be possible. Anchor loads will be necessary to help absorb the costs, and set-up overhead costs can be decreased through bundling and standardisation. There will undoubtedly be further technological developments in this sector as well.

There will generally need to be some form of capital cost subsidy to start a mini-grid. On the revenues side, those operating the mini-grid—whether public, private, or a mix—will have to get the tariffs right. There is need to establish: what can villagers afford, and what does the government allow operators to charge? The last resort should be subsidising operating costs.

It is important to remember that mini-grids will require significant community engagement to understand how people are going to use the electricity, and to ensure that they have a voice and a stake in the overall process.

Cooking is another important use of energy. Smart Villages held a workshop in Myanmar to explore this topic which highlighted that the key drivers of clean cookstoves are: health risks, environmental impacts, and social benefits. If less time is spent collecting firewood, children can go to school, and women can free up time for other tasks or take a break.

One of the key findings about cooking and cookstoves is the importance of culture, cooking habits and traditions. Moreover, it is clear that, like solar lanterns and other technologies, there are viable businesses in the field of cookstoves, but financing for both the producer companies and their customers is essential.

Product quality can remain an issue, especially for artisanal small-scale producers. There is also a need for increased efficiency and to reduce pollution even further. Certification to improve the quality of cookstoves may be a way forward. And, as with all small companies, these businesses will need technical and business support.

As the Smart Villages Initiative has developed, it has realised the importance of linkages between different sectors, and the water-food-energy nexus has proved to be one of the areas where synergy can be found. Water, energy and food are essential for human well-being and to meet the goals of sustainable poverty reduction and development. Sustainability of the natural resource base is under threat due to economic growth, over-exploitation of natural resources and eco-systems, urbanisation, climate change, and rising population.

From the Smart Villages Initiative's findings, the siloed approach and lack of coordination need to transform into integrated, cross-ministry policies and initiatives that are based on a better understanding of synergies and competing interests. In doing so, a participatory and bottom-up approach needs to be followed that builds on existing practices and respects local cultures. Moreover, a conducive environment needs to be created for the private sector, and access to affordable finance must be improved. Capacity within the policy community and in the villages themselves needs to be built. Particular attention must be paid to smallholder farmers in poor areas where it is more challenging to improve livelihoods. Lastly, the full participation of both men and women needs to be ensured.

In the Smart Villages Initiative workshop in Singapore, resilience was the main topic. It is clear that rural development gains are hard-won but easily lost in a natural or man-made disaster. As you build prosperity, you can move from subsistence to a life with margins. With energy and ICT, people can be more connected and build skills and knowledge. In Nepal's recent earthquake, the

plight of those in remote villages was sometimes not known for days. They needed connectivity that would be resilient in the case of a disaster. Moreover, services need to be improved, including health, lighting, and post-disaster welfare. Other factors include the fact that social capital is just as important as physical capital—that is, communities that can come together to re-build. The community's role in environmental stewardship is also significant.

Regarding the Sustainable Development Goals (SDGs), the level of ambition for Goal 7 on energy access needs to remain high, as does that for the other goals. John Holmes noted that energy access is a key enabler of most other SDGs, and that the development community should ensure that a "silo" mentality does not take over. It is also crucial to get the implementation right of Goal 17, on revitalising the global partnership for sustainable development. There is a need for better coordination, sharing of information, spending less time chasing small sums of money, university collaborations, sharing experience and knowledge across sectors or fields, and evaluating development outcomes.

Question and answer session

Participants noted that countries could make most of the donors work together in order to have a more coordinated effort on energy access, if they insist on it. It is not common, but it is possible.

On policy, is it possible that we treat rural development as we have climate change? COP21 managed to get all the countries to sign an agreement. Can the same be achieved for rural development? Rural areas can indirectly affect cities; therefore we cannot deliver all the SDGs without rural development. The Smart Villages Initiative offers a platform to bring together those who are interested in achieving this, but there is need for an inspirational goal and a global push.

On innovation and resilience, participants noted that donors have different interpretations of what that resilience means. John Holmes pointed out that a common-sense definition is perhaps best: resilience means to minimise damage and maximise capacity to recover afterwards. He emphasised that 24 million people go back into poverty each year because of disasters.

Regarding university engagement, many researchers would like to be involved in improving energy access in off-grid communities, but the connections are sometimes missing. In grant applications, one always has to show the benefit to the (developed) donor countries, for example. To create inter-institutional connections, multiple projects could team up to improve their visibility. They could start with international funding, which creates connections and visibility, and then seek out national or university funding to expand their activities.

Keynote presentation 1: Energizing rural India one village at a time—Challenges & opportunities for South and Southeast Asia

Rustam Sengupta, BOOND, India

Rustam Sengupta began by introducing himself as a "reluctant entrepreneur" who started his clean energy company in 2010, after spending some time with energy entrepreneurs he knew and realising that they had a different trajectory and were working hard to achieve change in the field. His company now has US$4.5 million in revenue and produces 8-10 MW per year.

In India, there is a goal to reach 100 GW for installed solar capacity by 2022. Of this, 38% would be on rooftops for urban power, 60% for on-grid utilities, and 2% would be for the off-grid sector. However, in 2017, 30% of the population still has no access to electricity.

He noted that one of the main challenges is geography and remoteness. The cost of delivering

a product to customers is very high. Moreover, skills are extremely deficient in off-gird areas, and companies have no way of knowing what happens to their equipment when they are not there and how the energy is being used. Even in Bangladesh, there have been bad experiences of systems not lasting their full lifetimes: some batteries lasted 1.5 years rather than 5 years. That is because the batteries had not been serviced, and the tender had been simply awarded to the company that had the lowest bid. In his opinion, an apprentice programme with on-the-job training helped his company to build a strong pipeline of local people who can service their own batteries.

