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Defeating energy poverty: A call to invest in scalable, solutions to energy access for the poor

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Energy and persistence conquer all things

– *Benjamin Franklin*

Overview:

Energy poverty, is arguably the most pervasive and crippling threat society faces today. Lack of access impacts several billion people, with immediate health, educational, economic, and social damages. Furthermore, how this problem is addressed will result in the largest accelerant of global pollution, or the largest opportunity to pivot away from fossil-fuels onto the needed clean energy path. In a clear example of the power of systems thinking, energy poverty and climate change together present a dual crisis of energy injustice along gender, ethnic, and socioeconomic grounds, which has been exacerbated if not caused outright by a failure of the wealthy to see how tightly coupled is our collective global fate if addressing climate change fairly and inclusively does not become an immediate, actionable, priority.

While debate exists on the optimal path or paths to wean our economy from fossil fuels, there is no question that technically we have today a sufficient knowledge and technological foundation to launch and to even complete the decarbonisation (IPCC, 2011). Critically needed is an equally powerful social narrative to accelerate the clean energy transition. *Laudato Si'* provides a compelling formulation of the injustice that is both greed and pollution, but an ongoing outreach and partnership effort is needed to truly leverage its powerful message.

In this essay we present examples across scales of the evolving knowledge base needed to build universal clean energy access. This leads to a formulation of an action agenda to defeat energy poverty and energy injustice.

1. The Multi-Faceted Nature of Energy Poverty and Injustice

In what has become one of the most important and widely quoted assessments of the current state of energy poverty, we now hear daily that, 'that over one billion people today lack access to modern energy services'.

This striking statement has become the rallying cry of the United Nations, the World Bank, and a myriad of non-governmental groups. It is certainly true, but at the same time, it grossly understates the levels and impacts of energy poverty around the planet. Energy poverty is far more than an issue in remote villages of South Sudan, in urban slums in Mexico City, Jakarta, or East Los Angeles, California. Energy poverty exists on multiple levels, from families lacking sufficient, secure, and safe access to, entire peri-urban communities where infrastructure is actively denied for political reasons, to the growing ranks of refugees of climate change and human conflict.

2. A Framework for Learning and Innovation

A variety of factors – all shameful in hindsight -- have retarded the progress of a pro-poor, pro-environment research, testing, and action agenda. The problems of household particulate – black carbon – and trace gas pollution from indoor cooking and heating has been known and studied since the 1950s, and yet only recently has there been any significant scale-up of the solutions. Similarly, the need to think systematically about the cumulative impacts of human activity on nature can be found in writings going back centuries. In one telling example, the Sixth Governor General of Upper Canada (present day Ontario), Sir Francis Bond Head[1], wrote eloquently that:

> *But one of the most wonderful characteristics of Nature is the manner in which she often, unobservedly, produces great effects from causes so minute as to be almost invisible, and accordingly while the human race — so far as an alteration of climate is concerned — are labouring almost in vain in the regions in question, swarms of little flies, strange as it may sound, are, and for many years have been, most materially altering the climate of the great continent of North America!*
>
> (Head, 1846)

These any many other examples of an early knowledge with minimal to non-existent actionable uptake underscore the problem of knowledge without actionable agenda. While many forms of this 'valley of death' exist today, one clear enabler of action is the ability to empower intellectual advances in areas derided or dismissed by the mainstream. Cookstoves, clean energy, climate change, and social, ethnic and other injustices all fall squarely into this area.

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[1] For identifying this powerful quote, I thank KelleyAnne Malinen and Chérif F. Matta of Mount Saint Vincent University. They provide the biography that: "Well before global warming-driven "*climate change*" began its move into the World conciousness in the ninteen sixties, a Canadian author and public servant, Sir Francis Bond Head (1793 - 1875) uses variations of the term and as early as in 1846 in his book "*The Emigrant*" (Fig. 1). Sir Francis Bond Head was the sixth Lieutenant-Governor of Upper Canada (Ontario) from 1836 to 1837 under King George IV and then under Queen Victoria from 1837 to 1938, during the first year of her reign."

One strongly empowering framework is to appreciate originality, importance, and avenues for action that novel investigations can afford the early implementer. In his seminal book, *Pasteur's Quadrant*, the political scientist Donald Stokes summarized this value in classic 2 x 2 matrix of opportunities (Figure 1).

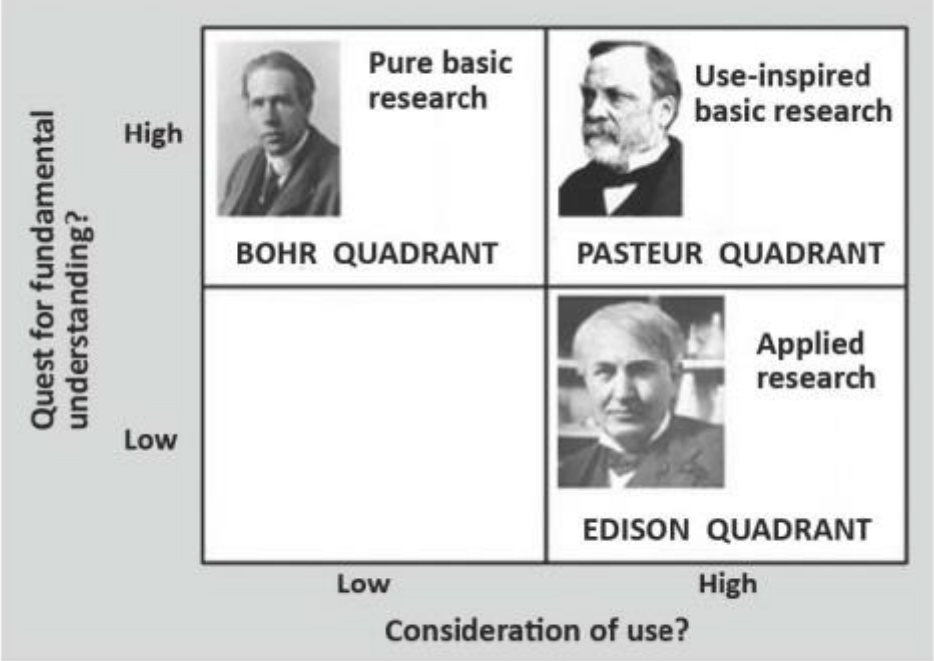

Figure 1: Pasteur's Quadrant and the power of formulating formerly applied research as fundamental (Stokes, 1997). The empty "Low-Low" quadrant has been variously and humorously described, generally with self-depreciation as the zone of 'university presidents', or of 'of social media gadflies'.

It is clear that raising the mundane to an intellectual, political, and commercial level comparable to other texts and tenets of society is vitally needed for the natural, social, psychological and policy tools needed for energy access sustainability. If we utilize it effectively, *Laudato Si'* can be one of these grand ethical and intellectual levers.

