AFFORDABLE ENERGY
FOR
HUMANITY:
IF NOT NOW, WHEN?

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1 The Challenge of Energy Access

A major 'Global Change Initiative' – led by the University of Waterloo and Karlsruhe Institute for Technology – is underway to establish a platform for research and development of innovative energy technologies to drive large-scale adoption intended to reach every global citizen.

The primary goal is to achieve energy affordability on a global scale.

We offer a working definition of 'affordable energy', namely, the cost of basic energy services must be less than 10% of disposable income for an individual or a household. For a person living on $2 per day, the energy cost must not exceed 20 cents/day.

This highly challenging target not only has clarity of purpose, it is a metric against which progress can be measured. Realization of the vision rests on critical advances in the scientific and technological capacity to deliver innovations on a scale large enough to render energy poverty a phenomenon of the past.

Through this global change initiative, we bring into sharp focus the need for the development of a cleaner, low carbon energy system that is as responsive to the threat of climate change as it is to the needs of those who have very little access to energy.

Our focus is on scientific research and next generation technologies – to reduce cost by at least an order of magnitude – with the expectation that such an achievement can be instrumental in delivering affordable energy as the positive force of change.

2 Why a Global Change Initiative?

Affordable energy remains a central feature of human development goals and its linkage to water, food, security, health and well-being is as strong as it is pervasive.

It is a moral obligation and a matter of global conscience that we bring into the center of policy discussions the plight of some 2.5 billion people in the world without reliable access to electricity or basic energy services.

Those who live in extreme poverty (<$1.25/day) and the 'proverbially' poor on less than $2/day remain with us in about the same numbers from one decade to the next. The vicious cycle of energy poverty begins with lack of access to affordable energy. Once trapped in this vortex of deprivation, lack of modern energy services translates into low economic productivity, time consumed by drudgery, and limited opportunities for income generation.

This is a major failing of the existing global energy system; vast in scope but persistent in its indifference to the needs of a third of humanity. Through an interconnected system of pipes and pipelines, power plants and processing plants, the global energy system extracts a massive amount of primary energy annually (upwards of 550 EJ) and yet leaves millions to scour the forests for twigs and branches for basic needs. If the energy poor are to be drawn into the mainstream of global economic

well-being, then access to low cost energy is a fundamental requirement. Energy poverty remains a barrier to economic well-being for such a large proportion of humanity that the rationale for action now is compelling.

The importance of energy access has been recognized by several organizations including the United Nation's Sustainable Energy 4 ALL (SE4ALL) program, the World Energy Council, the World Bank, NGOs and many charitable foundations. It is also comprehensively documented in the Global Energy Assessment (2012). Although progress, at the global level, has been tangible, it has been slow and not large enough in scale and scope to address the basic human needs of a large swath of humanity. Massive diffusion of new technologies that can provide energy services at much lower cost is the necessary building block to help make a difference in the lives of so many that have so little.

To effect meaningful change, we need to marshal the vast intellectual capacity of humanity in order to address two of the most important challenges of the century – and to do so in concert. We must achieve a low carbon energy system that also meets the requirement of affordable energy for the all of humanity.

It is clear that universal energy access cannot be achieved without a major scientific and technical push to lower costs by a very large margin, to improve reliability, again by a large margin and find robust solutions that are scalable at the global level.

Our primary focus is scientific research and development of next generation technologies that will yield large improvements in the overall performance of existing energy systems.

In spite of all the good will and positive intent, politicians and policy-makers have been stymied over the decades by several competing demands – the geopolitics of energy supply, demands for energy security and the compelling evidence to address the threat of climate change from fossil fuel emissions. We observe that it is as much a failure of the scientific and technical community as it is the shortcomings of policy-makers to deliver effective solutions that are reliable enough to meet the twin goals of affordable access to energy and reduced emissions from energy supply. In our view, it is incumbent upon the scientific community to go beyond articulating a statement of the problem and to proffer a suite of practical solutions to help break the log-jam.

3 Research Domains

The primary goal is to develop a platform for rapid diffusion and adoption of low cost solutions in diverse contexts and markets. A sustained effort – over two seven year cycles of development – is envisaged in support of such a platform.