He called for greater attention to service and quality. Notably, there are no standards or parameters in the solar energy sector. Another challenge is high capital costs; for example, farmers would rather buy diesel instead of paying a higher initial cost for a solar water pump. He also noted that businesses in the sector have an over-dependence on soft funding, which prevents creation of strong business models.

Rustam Sengupta called for stronger monitoring, which requires robust data. As an example, companies could use mobile phone infrastructures to obtain data on energy usage and share it.

Finally, while BOOND has now moved out of its start-up phase, they still find it difficult to obtain finance.

Question and answer session

Attendees were interested to know how BOOND collected payment, particularly in cash. Rustam Sengupta said there are three ways in which they manage the collections:

(1) A collection agent visits customers to collect cash twice a month. This is an expensive method.

(2) Micro-entrepreneur model: micro-grids are pre-paid for entrepreneurs. The entrepreneurs then buy and sell credits at a profit.

(3) The bank lends debt to BOOND or entrepreneurs to fund the collections and charges a small premium for the loan.

Another question was: how does BOOND's micro-utilities model work? The common approach is that a micro-utility is set up (as a non-profit or for-profit enterprise) with BOOND and the community as equity holders. Subsidies and debt are then disbursed into the account of the micro-utility, which then frees up the BOOND's funds (it retains only 10% equity), and the business pays back any remaining debt from tariff collections. Most micro-utilities have a payback period of 3.5-4 years. The micro-utility continues to operate after BOOND exits because the owners agree on a suitable energy tariff after paying off the debt. For the micro-utilities that are wholly owned by BOOND, the community are viewed as paying customers, who are engaged to help design the mini-grid, e.g. by informing the company about the appliances they plan to use to determine the size of the mini-grid.

The participants were interested to know how some villagers had increased their income (e.g. from 4,000 to 10,000 rupees) after gaining access to electricity, and the kind of enterprises they were involved in. BOOND do not set up mini-grids that comprise a motor, as it is difficult to make such mini-grids and other associated machinery sustainable. BOOND mostly supply power to shopkeepers so that they can have proper lighting and work during hours of darkness. BOOND stay away from livelihood models because they need to ensure that their projects have a payback period of 3.5-4 years. They make evidence-based decisions to support their for-profit business model.

In terms of land and land ownership, BOOND buys land or uses farmland. All of its micro-grids

are based on privately owned land, and it has a contract with the owner.

Regarding the fact that BOOND sells electricity, participants wanted to know whether they faced any problems or challenges from regulatory authorities. In general, Indian companies grow in spite of government regulation. The regulators consider BOOND to be small and harmless. This has allowed them to grow unhindered. BOOND also received a lot of help in the beginning, but it is getting harder now that it is no longer a start-up. BOOND also has to compete with those selling diesel and other alternative sources of energy. Most of the staff members are also good politicians, so the company is now more and more involved in lobbying the government about clean energy matters.

In terms of reducing operating costs, BOOND bought a truck in 2016 in order to reduce the cost of transporting personnel and equipment over long distances. The company operates on low volumes and contractual transportation was overly expensive. Now, BOOND offers their truck to other entrepreneurs for a fee.

Keynote presentation 2: Overview of issues and opportunities for rural energy access for development in South Asia

Debajit Palit, The Energy and Resources Institute (TERI), India

Globally, the energy access situation has been improving: there has been an annual growth in access to electricity over the past few years. It reached 0.6% during 2010-2012, which is close to the target growth rate of 0.7% necessary for universal access by 2030. Advances in India and South Asia have been the main drivers behind global progress. In India, 155 million people gained access to electricity during the period 2009-2014, while in Bangladesh the figure was 35 million people over the same period. However, achieving the goal of electricity access for all by 2030 will depend critically on the top 20 access-deficit countries. Three of these countries are in South Asia: Bangladesh, India, and Pakistan.

There are also sub-national inequities, in which some regions have less access to energy. It is also true that there is a gender imbalance in energy access: fewer women have access to energy, especially female-headed households. There are no programmes for addressing these imbalances in South Asia.

Debajit Palit described key challenges for both the supply side and the demand side. For the supply side, these include:

- Long breakeven periods for investors due to poor tariff structures (set mostly in line with current fuel costs)
- The sector is not properly regulated leading to several problems, such as consumers paying much higher than fair price or supplier monopoly
- Lack of appropriate financing for mini-grids: low cost, long tenure debt is critical
- Poor supply chain for hardware, e.g. quality issues
- Uncertainty in the sector, such as poor transition or main grid integration planning by operators and investors
- Inability to diversify the consumer base
- Lack of demand aggregation at the sub-district level
- Lack of evidence on long-term business viability, such as poor understanding of the IRR profile

In South Asia, some people do not see solar home systems (SHS) as a route to electrification. In fact,

Bangladesh did not count or recognise SHS as a means for electrification for some time. They only started to include them in government statistics in 2012. In 2009 there were 90 million people without access to electricity in Bangladesh; now this number has come down to 60 million. However, the accuracy of these estimates is unverified.

Regarding mini-grids, they are generally underperforming. Moreover, there is no clarity on policy. Tanzania has one of the best mini-grid policies in the world that takes a holistic approach to energy planning. However, even in those places with good policies, political changes and personnel changes mean that there is less momentum to implement the policies. For example, in the last six months, the Tanzania Electricity Supply Company (TANESCO) announced that it would implement electricity projects aimed at connecting the whole country to the national grid in the next five years, which is a drastic shift. Generally, mini-grids have higher transaction costs than solar home systems, while SHS can reach more people.