Energy poverty exists at many scales: from the classic 'three stone fires' of rural homes in the poorest nations to rapidly growing urban communities, to rich nations that deny their own citizens even the most basic forms of energy infrastructure. In the next three sections, we illustrate the power of an approach that values the *Pasteur's Quadrant* perspective for a) rural cookstoves; b) mini-grids for community energy services, and c) the need and opportunity to transform the dirtiest, large-scale grids to meet both household and industrial energy needs.

3. Intra-Household Scale: Cookstoves, Women, and Health

Women, who gather or purchase fuel, cook, and handle fire considerably more frequently than men, also have much higher exposure to the health impacts of energy use, including respiratory or eye diseases due to indoor smoke, burns, or back pain and injuries from carrying heavy loads

While these increased health risks have long been recognized (Kammen, 1995), detailed analysis illustrates that even the scientific tools used for quantifying exposure and disease relationships need to pay attention to details of women's work to properly assess the magnitude of the health risks associated with household energy tasks.

A now rich literature exists on the exposure to indoor smoke under actual conditions of use has shown that stove emissions are highly episodic and that peaks in emissions commonly occur when fuel is added or moved, the stove is lit, the cooking pot is placed on or removed from the fire, or food is stirred (Figure 2). Quantitative and qualitative data on time-activity budgets also indicate that female household members are consistently closest to the fire when the pollution level is the highest. Other household members may be outside or away from the house at such times, especially during the hours when the fire is lit or extinguished.

Starting in 1994, my student Majid Ezzati and I began what became the first natural experiment on the health impacts of stove and fuel choice in rural homes. Our project near Laikipia Kenya was hampered by the lack of digital pollutant concentration measurement equipment that is available today, but with persistence and a great deal of community cooperation, was able to chart the health outcomes of over 500 villagers over a four-year period (Ezzati and Kammen, 2011; Bailis, Ezzati, and Kammen 2005).

Figure 2: a) Women collecting firewood in Kitui District, Kenya. B) Ethiopian *enjera* stoves showing common open access design for ease of use, but also high energy loss. Photo credits: Daniel M. Kammen

At the time we began the work, the value of this experiment was questioned because of both the difficulty of undertaking the work, but also because high initial exposure levels (over 7000 micro-grams of particulates per cubic meter ($\mu g/m^3$) so many times the US and European 'do not exceed' standard of ~ 100 $\mu g/m^3$ that many public heath officials thought that meaningful reduction via the transition to improved stoves would have little effect, not because the stoves were ineffective, but because the chasm was so large.

Figure 3 shows the exposure data obtained using an approach that considers the full exposure patterns and profile of individuals, divided into exposure during high-intensity and low-intensity episodes respectively. **Error! Reference source not found.** further compares these values with the exposure estimates obtained using only average pollution concentration at a single point

and time spent inside (i.e. without taking into account either the spatial distribution of pollution or the role of activity patterns).

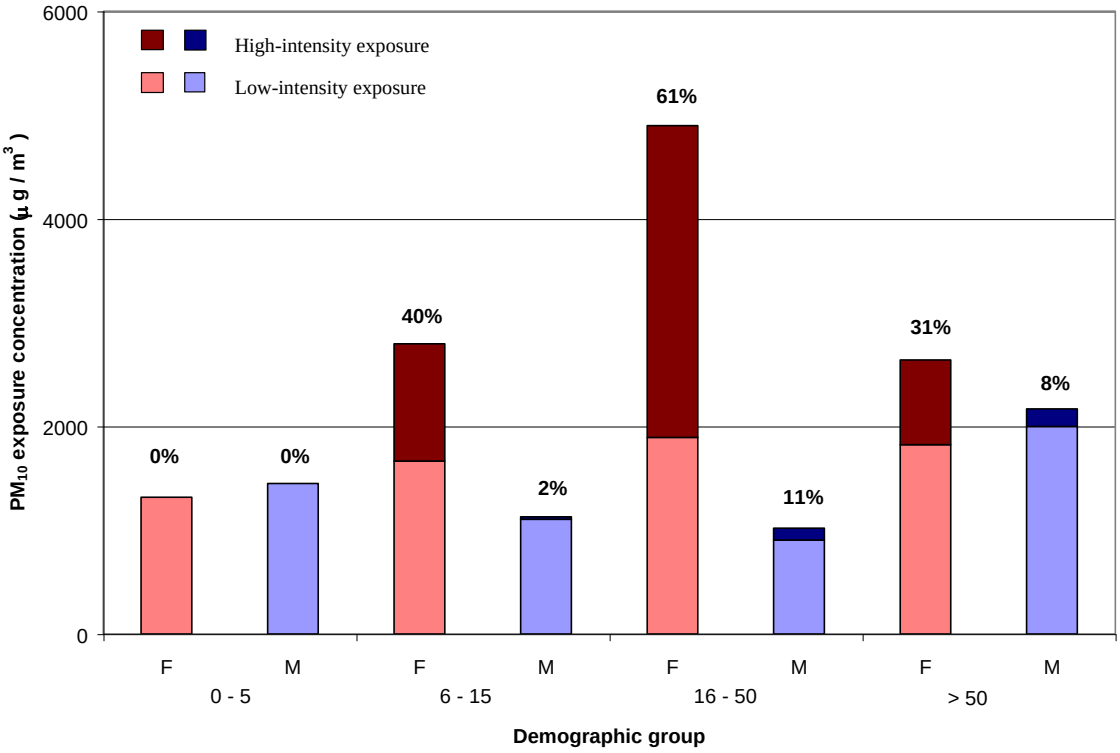

Figure 3: Total daily exposure to PM_{10} into high-intensity (darker shade) and low-intensity (lighter shade) exposure. For each demographic subgroup (Females, Males, by age), where the total height of the column is the group average exposure concentration divided into average for high- and low-intensity components. The percentages indicate the share of total exposure from high-intensity exposure. The high-intensity component of exposure occurs in less than one hour, emphasizing the intensity of exposure in these episodes. For further details see Ezzati and Kammen (2001).

As seen clearly in **Error! Reference source not found.**, the ratios of exposure estimates using average concentration at a single point to those using the exposure profile approach for the four age groups are 0.97, 0.44, 0.29, and 0.51 for females and 0.97, 0.91, 0.83, and 0.79 for males. The large variation of this ratio among the demographic groups indicates that ignoring the spatial distribution of pollution and the role of activity patterns in exposure could not only result in inaccurate estimates of exposure but also – and possibly more importantly – could bias the relative exposure levels of various demographic groups. The exposure of women, who cook and are most affected by high-intensity pollution episodes, would be underestimated most severely by using average pollution alone. This could in turn result in systematic bias in assessing the health impacts of exposure and benefits from any intervention strategy (*40*).