On an on-going basis, the outputs of research will be integrated into context-specific applications. Lessons learned from the field will in turn be fed back into research efforts in order to guide the development of field-ready solutions.

Key domains of research and development activities have been identified to support a multi-layered approach and a program that will draw on insights from several disciplines from basic sciences to engineering. Research in the social and

behavioral sciences will be integral to identifying how new knowledge can support commercialization of innovations.

The four domains of research are as follows:

Generation, Devices and Advanced Materials

Energy generation sources including solar, wind, bioenergy, hydro, geothermal, and next generation materials and storage

Information and Communication Technologies for Energy System Convergence

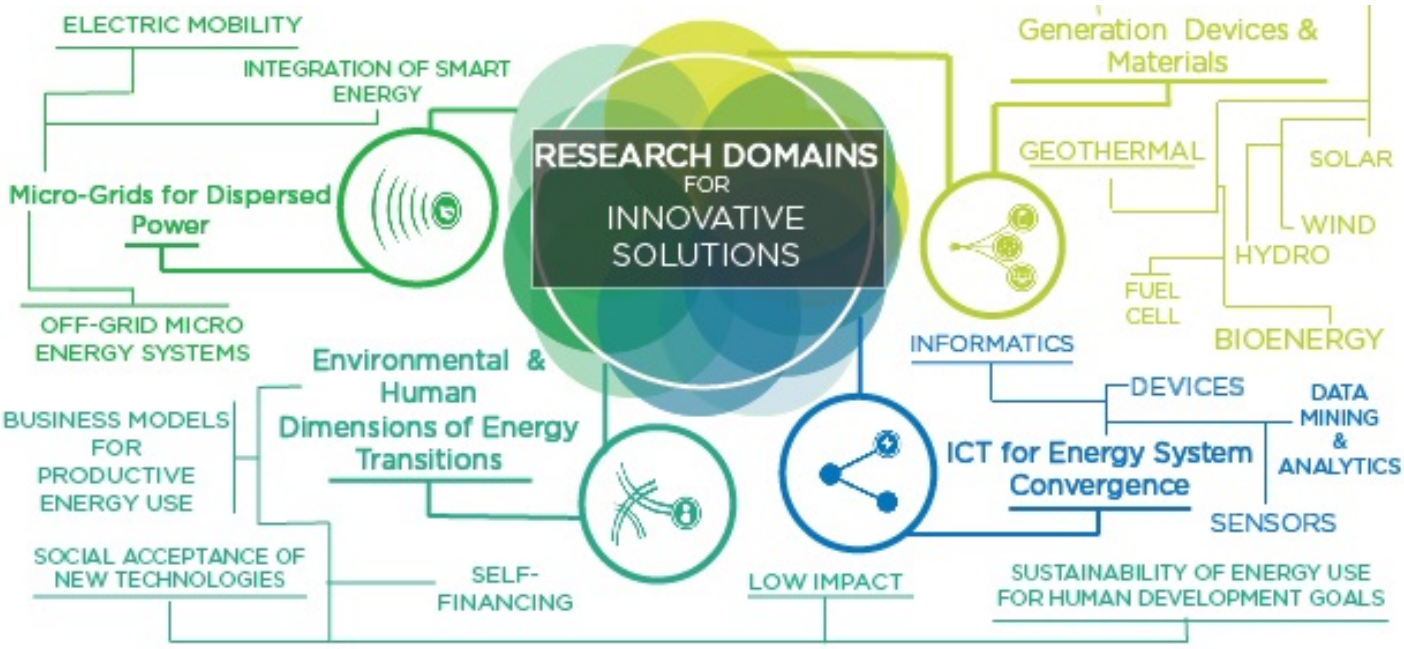
The convergence of ICT and energy systems through: informatics, sensors, data mining and analytics for ubiquitous energy applications

Micro Grids for Dispersed Power

Off-grid energy systems and their operation, integration of smart energy networks

Environmental and Human Dimensions of Energy Transitions

Sustainability of energy provision for human development: public policy, business models, financing, environmental and cultural issues



4 Cost and Value

The graphic below (figure 1) shows how the cost of energy and the value it delivers in different quantities depends upon context: the energy poor (green), versus those in wealthier, energy-intensive areas (blue). It is a powerful depiction of the idea that a level of energy service at different price points has a different value to the end consumers depending on their situation.