Banks do not as yet see a proper business model for mini-grid development. If surveyed, people will say they like mini-grids; however, if the main grid comes, they will shift to it because they think the main grid is better. Generally, consumers are not willing to pay a higher tariff for a mini-grid—in other words, there is market failure at the bottom of the energy access pyramid.

On the demand side, there are further challenges for mini-grids:

- They are considered as a stop-gap or temporary arrangement (until the main grid comes) by many consumers, leading to limited buy-in
- A poor balance between pricing and availability of power (high prices for a service that does not meet duration or threshold consumption requirements)
- Market failure at the bottom of the pyramid, due to lack of demand and limited ability to pay
- Perceivably higher upfront investment by consumers vis-à-vis alternative fuels
- Consumer retention in the absence of a robust business model and perceived higher price than main grid electricity

Furthermore, there are additional challenges related to energy used for cooking. There is a large population without access to clean cooking fuels across South Asia, and biomass continues to be the dominant fuel. Even current improved biomass stoves do not always provide clean air for the women and children, who are suffering most from indoor air pollution.

In terms of adopting cleaner, more efficient biomass stoves there are several additional barriers:

- Overemphasis on technology and lack of attention to user-friendliness
- Lifestyle change may be required to use improved cookstoves
- Purchasing patterns (men tend to take decisions, while women are users)

While technologies exist for better options (LPG, induction top), income (in)elasticity is the key to their adoption. The hourly likely expenditure for LPG & induction stoves is INR 5-7 per hour vs. INR 2-3 per hour for improved biomass stoves. But the supply chain of modern fuels is a major challenge in remote sites, so most rural households resort to "fuel stacking", i.e. using more than one cooking fuel in a household, depending on factors like the food being cooked, the occasion, and the household member who is doing the cooking.

Recent studies have addressed the issue of gender, although without giving practical implications. There is a need to be more pro-active in including gender elements in policy and practice. Often, the different energy needs of men and women are not taken into account. Wider legislation, such as land rights and inheritance rules, affects women's degree of empowerment when electrification occurs. There is no policy in South Asia for female-headed households, yet to achieve any progress on the energy-gender nexus, women must be involved in the decision-making process. To this end, TERI is working with Energia to ensure that positive changes are made.

Debajit Palit also emphasised that more evidence and data needs to be collected, and that the academies of science are an important part of this effort. As of now, the SE4ALL framework is not collecting data.

There is scarcity amongst plenty in India regarding energy. The installed power capacity is more than 300 GW, but there are still 50 million households in the country without electricity access. Brownouts and blackouts continue, and losses are high; many distribution companies continue to lose money, though the new policy under Uday (a new fiscal turnaround and revival package for electricity distribution companies in India) appears to bring some hope. The key issues are inefficient distribution sector management and the operational inefficiency of distribution companies.

There remain 5,000 villages (i.e. 2 million households) that are without electricity in India. In addition, 49 million people are without electricity who live in villages already serviced by the main grid. If a village is connected to the main grid, it is not viable to create a mini-grid. Such a situation creates uncertainty. Where whole hamlets are without electricity, those might be the places that need mini-grids. But it remains crucial for the government to play its role and decide how to bring in low-cost capital and make the situation more certain for the private sector.

Keynote presentation 3: Issues and opportunities for the water-energy-food nexus in Asia

Suhas P. Wani, ICRISAT, India

Suhas Wani started by stating that 70% of the water used worldwide is for food production. In the 21st century we are facing many challenges, including a potential population increase to nine billion by 2050. Therefore we will require more water for growing more food, bearing in mind that animal-based food products (whose consumption is on the rise) require up to three or four times more water than their arable counterparts. The use of groundwater for irrigation poses a further challenge. In India, there are 22 million wells extracting ground water and the levels are decreasing by 0.5-1.0 metre each year. In terms of energy, the amount of energy needed to pump up and distribute water is very high. Often farmers think water will not be available when they need it, so they turn the pump on whether they need it or not at that moment.

There is a need to increase the efficiency of resources for sustainable intensification of agricultural and food systems. We can feed nine billion people but there is need to consider how we will manage land, and other resources. Our approach will need to change. In dryland agriculture, yields are two to five times lower than the achievable targets so there is a need to harness the potential of rain-fed agriculture.

ICRISAT's Watershed Programme carried out numerous studies to learn from the dryland farmers who perform above average. At the same time, they sought to find out why so many programmes continue to perform below average. One conclusion is that infrastructure goes bad when the community is not involved in the decision-making process. The key components for success are sustainability, equity, community partnerships, and so on.

They also found that a consortium approach to initiatives would work better because different ministries do not communicate to one another about their activities. so that farmers often have to deal with six different individuals to address an issue. Many farmers are diversified and produce animals, fruits, and vegetables from the same enterprise, so they need a one-stop shop to deal with for different products and services. Moreover, capacity building in the farming community is critical; for example, in the Adarsha Watershed in Kothapally, Southern India, agricultural water management interventions improved water resources availability and reduced runoff from 143 mm (19%) to 60 mm (8%).

Suhas Wani gave a further example of Powerguda, a project that focused on biodiesel (Pongamia) production from community wasteland interventions.