Increased access to clean energy sources can improve the day-to-day as well as long-term welfare of female household members. Health improvements, time, and/or money saved from energy needs may be used for leisure, participation in formal labour force, education, and community or commercial activities. This transfer of resources could be an important

mechanism to improve the status of women in developing countries. At the same time, in considering energy as a tool for improving the status of women, it is essential to note that the economic and social institutions, both inter- and intra-household, that hinder female access to adequate clean sources of energy are often the same that create other gender inequalities. In fact, it has been argued that the increased prominence of biomass as an economic commodity (e.g. as a source of energy for small-scale manufacturing) has attracted local entrepreneurs and business actors – mostly men – driving women to assume more marginal social roles and depend on inferior sources of energy (Kammen, 1995)[2]. In our study, we found that the transition from traditional wood-burning stoves to the cleanest charcoal burning stoves could cut pollution levels so significantly – and largely for women and children – that there was literally no more cost-effective intervention (Ezzati and Kammen, 2001) on a DALY (disability adjusted life year) than childhood immunizations and improved cookstoves.

Over the past decade, significant investment by the United Nations Foundation, strong vocal leadership from political leaders (e.g. Senator Hilary Clinton) and media figures (e.g. Julia Roberts) brought this issue to global attention, and funding, national programs, and ongoing research as well as MacArthur Prizes[3] have followed. We see an evolution from mundane (Kammen and Dove, 1997; Dove and Kammen, 2015) topic to Pasteur's Quadrant.

4. Community Scale: Minigrids

Today there is continued grid expansion with a range of projected trends in grid-based access through 2030 (which has become a benchmark year). The IEA, the most cited source, expects that over 900 million people in rural areas will remain without electricity by 2030, in contrast to only about 100 million in urban areas, with the vast majority in Sub-Saharan Africa (Alstone, Gershenson and Kammen, 2015). Sustainable Energy for All (SE4ALL, 2013), using data from the IEA, expects that reaching universal access will require grid extension for all new urban connections and 30% of rural populations, with the remaining 70% of rural people gaining access through decentralized solutions (via minigrids, via SHS and intra household, or 'pico' products, known widely as 'pay-as-you-go' [PAYG] energy access technologies). In fact, a legitimate argument exists that despite 'utility apologist' arguments, that mini-grids will, in time be cheaper, more reliable, and cleaner than large grid systems (Casillas and Kammen, 2010).

Despite more than a century of expansion, and an emerging recognition that access to electricity constitutes a human right, we identify pervasive "energy isolation barriers" that people continue to experience in the context of grid-based electrification as a result of multiple dimensions of remoteness: geographic, economic, and political. Complex geography, long transmission distances, and diffuse populations restrict grid extension in poor nations to many rural areas due to high marginal cost of connection compared to expected usage.

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[2] The dedication, innovations, and seminal contributions to this field by Kirk Smith deserves special recognition. Personally, my first contact in the energy-development field was with Kirk. For a small taste of his outsized role, see: http://www.kirkrsmith.org

[3] https://www.youtube.com/watch?v=jpqukxklLpI

The economic limitations of the rural poor are reflected in their low energy consumption, struggle to pay connection fees, and challenges in procuring household wiring and appliances. In fact, many households and businesses in "electrified" areas lack access, even directly beneath power lines. Finally, centralized grid extension often requires a degree of political power that is a barrier for disadvantaged rural and urban populations with opposition, marginalized, or diffuse societal and political affiliations who are not supported by strong institutions. People and communities without property rights may lack the stability to justify investments in fixed infrastructure, or permission from central authority to do so. Figure 4 presents a representative mini-grid in Sabah, Malaysian Borneo showing solar power (as well as micro-hydropower) powering telecommunications hardware as well as village lighting.

Figure 4: A village micro-grid energy and telecommunications system in the Crocker Highlands of Sabah, Malaysian Borneo. The system serves a community of two hundred, and provides household energy services, telecoms and satellite (dish shown), water pumping for fish ponds (seen at center) and for refrigeration. The supply includes micro-hydro and solar generation (one small panel shown here, others are distributed on building rooftops). Photo credit: Daniel M. Kammen.

Mini-grids were initially met with much derision and skepticism by the 'development elites' at many multinational agencies. They were seen as too complex and capital intensive for the amount of energy they provided, potentially beyond the technical know-how of communities, and too much of a threat – to be frank – to the tried and true monopoly utility model. While the story of mini-grids is far from complete, and huge challenges of support, financial models, and of interaction with the traditional utility grids persists, a clear path to relevance – and

potentially even energy provision domination – certainly exists. Figure 5 provides an overview of energy service provision from PAYG, mini-grid, and large-grid systems. The battle for customers is one that distributed PAYG and mini-grid systems are increasingly winning, one home, and one kilowatt at a time.

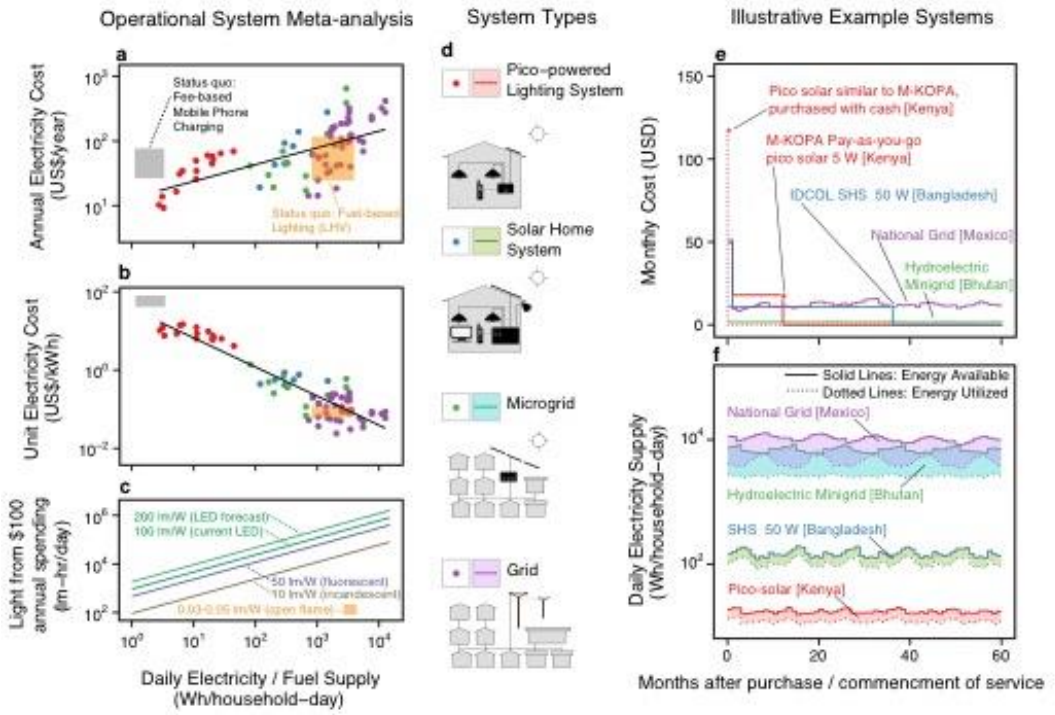

Figure 5: Source: Alston, Gershenson, and Kammen, 2015. Here we provide a mapping of PAYG, mini-grid, and large-scale grid technologies and levels of service provision (Alstone, Gershenson, and Kammen, 2015).