Small amounts of energy have high value and high positive impacts on human development potential, albeit, at a relatively high nominal cost. This also suggests that the amount of electricity needed to address many of the problems stemming from energy poverty is not great.

For people living with no access to electricity, the first few hundred watts can power life-changing tasks: turning on lights for reading and working at night, charging mobile phones to communicate with family or running small refrigerators.

Recognizing the concepts of value and cost (at varying levels of consumption) as well as the cost efficiencies of different technologies to deliver quantities at different price points (reflecting production cost) will in turn allow innovation to flourish.

To help unleash the economic productivity of those with very low incomes, provision of even a basic level of energy services can be the tipping point for a range of positive economic, social and cultural developments. For example, many regions with energy-poor individuals are endowed with renewable sources of energy such as sunlight, wind, biomass or waterways for generating hydroelectricity. A portable but durable solar power (i.e. Organic Photovoltaic technology) when compared

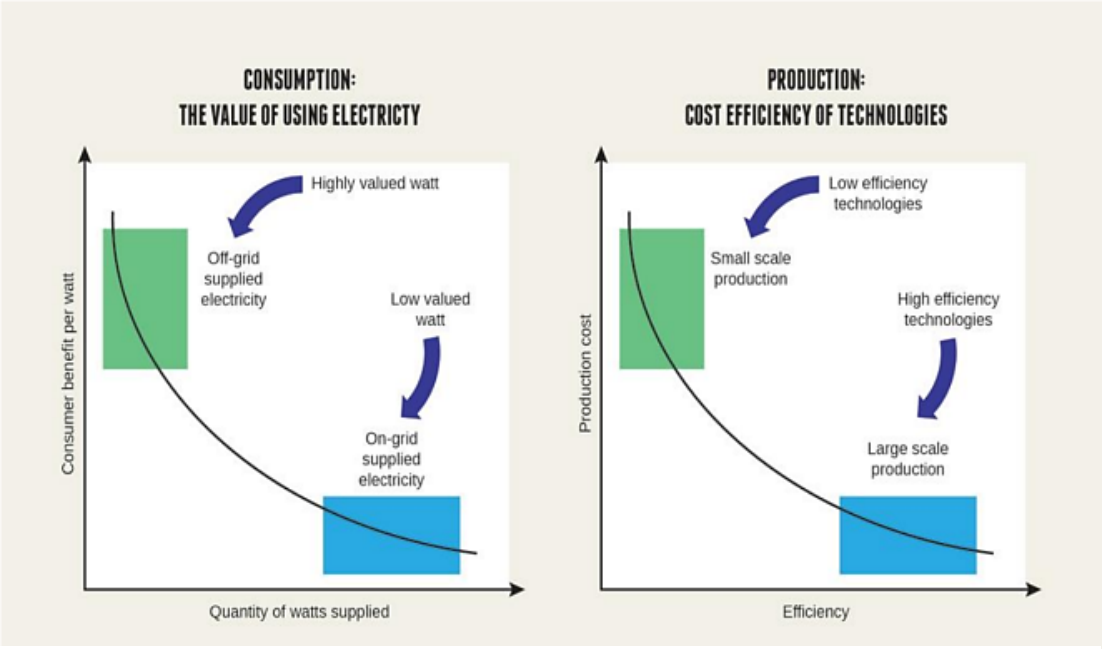


Figure 1: The Value and Cost of Energy (Waterloo Global Science Initiative 2011)

to burning kerosene at US$1 per week highlights the savings inherent in using solar energy over the medium term – even when the initial costs of deployment may be high.

5 A Fundamentally Different Challenge

Although this 'Global Change Initiative' builds on the current knowledge base of the existing energy system, the global challenge of energy access is fundamentally different.