- Oil from the seed was used to generate electricity, pump up groundwater, run farm equipment, and produce biodiesel for transport
- Oil cake was used as a substitute for chemical fertiliser and as a bio-pesticide
- The initiative provided means for fuel displacement, carbon sequestration, and provided carbon income to the community

In terms of the impact of this biodiesel initiative, they managed to make several positive changes, including:

- Building institutions
- Developing social capital
- Enhancing health and nutrition awareness
- Increasing incomes
- Environmental impacts:
    - Survival rate for plants was 85% of 4,500 trees (planted in 2002)
    - Oil yields in 2003, 2004 and 2005 were extracted from pongamia seeds collected in the nearby forest
    - Carbon emission reduction from fuel switch (from petroleum diesel to pongamia oil) is 78%
    - Carbon value is calculated at US$21 per tonne of carbon or US$5.722 per tonne of CO_2 equivalent

In terms of other sources of biofuels, there was a lot of hype around Jatropha at one stage because it is easy to grow on wasteland, and so on. There were tall claims. However, one still needs water, and there is a high labour cost associated with growing Jatropha. ICRISAT looked into Jatropha for the control of land degradation and trialled it in a 150-acre plantation (working together with GIZ); however, they found out that people could earn better wages doing something else with their time.

Suhas Wani closed his presentation by emphasising the need for a holistic view of development, particularly as it pertains to the water-food-energy nexus. In ICRISAT's experience, integrated watershed management has proved to be a growth engine in drylands, which helps in conserving natural resources and addressing water, food, and energy security. A decentralised approach to water harvesting can reduce the water-energy footprint in a dryland system. In addition, wasteland management has potential for producing biofuel as well as generating various ecosystem services. It is clear that renewable energy has untapped potential that can bridge the food demand-supply gap in dryland areas.

Keynote presentation 4: Clean and sustainable cooking in South and Southeast Asia: How do we make it happen?

Hong Hanh Nguyen, SNV Netherlands Development Organisation, Lao

SNV is an international, independent NGO that focuses on three main sectors: agriculture, renewable energy, and water and sanitation. In terms of crosscutting issues, they also focus on climate change, gender, and deforestation. Active in 38 countries, SNV works closely with local communities on solutions that are locally owned, systemic, inclusive, tailored to local contexts, and that connect different stakeholders.

In terms of clean cooking solutions, SNV have run the National Biogas Programme since 2003. Worldwide, they have constructed over 150,000 biogas digesters, impacted 725,000 people, and reduced working time for women by 14 hours per week. They now employ 1,668 masons and 1,064 technicians. Their work has reduced CO_2 emission by five tonnes per digester annually.

SNV have won numerous awards for their work, including:

- Second largest household energy project registered with the Voluntary Gold Standard
- Energy Globe Award 2006 for contributions to reducing global warming
- Ashden Award 2010 for their innovative approach in tackling the twin problems of dangerous cooking practices and untreated animal waste.
- Humanitarian Award 2012 for outstanding social-economic and environmental impacts

SNV worked with the Vietnamese government on a biogas project, and it went so well that the Ministry of Agriculture kept the project and continues to manage it; SNV is now just a technical advisor.

Regarding advanced clean cookstoves, which Hong Hanh Nguyen presented in the health breakout session on the first day of the workshop, this programme began in 2016 in Lao, Cambodia, and Vietnam. It takes a market-based approach and makes use of accredited local artisans to produce and sell improved cookstoves.

Keynote Presentation 5: Energy and Resilience for Remote Islands: Vanuatu (Pacific) Case Study

Peter Johnston, Environmental & Energy Consultants, Ltd, Fiji

The Pacific islands present a particularly challenging set of circumstances for achieving rural electrification. Peter Johnston's presentation aimed to review 35 years of initiatives in the region, characterised by some success and many failures. He sought to derive lessons from these experiences, since there is currently little information available on the development of national off-grid programmes for remote islands.

Failures are typically due to multiple reasons, and mainly the result of poor design and maintenance rather than technical issues. Examples discussed include the construction of a community micro-hydro project in Vanuatu in 2014, where connections to distribute energy to the target homes have still not been implemented three years later. Design problems included the choice of materials for the construction of the penstock (made of plastic and supported by bamboo and wood), which meant that it was damaged after the first storm. Since the project was funded in expectation of economic returns generated from new economic activities, it was therefore a lost investment. Another failure was the construction in 2005 of a hybrid plant in Fiji; it was designed without a visit to the island and used non-commercialised technology. The project nonetheless received approval from the government. As is the

case with many standalone systems in the Pacific, there was no plan for back-up provision in case of system breakdowns.

Almost all of the failed projects were driven by the desire to promote specific technologies rather than by local needs, and for some their location was determined by political motives, such as the timing of elections or the place of origin of the ruling politician. A failure to factor in the high costs of working in remote islands, where the only possible transport route is by air, is another common reason for failure. Remoteness also makes revenue collection more expensive, and has resulted in some governments dropping user charges—something that always leads to the eventual collapse of projects. For the sustainability of energy projects, it is essential that the customers pay for operation and maintenance.

A further cause of failure has been a misalignment between installed capacity and existing demand, which is typically low in the region due to sparse population and poor infrastructure development of many islands. For this reason, mini-grids are often not economically viable solutions, even though governments often promote them. Conflicting approaches and priorities between donor organisations also undermine efforts.

Extreme weather events, which are very common in the Pacific region, also have to be considered carefully during project design, in addition to operation and maintenance mechanisms. It is important that resilience is built into the systems.

On the other hand, one success story related was an initiative deploying PV solar systems. The project worked very well due to the effective management practices of the solar company responsible, and because the initiative relied on well-trained local technicians. However, there are also many examples of failures in the solar systems sector.

In conclusion, a suitable institutional set-up is essential for success in energy projects. This would allow initially small initiatives to scale-up successfully. The effect of subsidies on determining the economic viability of investing in mini-grids was explored in the following discussion.

Panel discussion: How can off-grid energy support productive enterprise?