Today the gap between global population and those with electricity access stands at roughly 1.3 billion, with energy services for the un-electrified coming largely from kerosene and traditional biomass, including dung and agricultural residues. This 'access gap' has persisted as grid expansion programs and population have grown.

Globally, utility-scale grid expansion has roughly kept pace with the increase in the global population. About 1.2 billion people in 2016 are completely off-grid, and many ostensibly connected people in the developing world experience significant outages that range from 20-200+ days a year. The majority of these off-grid residents are in rural and underserved peri-urban areas. Current forecasts are that this number will remain roughly unchanged until 2030, which would relegate a significant portion of the population and the economies of many of the neediest countries on earth to fragile, underproductive lives with less options than they could otherwise have (Figure 6). Traditional grid extension will be slowest to reach these communities. Unless the advances in both energy and information systems that have occurred over the past decade are more widely adopted, there will be little if any chance to alter this trend.

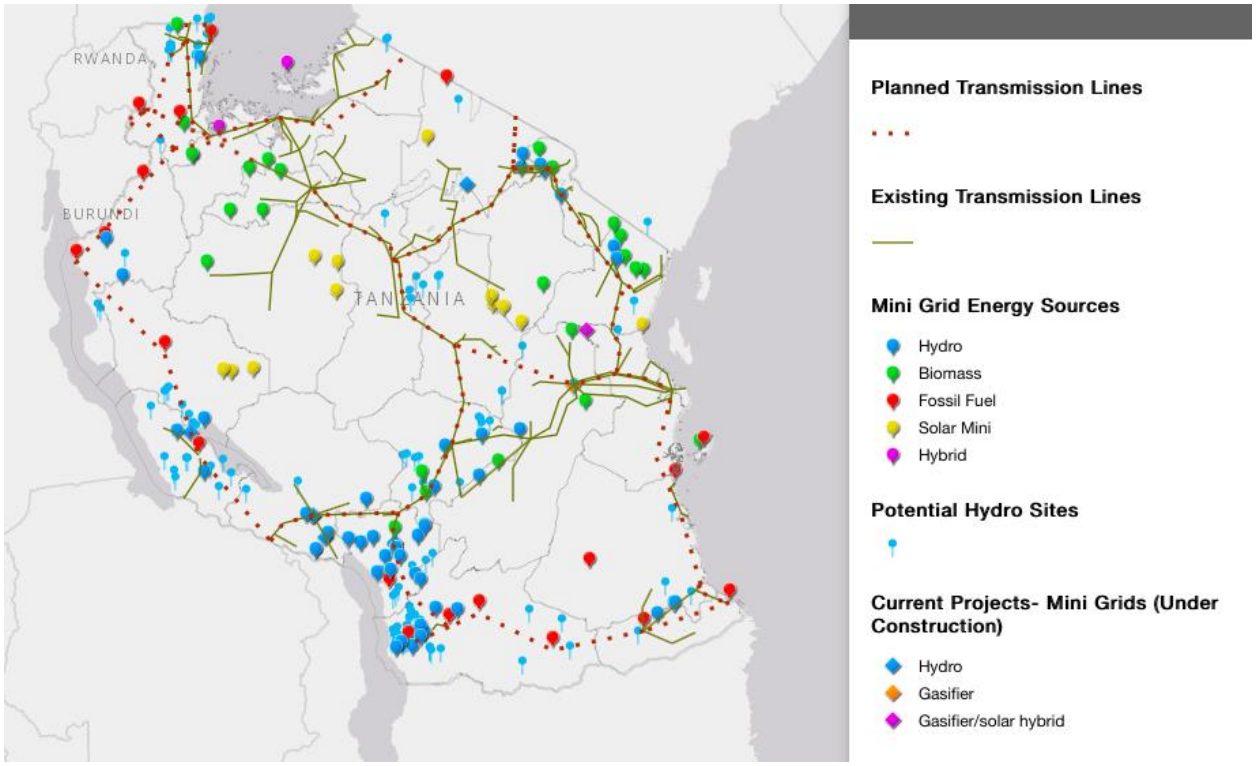

Figure 6: Map of existing and planned utility grid and the proliferation of mini-grid systmes across Tanzania. Source: http://www.wri.org/resources/maps/tanzania-energy-access-maps. For additional mini-grid assessments, See Schnitzer, *et al.,* 2014. Similar maps are emerging worldwide

4.1 Science Advances in off-grid systems

Recently we have seen an emergence of off-grid electricity systems that do not require the same supporting networks as the traditional forms of centralized power generation. These technological innovations are as much based on information systems as they are directly about energy technology. While traditional electricity grids can gradually pay off (amortize) the costs of expensive generation, transmission and distribution capital equipment across many customers and across many decades, a new business model is needed to rapidly bring energy services to the rural and urban poor. Mini-grids and products for individual user end-use such as solar home systems have benefitted from dramatic price reductions and performance advances in solid state electronics, cellular communications technologies, electronic banking, and in the dramatic decrease in solar energy costs and more recently in storage costs (Kittner, Lill, and Kammen, 2017). This mix of technological and market innovation has contributed to a vibrant new energy services sector that in many nations has outpaced traditional grid expansion.

The comparison between the utility model of central-station energy systems and this new wave of distributed energy providers is instructive. Traditional dynamo generators and arc lighting perform best at large scale, and they became the mainstay of large-scale electric utilities. The classic utility model of a one-way flow of energy from power plant to consumers is now rapidly changing. The combination of low-cost solar, micro-hydro, and other generation technologies coupled with the electronics needed to manage small-scale power and to communicate to

control devices and to remote billing systems has changed village energy. High-performance, low-cost photovoltaic generation, paired with advanced batteries and controllers, provide scalable systems across much larger power ranges than central generation, from megawatts down to fractions of a watt.

The rapid and continuing improvements in end-use efficiency for solid state lighting, direct current televisions, refrigeration, fans, and information and communication technology have resulted in a 'super-efficiency trend'. This progress has enabled decentralized power and appliance systems to compete with conventional equipment for basic household needs. These rapid technological advances in supporting clean energy both on- and off-grid are furthermore predicted to continue. This process has been particularly important at the individual device and household (solar home system) level, and for the emerging world of village mini-grids.