The existing electricity infrastructure delivers highly reliable service from centralized large-scale power plants connected to the power grid (transmission and distribution) at a relatively low unit cost of energy. The economies of scale for serving large populations (or load centers) are not the same as those for meeting the needs of the energy poor who live in remote and dispersed communities distant from the existing grid. The costs of extending the power grid to the rural poor have proven to be so prohibitive that the default policy option is taking no action – which effectively perpetuates the cycle of energy poverty.

To address energy access for communities distant from the grid, the development of 'off-grid' energy solutions holds enormous promise. Micro-power, distributed generation, cost-effective storage and a wide range of smart energy technologies can provide an opportunity for some regions to 'leap frog' the technologies of the central grid. An analogy is the wireless mobile phone that made the cost of building telephone landlines in emerging economies redundant.

We remain confident that an energy revolution is in the making that has the potential to effect a similar transition as mobile phones, on a global scale. Further, the promise of ubiquitous connectivity through the 'Internet of Things' comprises a pathway that could bring energy to those who need it most by fundamentally altering the business models and economics of provision of energy services.

We believe that the 'energy poor' of the world comprise a latent market opportunity but the vision rests on innovations that can deliver the solutions at the right cost (affordable) with a clear understanding of how the cost of energy service is linked to the value it delivers in a specific context.

6 Execution

The initiative strives for a multi-disciplinary and multi-sector approach to develop solutions and its success will depend on the commitment of many talented individuals and organizations. A formal collaboration has been forged between the University of Waterloo (Canada) and Karlsruhe Institute of Technology (Germany) to focus on integrating expertise and resources from existing research programs to align with the vision of this initiative. Bringing together the science, technology and engineering strengths of the two institutions is a central feature of the strategy for execution of the initiative.

(i) **The University of Waterloo** in Canada is a leading university recognized for innovation,

entrepreneurship and strong faculties in engineering, science and environmental studies. The focus on energy research at the Waterloo Institute for Sustainable Energy (WISE) and the Energy Research Centre compliments the capacities of KIT Institutes.

(ii) The Karlsruhe Institute of Technology is strongly integrated in both the European Energy Network Platforms EERA and EARPA, and in the European Knowledge and Innovation Community on Sustainable Energy (KIC InnoEnergy). The history of KIT as one of the leading German research and teaching institutions with major research in the energy field is well known.

The development of a detailed program to support this global change initiative is currently underway. A detailed definition of the program elements, identification of research experts, the timelines for deliverables from specific projects and the platform for integration of research results into real-world contexts is already underway.

We invite participation of researchers and their affiliated institutions and look forward to active engagement of thought leaders in the academy, civil society groups, philanthropic organizations, innovators, and government and industry leaders to provide specific support to help advance achievement the vision of 'Affordable Energy for Humanity.'

This initiative will help us calibrate our understanding of future global economic opportunities that link the challenge of achieving a low carbon energy economy to the needs of the energy poor.

Our specific requests to different organizations are tailored to their mandates and are aligned as follows:

5.1 Universities and research institutes – We invite individual researchers and research teams to identify their domain-specific expertise and commitment to participate.

5.2 Philanthropic foundations – We welcome individual philanthropic commitments and we will work with established foundations to obtain the necessary resources to support research and provide expertise to ensure successful deployment of projects.

5.3 NGOs with field experience – We invite input and welcome the knowledge and expertise obtained by these groups to help shape the research agenda so that it is targeted to achieve solutions that will have an impact on people's lives.

5.4 Civil society groups – We invite your participation and guidance and seek your commitment to help us raise the profile and awareness of energy access issues, as well as of this initiative.

5.5 Business and industry leaders and innovators – We seek your active engagement in specific domain areas to support research efforts and identify potential for rapid commercialization of solutions. It is our expectation that

markets will drive the innovation cycle and that breakthroughs will open up significant opportunities for creation of sustainable businesses.

5.6 Governments, national academies and international agencies – For large-scale deployment of new technologies, the co-operation of key public sector actors is integral to ensuring success. We welcome expert advice by national academies to shape our efforts, and the collaboration of governments and other agencies in developing pathways for implementation of promising technologies.

"The poor of the world – those who need energy most – provide a compelling rationale for the development of energy solutions that are scalable, available at a low cost and based on a sustainable supply of clean energy"

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