Access to Sustainable Energy Project: Policy Reform in the Philippine Energy Sector
Karen Jacob, World Bank, Philippines

Karen Jacob's presentation focused on the reform of the energy sector in the Philippines, which was originally government owned and managed. The facilities were, however, old and needed repair and upgrading, and the Manila metropolitan area suffered three to six hours of brownouts a day, rotated by zone. The Electric Power Industry Restructuring Act (EPIRA) of 2001 and the Renewable Energy Act of 2008 led to increased investments in wind and solar energy, and promoted consumer empowerment; open business access to transmission and distribution; increased industry accountability; and an unbundling of the electric tariff. As a result, the electricity sector is now mostly privately owned and operated, and while transmission operations remain government owned, new investments and operations have been assigned to a private concessionaire on a long-term basis.

In terms of power distribution, there are 20 investor utilities and 120 electrical cooperatives, which are owned by consumer members. Of these cooperatives, 100 are connected to the main transmission grids in Luzon, Visayas, and Mindanao, while the remaining 20 are autonomous and located on different islands.

The electrification rate for the Philippines currently stands at 90%; however, what remain to be electrified are the most challenging, poor, and

remote areas. The aim is to reach full coverage by 2020. The World Bank is assisting the Department of Electricity in supporting the electricity cooperatives in improving access and facilitating the contribution of renewable energy to the mix through technical assistance, institutional strengthening and mobilisation of investment. The focus of the programme will be Mindanao, the areas with the lowest access rates and worst electricity reliability. Solar home systems will be distributed to 10,500 households, and there is a plan to increase rural energy provision by 14 MW via solar-powered mini-grids.

Critical for effective and sustainable projects, concluded Karen Jacob, is full support and commitment from the government. Energy provision coupled with economic incentives for improving livelihoods is very powerful, and it can particularly benefit women. For example, coffee producers in the Philippines are now able to add value to their products because they can access electricity to roast and grind coffee beans, obtaining a much better price for their produce. Electricity also allows flower and vegetable farmers to extend their working hours.

In the Q&A session it was clarified that the financing provided by the World Bank is a grant, not a loan. The funds will be funnelled to electricity cooperatives selected through consultation, and not to individual households. The grant will cover the cost of the PV panels, but installation and maintenance charges will have to be paid for by individual households, who ought to be members of the cooperative and have received training to qualify. The scheme does not include costs for maintenance or battery replacement: systems for managing and financing these operations are put in place by individual cooperatives. In future there is a need to look at ways to fund higher levels of energy provision for productive uses.

There is also a need to carry out studies to determine the impact electricity access has on women's livelihoods, and on health and education at the community level.

Wobe financial services, Citra Savitri, Indonesia

Wobe is a financial technology start-up based in Jakarta, Indonesia, designed to provide income generation opportunities to lower- and middle-income individuals who earn less than US$400 a month and have no access to a bank account. It consists of an Android-based app that allows users to buy and sell prepaid mobile phone credit, known locally as pulsa. Wobe partners with community and commercial organisations such as micro-finance and non-profit organisations. Anyone with an Android phone is able to become an agent. The company plans to eventually expand its services to the SE Asian region, where over 740 million people earning less than US$10 a day reside.

IEEE Smart Village, Farid Khan, India

Mtekpro and IEEE Smart Village provide seed funding to rural entrepreneurs to use energy as a basic enabler; for example, to support employment, education, and enterprise development. While energy is essential, local demand is also critical for success. Initiatives discussed include Africa Development Promise, which started as a small mushroom farm and achieved 400% increase in revenue in the first year. Another example related is a fair trade initiative in the UK, which works with partners in India and South America to produce and sell handicrafts.

Education is key for sustainability, and Mtekpro funds projects promoting education even in cases where there is no model for the generation of revenue. The only condition provided is that access to the facilities financed is not refused to other users. Mtekpro and IEEE Smart Village also support rural mini-grids, especially when they can be combined with an anchor load.

Off-grid development in Pakistan, Nafees Ahmad Khan, Pakistan

The Pakistan Poverty Alleviation Fund (PPAF) is a Pakistani government initiative established in 2000 as a public-private partnership for delivery of resources and implementation of development projects at the grassroots level. It operates by facilitating access to funds through two financing arms of PPAF. Loans are provided for the provisioning of microfinance and enterprise development through partner organisations, and PPAF also awards grants. It also provides technical and management assistance to partners for design and implementation of projects. All programmes and interventions are driven by community demand.

Pakistan is home to 30 million people without access to electricity, and the electricity provision to the grid-connected population is also inadequate, with eight to 12 hours of load shedding. While the cost of extending the grid to rural areas is prohibitively expensive, Pakistan is well endowed with natural resources for the generation of renewable energy. The government is currently financing the development of renewable energy projects through the Independent Power Producers (IPP) initiative.

There is a proposal to set up differential tariffs for domestic (5 US cents/kw) and commercial (7-8 cents/kw). The system has the flexibility to add additional consumers. However, workshop participants agreed that a key challenge is translating added capacity into productive innovation and enterprise.

Plenary feedbacks and discussion: key messages for policy makers

Water, energy, and food

The nexus between water, food, energy, and cooking is very complex, and the interrelations between the elements present different characteristics that vary across locations. Water is key for food production (in the field for growing crops, and in the kitchen for preparing meals), but is also needed for other household and productive uses, and in some cases, also to generate electricity. Similarly, livestock often play an important role in agricultural systems (as a source of manure and as farm labour), but also contribute to the household's nutrition and for the generation of energy (e.g. biomass). It is therefore important to have a good understanding of the target system to design and implement appropriate solutions, to ensure that they match local conditions and demands. It is also critical that projects take a holistic approach, to avoid designing interventions that address just one component and possibly have unintentional negative effects on other components of the nexus. Synergies and trade-offs must be identified and managed accordingly. One issue that needs to be addressed during planning is the choice of the appropriate technologies to identify the best solutions. For agricultural applications, technologies for minimising post-harvest losses and value addition should be prioritised.