5. Utility Scale: Grid Expansion and Its Dramatic Alternatives

> Going up that river was like travelling back to the earliest beginnings of the world, when vegetation rioted on the earth and the big trees were kings.
> - Joseph Conrad, *Heart of Darkness*

In 2008 I was approached by a consortium of NGO groups In Sabah, Malaysia to offer alternatives to a coal-fired power plant. Sabah, a small, and generally well managed state, is the former British North Borneo, famous for rare mega-fauna and Mount Kinabalu. Our report, *Clean Energy Options for Sabah* (McNish, Kammen and Gutierrez) (Figure 7) and a great deal of community education and outreach helped to overturn a decision to purchase a 300 MW used coal-fired power plant from China and instead to invest in expanded distributed renewables, and improved grid, and natural gas.

This victory helped to connect our team to a more challenging case, that of the larger and more ecologically and culturally brutalized state of Sarawak. My excitement, simply to have been approached by the community activists organized by LEAP in Sabah, however was multiplied when I learned that the reward for taking on one seemingly lost cause can be others. Soon thereafter, we were asked to look at the conditions in the far more degraded ecological situation that is the neighboring East Malaysian state of Sarawak.

Figure 7: TOP LEFT - The RAEL report, *Clean Energy Options for Sabah;* TOP RIGHT – Presenting the Report to the Environment Minister; BOTTOM LEFT – Coverage in *The Borneo Post,* "Anti-coal stand has support'; BOTTOM RIGHT – large public turnouts at events to discuss and debate the report findings.

The victory against big coal in Sabah inspired a new kind of discussion around energy to happen across the region. Activists from throughout Asia working on campaigns against "dirty" energy projects like coal and dams were talking to clean and appropriate energy practitioners. This culminated in the "Southeast Asia Renewable Energy Peoples' Assembly" hosted by LEAP and Green Empowerment, but involving practitioners and activists from over 11 different countries. It was at this event that the strategy to confront the problem of dam expansion in Sarawak with an analysis and demonstration of alternatives was born. LEAP, Green Empowerment, and Tonibung worked with SAVE Rivers to devise a strategy to support the existing campaign against the Baram Dam by demonstrating the viability of renewable alternatives: both through tangible mini-grid projects in the field and high level academic analysis. It was shortly after this that RAEL was engaged, and the initiative received a pledge of financial support from the Rainforest Foundation Norway.

While SCORE was being marketed internationally as a "build it and they will come" energy project, making the project palatable locally relied on securing buy-in from Sarawakians who still lacked access to energy and other modern amenities. It also happened that those who would be displaced by the dams themselves fell into this demographic. This was especially true within the Baram River Basin, where those fortunate enough to afford diesel for generators mainly relied on logging companies to provide it in exchange for rights to log their land. SCORE promised them affordable electricity and more, but the only reference point for Baram's residents for what their future might look like was the Bakun Dam.

In 2002, as Sarawak was completing the Bakun Dam, one Kenyah-Badang community that would have been displaced refused to accept the resettlement package and instead relocated their settlement just outside the dam's reservoir. Gara Jalong, the tenacious and charismatic leader of Long Lawen, had led the village against the many timber companies encroaching on indigenous lands in the 1980's, then against dam developers in the 1990's. Gara also sought out professionals with experience in rural electrification via micro-hydro, to provide a sustainable source of energy to his people. He succeeded eventually, in securing the support of Portland, Oregon based NGO Green Empowerment, the Berkeley-based Borneo Project, and Sabah-based PACOS Trust. This turned out to be the first community-driven, owned and operated mini-grid in Malaysia, and it would influence the discussion around energy and indigenous self-determination for years to come.

Since 2002, indigenous organization Tonibung and Green Empowerment have worked together to install 30 mini-grids across the Malaysian states. After SEAREPA, the two organizations focused efforts around developing micro-hydro and solar PV powered mini-grids in the Baram. This was an opportunity for Baram's people to show neighboring communities and their leaders that distributed, affordable, and environmentally sustainable electrification solutions were possible. Among the systems that was installed was one for the village of Bario Asal, completed in 2010[4].

During our meeting with the Chief Minister, he stated that extending energy access to Sarawak's rural residents was of paramount importance to him, inviting us to submit a plan to operationalize some of the findings of the report. This also included proposing solutions for scaling up the delivery of mini-grids in rural Sarawak.

5.1: A clever deception: the Sarawak Corridor of Renewable Energy (SCORE)

In Malaysian Borneo, like much of Southeast Asia has experienced not only a brutal wave of deforestation, but also a surge in mega-hydro power projects ostensibly to facilitate industrial productivity and consumption. The Three Gorges Dam of China was completed in 2006 while the Nam Theun Dam (complet ed in 2010) and the Xayaburi Dam (under construction) in Laos are the first of a series of dams being built in the transboundary Lower Mekong Basin. The

[4] Additional mini-grid systems were also built in Pa'Ramapuh, Tanjung Tepalit, and the Penan villages of Long Lamai and Long Kerangan.

island of Borneo, too, has abundant natural resources, immense global ecological importance, exotic megfauna of orangutans and dwarf rhino and pygmy elephants, and hornbills (Figure 8) and a largely rural human population – some former headhunters -- and an agrarian economy that is also on the cusp of major industrial dislocation due to hydropower development.

Figure 8: LEFT - dominant male orangutan at the Semenggoh orangutan preserve, a tiny 6 ha facility housing over 30 displaced individuals; MIDDLE – [Puntung], a young female critically endangered pygmy rhino captured in a rainforest bordering an expanding palm oil plantation. RIGHT – a rhinoceros hornbill sits in one of the fruiting trees. Photos: Daniel Kammen

In 2006, the Federal Government of Malaysia embarked on a number of initiatives to promote balanced regional development and accelerate growth in designated geographic areas through the Tenth Malaysia Plan. The Plan describes a philosophy of development focused on decentralizing economic growth away from the federal capital through the establishment of *economic corridors* in different states. The Sarawak Corridor of Renewable Energy (SCORE) is a corridor in central Sarawak, an East Malaysian state on the island of Borneo. SCORE differs fundamentally from the other Malaysian economic corridor projects in its predominant emphasis on hydropower[5].

Sarawak (Figure 9), is the poorest and most rural state in Malaysia, and thus a perfect playground for both big, undisciplined projects, and for profiteering. An increased focus on cheap electricity to attract manufacturing and industry became the state's approach to achieving high income economy status. The current peak annual energy demand in Sarawak is 1250 MW, met by a mix of diesel, coal and natural gas generation either operated or purchased by the state utility company. At least 12 large hydroelectric dams and two coal power plants, together constituting 9380 MW of capacity, are scheduled to be built before 2030 (Sovacool and Bulan, 2011). Six dams are scheduled to be completed by 2020 with three major dams already under different stages of development.

In 2012 the 2400 MW Bakun dam became operational. At 205 meters high it is Asia's largest dam outside China. The dam's reservoir submerged 700 km^2 of land and displaced about 10,000 people. In 2013 the 944 MW Murum Dam was completed and the 1,200 MW Baram Dam was scheduled for construction.

[5] "What is SCORE?," *Regional Corridor Development Authority (RECODA)*, 2015. [Online]. Available: http://www.recoda.com.my/invest-in-score/what-is-score/. [Accessed: 01-May-2014].

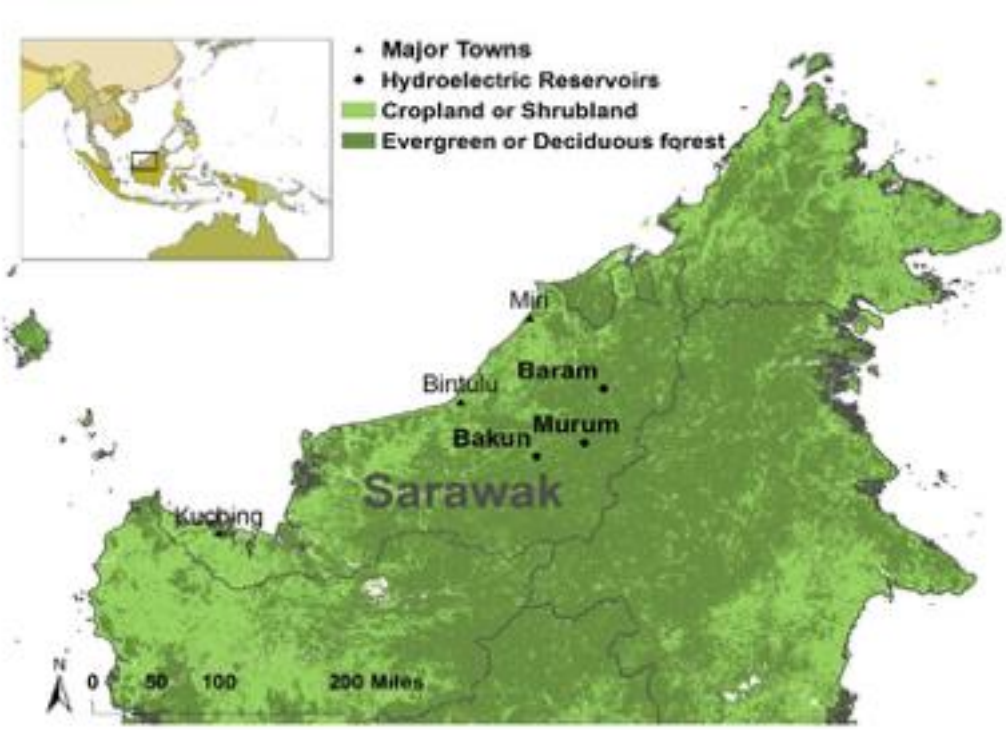

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Figure 9: Map of northern Borneo showing Sarawak, the dam sites, with Sabah at top right.

These projects - SCORE – sum to a targeted nine-fold increase in energy output between 2010 and 2020, or from 5,921GWh to 54,947GWh, which represents a 16% annual growth rate. In terms of installed capacity this translates to an expansion from 1,300MW in 2010 to between 7,000MW and 8,500MW in 2020. No extant demand exists for this power, yet the ecological and community damage would be extreme.

To battle against such an over-reach of projects is difficult because little else will offer as much apparent gain – gigawatts (10^9) of new power. Malaysia has little need for this power. Unless, that is, one also presumes further mega-project such as a huge transmission cable to export power to peninsular Malaysia (and then to China?) or a huge bauxite to aluminum refining project (which probably could not compete with Brazil's bauxite wealth and massive and already installed hydropower. This raises the specter of the true motivation for SCORE: a means to attract billion of foreign, likely largely Chinese investment. $100 billion is the number often floated. In face of this, the 'tiny' story of the 300 MW coal plant and relatively orderly Sabah pales by comparison.

The story is further complicated because with so many proposed dams, and even less quantitative analysis of the energy options or cost and benefit trade-offs in the literature or the public discussion over this conflict, it is very hard for opposition to develop a clear narrative.

A doctoral student of mine, co-author, and now Senior Research Director for several international organizations energy access and environmental, Dr. Rebekah Shirley from Trinidad and Jamaica, set out to scale up and make far more sophisticated the modeling packages we

built for the Sabah study. With such a modeling tool, we could then address the question: What are feasible alternative energy futures for East Malaysia that meet future energy demand for the local population given priorities of (a) cost, (b) reliability and (c) environmental impact?

While I won't describe that model in technical detail here; the interested reader is directed to our papers that detail the analytic tool itself, the data sets, and many of the specific results (Shirley and Kammen, 2015). Our results appeared locally in late 2015, and we immediately began to hold open meetings to present these models, and our findings (Figure 10).


Figure 10: LEFT activist team dinner with Dr. Rebekah Shirley, second from left and Prof. Kammen, middle, flanked by community activist leaders from across Sabah and Sarawak. Peter Kallang (L) Peter Kallang, Chairman of SAVE Rivers, Gabriel Sundoro Wynn (second from Left), the Asia Regional Director for Green Empowerment. Kammen (second from Right, and Lawyer and Sarawak Assemblyman See Hee Chow is at far right.

Our findings were stark and robust: Sarawak's current installed capacity including Bakun already exceeds expected demand in 2030 demand under the business-as-usual (BAU) growth assumption. So, there is no additional need to build out more capacity under the government's own BAU growth forecast. The Bakun Dam itself can provide more than 10,000 GWh per annum. Under a 7% electricity demand growth assumption, this represents half of expected demand by 2030. Even under the more aggressive 10% growth assumption, Bakun alone will satisfy a third of demand in 2030. Completion of the two additional dams currently under construction (Murum and Baram) would oversupply 2030 demand under 7% growth, leading to a large excess capacity, and would require a marginal amount of additional generation under 10% growth.

The already well-established blockade against the dams used our results immediately. Not only were there now blockades and protests, but also teach-ins, op-pieces, and international commentary. In one of the most peculiar twists, the Norwegian 'hired gun' Minister of Energy took to combating the coverage our work received with statements to press that 'Sarawak would not listen to 'flippant' analysis by *foreigners.*

Press coverage was extensive (Figure 11).