The number of actors operating in this nexus area is large and varied, and therefore good coordination is central for success. Bottom-up approaches through the involvement of the community, private sector, and local government, as well as other actors in rural development initiatives at the planning stage, should be promoted to ensure the success and sustainability of interventions.

Effective policies are essential, as is policy cohesion. One example discussed was water management strategies, and the effect that overuse and/or contamination of groundwater can have on soil health and long-term sustainability of ecosystems. In some areas groundwater use is regulated, but this is not universal. Effective surface water collection and management need to be promoted. Subsidies and their effect on the nexus need more attention, and an example discussed was the effect on water use of policies promoting rice production in some parts of Asia, which also resulted in a decrease in production of crops that require less water to grow. It is important that value chains

are assessed with their long-term potential and sustainability in mind.

Financing for projects addressing this nexus is available from several sources, but obtaining money for capital costs is often a challenge.

Productive uses

A common issue related to the development of productive enterprises once a community obtains access to electricity is that its members do not often have a clear understanding on how they may add value to their products and reach new or better markets. Interventions need to be guided to be effective: there is a need for matching demand and delivering products in a timely manner. It is also critical that technology is not provided for free.

Interventions to promote economic development in communities through the provision of energy are carried out by a number of sectors with different types and levels of expertise (e.g. government organisations, private companies, universities, and civil society), but coordination of efforts is often poor. Since interventions need to be holistic to be effective, an entity in charge of overseeing and coordinating efforts, and matching partners with complementary expertise, was proposed as a solution. The government may take on this role and also provide incentives to the private sector to encourage investment in the sector. Another important role for the government could be acting as a broker between the community and private sector organisations, since it is important to build trust (the community must not be or feel exploited, while the private sector must be able to rely on a reliable source of materials and market for their products or services).

The 'One district-One product' policies (in which each district concentrates on producing one product well) have been successful in some cases in Thailand, but this does not work for all products. Capacity building and education of all actors, including community members, are key for positive interventions. Examples of successful enterprises linked to energy provision are the development of tourism (homestays) in communities and organic farming.

Funding for rural electrification projects can be derived from a range of sources, including government, the private sector, NGOs, and the community itself, and can be obtained as cash and in-kind contributions, and through crowd funding. Critical for long-term positive impacts and sustainability is that projects are approached as businesses.

Health and education

The topic is very broad and several aspects were discussed. 'Smart villages' are important as a means of proving more opportunities for rural areas, especially where large-scale migration to urban areas is a problem. Although suitable policies to support this are very important, governments in developing countries are sometimes unaware of the problems of rural areas, and hence unwilling or unable to develop new policies to address them. Lack of suitable policies also affects the intervention of the private sector, in particular at the stage of project implementation. The establishment of an entity in charge of overseeing and coordinating projects, and for ensuring continuity and sustainability after the end of interventions, was proposed as a means of increasing efficacy. Governments should also establish effective advisory boards with members who not only understand the problems but also have a problem-solving approach to provide solutions. Regional coordination and sharing of lessons derived from both successes and failures is also very important to move forward and maximise return on investments.

A further role of the government would be to promote local leadership in interventions, since national actors often have a better understanding

of the needs and demands of the country. It is critical to develop policies that counteract the 'brain drain' in developing countries, where the lack of professional support and career opportunities results in educated people moving abroad, something that undermines the countries' development. Education and training is important for the success of initiatives, but also for communities to realise that some of their solutions are in their hands, and do not depend on outside influence.

The participants agreed that money for projects was not an issue per se, since funding is available from different sources. Key issues are, however, how the funding is spent and prioritised.

Herb Wade, an experienced off-grid energy consultant who has worked throughout the South Pacific, weighs in on the discussion following colleague Peter Johnston's presentation.

Annex 1: Agenda

Day 1, Tue 7 March: How energy access in off-grid villages can enable improvements in education and healthcare at the village level

08.30 - 09.00	Registration and networking	
09.00 - 09.05	Workshop introduction and overview	Bernie Jones, Smart Villages Initiative Moritz Reid, Global Young Academy
09.00 - 09.25	Welcome address	Dr Yongyuth Yuthavong, former Deputy Prime Minister, Thailand
09.20 - 09.50	Introduction to the Smart Villages Initiative -SVI and GYA reflections on energy-education and energy-health interactions	John Holmes, Smart Villages Initiative
09.50 - 10.20	Keynote presentation 1: Health Issues: Opportunities and challenges to enhance village level healthcare in South and Southeast Asia through energy access and ICT	Jay Evans, Medic Mobile, Nepal
10.20 - 10.50	Keynote presentation 2: Education Issues: Opportunities and challenges to enhance village level education in South and Southeast Asia through energy access and ICT	Sowirin Chuanprapun, UNESCO Bangkok, Thailand
10.50 - 10.55	**Group photo**	
10.55 - 11.20	**Coffee break**	
11.20 - 11.40	Keynote presentation 3: Health Issues: Experiences of the health-energy interaction at village level	Avishek Malla, Sunfarmer, Nepal
11.40 - 12.00	Keynote presentation 4: Education Issues: Experiences of the education-energy interaction at village level	Farid Khan, IEEE Smart Village, India
12.00 - 12.20	Keynote presentations 5: Integrating energy-health-education: Experience of the interaction at village level	Mike Rosenberg, Aleutia Energy, UK
12.20 - 13.00	Plenary discussion of common issues: ICT as an enabler, attracting staff, synergies, need for holistic/welfare outcomes approach, evaluating outcomes, roles of different players (multilaterals, governments, entrepreneurs, etc.)	Bernie Jones, Smart Villages Initiative