Figure 11: Protesters citing (and holding) copies of the Shirley and Kammen study add ammunition to the wider social dialog around the need for mega-dams, and the dubious possibility of billions of foreign investment (from the 11 August article in *The Borneo Post).*

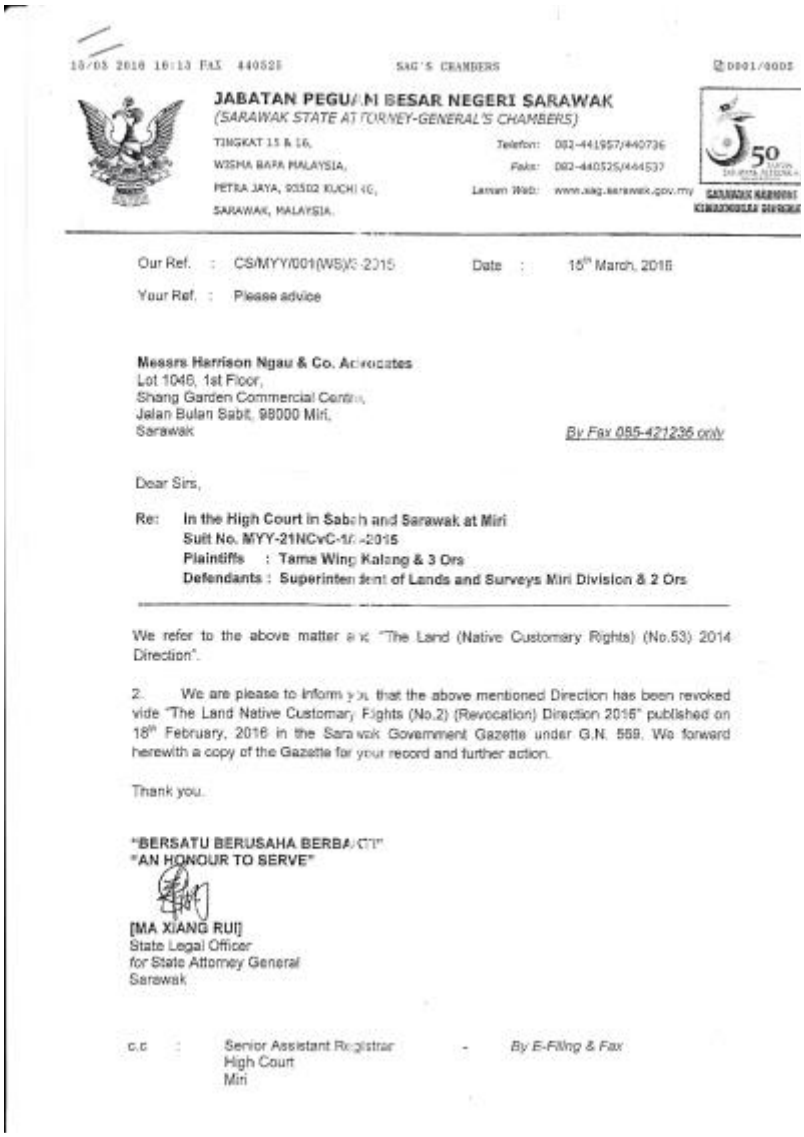
A breakthrough

In response to the new study, press coverage, indigenous protests, and a meeting I had with the Chief Minister something remarkable and unexpected happened. On 30th July 2015, a moratorium on further work for the Baram dam was announced by the Chief Minister.

Then, on March 21, 2016 a legal decision to solidify this position was announced (Figure 12): the Government of Sarawak revoked the classification of the land that dam developers has used to extinguishing the native rights of ownership for the contested dam site. This remarkable turnaround victory was a demonstration of local community activism and the importance of science communication, as research published by the Renewable and Appropriate Energy Laboratory identifying financially viable commercial power production alternatives for the state, played a major role in the developments.

It is in many ways quite hard to appreciate such a sudden and clear victory. It resulted from the years of community organizing needed to staff a blockade, and endless community and press outreach, but it also would not have been possible without the analytical hammer that our study brought, and was then used so effectively by the community. To have all this effort distilled into a single, clear, unequivocal edict is a rare, sweet, and shockingly sudden outcome.

No environmental victory is ever final, of course. One moment's victory then demands constant vigilance, as anything can be overturned, by a change in political party, a shocking election result, or by illegal land grabs and invasions. In the case of the Baram dam, the paper is clear, but shortly thereafter the Chief Minister passed away. While the law stands, what was once final is never quite so final with the inevitable change of officials. For now, however, things are in a good place.



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Our Ref. : CS/MYY/001(WS)(3-2015 Date : 15th March, 2016

Your Ref. : Please advice

Messrs Harrison Ngau & Co. Advocates
Lot 1046, 1st Floor,
Shang Garden Commercial Centre,
Jalan Bulan Sabit, 98000 Miri,
Sarawak

By Fax 085-421236 only

Dear Sirs,

Re: **In the High Court in Sabah and Sarawak at Miri**
Suit No. MYY-21NCvC-1/3-2015
Plaintiffs : Tama Wing Kalong & 3 Ors
Defendants : Superintendent of Lands and Surveys Miri Division & 2 Ors

We refer to the above matter and "The Land (Native Customary Rights) (No.53) 2014 Direction".

2. We are please to inform you that the above mentioned Direction has been revoked vide "The Land Native Customary Rights (No.2) (Revocation) Direction 2015" published on 18th February, 2016 in the Sarawak Government Gazette under G.N. 559. We forward herewith a copy of the Gazette for your record and further action.

Thank you.

"BERSATU BERUSAHA BERBAKTI"
"AN HONOUR TO SERVE"

[MA XIANG RUI]
State Legal Officer
for State Attorney General
Sarawak

c.c : Senior Assistant Registrar - *By E-Filing & Fax*
High Court
Miri

Figure 12: Edict from the Chief Minister of Sarawak cancelling the permit to build the next, the Baram, dam.

6 Assessment: The Benefits of Diverse Technology Options to Provide Energy Services

With these technological cornerstones at the household to community to large-scale, aid organizations, governments, academia, and the private sector are developing and supporting a wide range of approaches to serve the needs of the poor, including pico-lighting devices (often very small 1 – 2 watt solar panels charging lithium-ion batteries which in turn power low-cost/high efficiency light emitting diode lights), solar home systems (SHS), and community-scale micro- and mini-grids. Decentralized systems are clearly not complete substitutes for a reliable grid connection, but they represent an important level of access until a reliable grid is available and feasible. They provide an important platform from which to develop more distributed energy services. By overcoming access barriers often through market-based structures, these systems provide entirely new ways to bring energy services to the poor and formerly un-connected people.