Day 1, Tue 7 March: How energy access in off-grid villages can enable improvements in education and healthcare at the village level

13.00 - 14.00	**Lunch break**	
14.00 - 15.00	Parallel sessions for education and health: -Panel discussion with interaction with participants - Exploring the role of multilaterals, governments, entrepreneurs, etc.	**Health** 1. Chaw Chaw Sein, Forest Research Institute, Myanmar 2. Nguyen Hong Hanh, SNV, Lao 3. Jay Evans, Medic Mobile, Nepal **Education** 4. Clémentine Vignault, Slate2learn, UK & India 5. Dil Bahadur Shrestha, National Resource Center for Non Formal Education Center for Education for All, Nepal
15.00 - 16.00	Parallel session discussion of 3 or 4 key questions (coffee and tea available in the room rather than as a break)	
16.00 - 16.40	Plenary feedback and discussion	
16.40 - 17.00	Identify key messages for policy makers, development organisations, entrepreneurs and other stakeholders	
17.00	**Close**	
18.30 - 20.30	**Dinner/Reception** Venue: **Jim Thomson House** Pick up from Mandarin Hotel at 17:45	

Day 2, Wed 8 March: The role and viewpoint of young scientists on science-policy issues related to smart villages

09.00 - 09.15	Welcome and Introduction of the GYA	Dr Almas Awan and Dr Moritz Riede, Global Young Academy
09.15 - 10.00	Keynote presentation: Challenges and Opportunities for International Collaboration in Green Science, Technology and Innovation	Prof Mohamed Hassan, TWAS Executive Director a.i., Italy, President of the Sudanese Academy of Sciences, Past President of IAP

Day 2, Wed 8 March: The role and viewpoint of young scientists on science-policy issues related to smart villages

10.00 - 10.15	Q & A, Discussion	
10.15 - 10.45	Women and their potential role in smart villages, using Science and Technology	Dr Sohasini Sudtharalingam, International Development Consultant, UK
10.45 - 11.00	Q & A, Discussion	
11.00 - 11.30	**Coffee break**	
11.30 - 12.00	Education and Development in Rural Communities	Dr Aftab Ahmad, National Academy of Young Scientists (NAYS), Pakistan
12.00 - 12.15	Q & A, Discussion	
12.15 – 13.00	Plenary Discussion on the Role of Education and Women in Smart Villages	Dr Sohasini Sudtharalingam, Dr Aftab Ahmad
12.30 - 14.00	**Lunch break**	
14.00 - 14.30	Energy Innovations as a Major Factor for Transition to Smart Villages	Dr Bart Kolodziejczyk, Business Development Director, H2sg Energy Founder and Managing Director, Scientists-in-Residence, Australia
14.30 - 14-45	Q & A, Discussion	
14.45 - 15.15	**Coffee break**	
15.15 - 15.45	Smart Villages: the power of Innovation and Human Centred Design	Dr David Ireland, Chief Innovation Officer, ThinkPlace, Australia
15.45 - 16.00	Q & A, Discussion	
16.00 - 16.40	Plenary discussion on the Potential of Technology & Open Science in Smart Villages	Dr Bart Kolodziejczyk, Dr David Ireland, Dr Christa Hasenkopf
16.40 - 17.00	Identify key messages for policy makers, development organisations, entrepreneurs and other stakeholders	Almas Awan, Moritz Riede
17:00	**Close**	

Day 3, Thu 9 Mar: Synthesis of what SVI has learned from its engagement programmes in South and Southeast Asia

09.00 - 09.20	Welcome and introductions: brief summary of day 1 and 2	Bernie Jones, Smart Villages Initiative
09.20 - 10.00	SVI: review of findings of engagement programmes in South and Southeast Asia, followed by discussion.	John Holmes, Smart Villages Initiative
10.00 - 10.30	Keynote presentation 1: Overview of issues and opportunities for rural energy access for development in South and South East Asia	Rustam Sengupta, BOOND Engineering & Development Pvt. Ltd, India
10.30 - 11.00	Keynote presentation 2: Overview of issues and opportunities for rural energy access for development in South Asia	Debajit Palit, The Energy and Resources Institute (TERI), India
11.00 - 11.30	**Coffee break**	
11.30 - 12.00	Keynote presentation 3: Issues and opportunities for the water-energy-food nexus in Asia	SP Wani, ICRISAT, India
12.00 - 12.30	Keynote presentation 4: Clean/sustainable cooking in South and Southeast Asia: how do we make it happen?	Nguyen Hong Hanh, SNV Netherlands Development Organisation, Lao
12.30 - 13.00	Keynote presentation 5: energy for islands (or energy and resilience)	Peter Johnston, Environmental & Energy Consultants Ltd., Fiji
13.00 - 14.00	**Lunch break**	
14.00 - 15.00	Panel discussion: How can off-grid energy support productive enterprise?	**Policy** 1. Karen Jacob, World Bank, Philippines 2. Citra Savitri, Wobe, Indonesia 3. Nafees Ahmad Khan, Pakistan **Entrepreneurs** 3. Farid Khan, IEEE Smart Village, India
15.00 - 16.00	Breakout Session (3/4 groups) addressing set questions relating to energy access for development and making smart villages happen. (Coffee/tea on the go.)	Bernie Jones, Smart Villages Initiative
16.00 - 16.50	Plenary feedbacks and discussion: key messages for policy makers, etc.	

Day 3, Thu 9 Mar: Synthesis of what SVI has learned from its engagement programmes in South and Southeast Asia

16.50 - 17.00	Next steps	John Holmes, Smart Villages Initiative Moritz Riede, Global Young Academy
17.00	**Close**	

Annex 2: List of participants

Name	Designation	Organisation	Country of operation
Debajit Palit	Associate Director	The Energy and Resources Institute	India
Jay Evans	Regional Director Asia	Medic Mobile	Nepal
Sowirin Chuanprapun	Project Officer, Section for Educational Innovation and Skills Development (EISD)	UNESCO Bangkok	Thailand
Chaw Chaw Sein	Researcher	Forestry Research Institute	Myanmar
Avishek Malla	Director of Engineering and Operations	SunFarmer Nepal	Nepal
Peter Johnston	Director	Environmental & Energy Consultants, Ltd.	Fiji
Citra Savitri	Impact and Growth Director	Wobe, Indonesia	Indonesia
Karen Jacob	Social Development and Resettlement Specialist	World Bank	Philippines
Farid Khan	Renewable Energy Consultant & Principal Consultant	IEEE Smart Village - South Asia	UK/India
Bernie Jones	Project Co-leader	Smart Villages Initiative	UK
John Holmes	Project Co-leader	Smart Villages Initiative	UK
Tinashe Chiurugwi	Research Associate	Smart Villages Initiative	Australia
Claudia Canales	Project Manager	Smart Villages Initiative	Norway
Yan Zhang	Research Associate	Smart Villages Initiative	UK
Molly Hurley Depret	Storyteller and Policy Manager	Smart Villages Initiative	Luxembourg
Mohamed H.A. Hassan	Executive Director, a.i.	The world academy of Science, TWAS; President, Sudanese Academy of Sciences; Past President, IAP	Italy
Christa Hasenkopf	Co-Founder	Open AQ (Air Quality)	US
Kyriacos Koupparis	Regional Science, Technology, and Innovation Advisor	USAID Bangkok	Thailand
Aphiya Hathayatham	Vice President	National Science Museum	Thailand
Ganigar Chen	Director of Office of Public Awareness of Science	National Science Museum	Thailand
Worajit Setthapun	Dean, Asian Development College for Community Economy and Technology (adiCET)	Chiang Mai Rajabhat University	Thailand

David Ireland	Principal and Global Innovation Lead	ThinkPlace	Australia
Sohasini Sudtharalingam	Consultant (International Development)	PwC	UK
Bart Kolodziejczyk	Research Fellow	Monash University	Australia
Uttam Shrestha	Vice-Chancellor's Research Fellow	University of Southern Queensland, Global Young Academy	Australia
Almas Awan	Researcher	ThoMSon Mass Spectrometry Lab, Global Young Academy	Brazil
Lim Boon Han	Assistant Professor	Universiti Tunku Abdul Rahman, Global Young Academy	Malaysia
Moritz Riede	Associate Professor	University of Oxford Global Young Academy	UK
Kriskrai Sitthiseripratip	Project Leader	National Metal and Materials Technology Center	Thailand
Clémentine Vignault	Director	Slate2learn	UK/India
Rustam Sengupta	Founder & Chairman	BOOND Engineering & Development Pvt. Ltd	India
Mike Rosenberg	Founder & CEO	Aleutia Energy	UK
Nguyen Hong Hanh	Renewable Energy Advisor	SNV Netherlands Development Organisation	Vietnam
Suhas P Wani	Research Program Director, Asia and Director, ICRISAT Development Center	ICRISAT	India
Dil Bahadur Shrestha	Director	National Resource Center for Non Formal Education Center for Education for All	Nepal
Nafees Ahmed	General Manager, Hydropower and Renewable Energy	Pakistan Poverty Alleviation Fund	Pakistan
Herb Wade	Renewable Energy and Energy Efficiency Consultant	Independent	Thailand
Lim Jeng Shiun	Senior Lecturer	Faculty of Chemical and Energy Engineering, Universiti Teknologi Malaysia	Malaysia
Vinitha Thadhani	Senior Research Scientist	Sri Lankan Institute of Nanotechnology	Sri Lanka
Nuwong Chollacoop	Lab Head	Renewable Energy Laboratory, National Metal and Materials Technology Center (MTEC)	Thailand

Orakanoke Phanraksa	Co-Chair, IP Policy Manager	GYA, NSTDA	Thailand
Ho Wai Shin	Senior Lecturer	Faculty of Chemical and Energy Engineering (FCEE), Universiti Teknologi Malaysia (UTM)	Malaysia
Usman Munawar	Research Officer	KICS - University of Engineering and Technology	Pakistan

SMART VILLAGES

New thinking for off-grid communities worldwide

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GLOBAL YOUNG ACADEMY

The Global Young Academy

The Global Young Academy aims to become the voice of young scientists around the world. To realise our vision we develop, connect, and mobilize new talent from six continents. Moreover we empower young researchers to lead international, interdisciplinary, and intergenerational dialogue with the goal to make global decision making evidence-based and inclusive.

The GYA provides a rallying point for outstanding young scientists from around the world to come together to address topics of global importance. As of 2014, the GYA has reached its full capacity with 200 members, leading young scientists (defined as an average age of 35 years and at the beginning of their independent academic career). 2016 GYA has in addition to its 200 members 134 alumni. Altogether 70 countries from all continents are represented. Members are selected for the excellence of their science and their commitment to service and are serving five-year terms. The vibrancy of the GYA results from the energy of its members who are passionate about the role of science in creating a better world. The GYA is governed by an Executive Committee that reflects the diversity of its membership and is supported by a Senior Advisory Board composed of outstanding senior scientists and science managers, respectively.