Meeting peoples' basic lighting and communication needs is an important first step on the 'modern electricity service ladder' (Masera, *et al.*, 2000; Saatkamp *et al.*, 2000). Eliminating kerosene lighting from a household improves household health and safety while providing significantly higher quality and quantities of light. Fuel-based lighting is a $20 billion industry in Africa, and tremendous opportunities exist to both reduce energy costs for the poor, and to improve the quality of service. Charging a rural or village cell phone can cost $5 – 10/kWh at a pay-for-service station, but less than $0.50 cents/kWh via an off-grid product or on a mini-grid.

This investment frees income and also tends to lead to higher rates of utilization for mobile phones and other small devices. Overall, the first few watts of power mediated through efficient end-uses lead to benefits in household health, education, and poverty reduction. Beyond basic needs there can be a wide range of important and highly-valued services from decentralized power (e.g., television, refrigeration, fans, heating, ventilation and air-conditioning, motor-driven applications) depending on the power level and its quality along with demand-side efficiency.

Experience with the 'off-grid' poor confirms the exceptional value derived from the first increment of energy service—equivalent to 0.2-1 Wh/day for mobile phone charging or the first 100 lumen-hours of light. Given the cost and service level that fuel-based lighting and fee-based mobile phone charging provide as a baseline, simply shifting this expenditure to a range of modern energy technology solutions could provide a much better service, or significant cost savings over the lifetime of a lighting product (typically 3 - 5 years).

Testing laboratories that rate the quality of the lighting products and disseminate the results are an invaluable step in increasing the quality and competitiveness of new entrants into the off-grid and mini-grid energy services space. The *Lighting Global* (https://www.lightingglobal.org) programme is one example of an effort that began as an industry watchdog, but has now become an important platform that provides market insights, steers quality assurance frameworks for modern, off-grid lighting devices and systems, and promotes sustainability through a partnership with industry.

7. Conclusion: An Action Agenda for Energy Access

Exploit Information Technology:

The information technology revolution has dramatically closed the gap between off-grid, mini-grid and utility-grid scale management solutions and costs. In fact, the diversity of new energy service products available, and the rapidly increasing demand for information and communication services, water, health and entertainment in villages worldwide has built a very large demand for reliable and low-cost energy. Combining this demand with the drive for clean energy brings two important objectives that were for many years seen as in direct competition with alignment around the suite of new clean energy products that can power village energy services.

To enable and expand this process, a range of design principles emerge that can form a roadmap to clean energy economies:

- *Establish clear goals at the local level:* Universal energy access is the global goal by 2030[7], but establishing more near-term goals that embody meaningful steps from the present situation will show how what is possible and at what level of effort. Cities and villages have begun with audits of energy services, costs, and environmental impacts.
- *Empower villages as both designers and as consumers of localized power*: Village solutions necessarily vary greatly, but clean energy resource assessments, evaluation of the needed infrastructure investment, and, most often neglected but most important, the social structures around which sufficient training exists to make the village energy system a success. In a pilot in rural Nicaragua, once the assessment was complete[8] movement from evaluation to implementation quickly became a goal of both the community and a local commercial plant.
- *Make equity a central design consideration:* Community energy solutions have the potential to liberate women entrepreneurs and disadvantaged ethnic minorities by tailoring user-materials and energy plans to meet the cultural and linguistic needs of these communities. National programmes often ignore business specialties, culturally appropriate cooking and other home energy needs. Thinking explicitly about this is both good business and makes the solutions much more likely to be adopted.

Each of these steps warrants a further narrative, one that relies not only on science and technology, but also centrally on narrative. *Laudato Si'*[6] is such a text: a compelling argument that blends and uses science, technology, and economics in a larger *integral ecology* that is as respectful of culture as it is of community and social justice, but one that at the same time presents a vision of the positive nexus of science, technology, policy, and above all, culture and community.

Acknowledgements

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[6] To further integrate this work with the inspiration that is *Laudato Si',* we include here the output of a worksship sponsored by the Pontifical Academy of Sciences where we compiled an 'action agenda' for the continued use of the Encyclical (Parker and Kammen, 2017). We include that here as Appendix A.

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Appendix 1: "Actualizing the Encyclical" Findings of the November 2, 2016 Pontifical Academy of Sciences Workshop on the Encyclical.

Laudato Si' is a powerful text, political and poetic, and deeply inspiring. It addresses the most critical issues of our time in vision and substance. It elucidates the necessity and means of "individual ecological conversion", to see the "world as a sacrament of communion." Two of its guiding tenets are "the human environment and the natural environment deteriorate together", and that we have mutually reinforcing obligations to the earth and to each other. The Beatitudes provide the philosophy to shape our work of transforming and healing society and our planet. The Encyclical provides the blueprint.

Action Recommendations

1. Expand the dialogue with those with influence and power (noting specifically those who drive investment decisions) on the dovetailing of environmental and social issues - "the book of nature is one and indivisible" - and its relevance and implications; toward that end establish a sustainable investment advisory committee for the Vatican's own investment activities.
2. Continued personal engagement and presence of the Pope in delivering and keeping current the message of *Laudato Si'*. The more Pope Francis speaks about climate change and *Laudato Si'*, the more he will influence public opinion around the world.
3. A detailed and well-resourced communication and messaging strategy for *Laudato Si'*, targeted to diverse audiences, which stresses the urgency of the challenge. A plan, differentiated in style, tone, pace and suggested terms of engagement for the four different generations that are active at this moment in history. The different generations should be addressed on their own terms, and with their input. Engage leaders in social media to spread and evolve the message of *Laudato Si*'.
4. That the institution of the Catholic Church, serving as spiritual guide and moral messenger, also serve as physical and behavioral example, modeling in microcosm, the planetary vision of *Laudato Si'* by accelerating the conversion to sustainable stewardship of its own land and assets, the Church's training programs for priests being a powerful, integral aspect.
5. Promote an interdisciplinary interfaith forest, land and climate initiative - which acknowledges the "mysterious relations between things" - convened and directed by an inclusive public private partnership.
6. Be aware of and address the emotional and spiritual implications and sorrow deriving from our "disfigurement" of our common home, which we have "burdened and laid waste," and from distressing commercialism, which "baffle[s] the heart." *Laudato Si'* needs to be widely discussed, shared and acted upon in public and mental health circles, for which it has profound relevance.

Principles to incorporate in the various work of our communities, and additional points of discussion

7. Understand the relationship between "velocity" of current culture and the loss of internal, spiritual time and time for reflection, which is necessary for building a just and compassionate society. "It seems the faster we are carried along, the less time we have to spare." (Booth Tarkington, 1918)
8. Recognize that energy poverty is a major impediment to equity and harmony both within and between communities and nations, and greatly impedes our progress in sustaining the Earth as our common home.
9. Support grass roots activist movements and individuals, as powerful countervailing as well as spiritually enriching forces that make the need for global stewardship vibrant and accessible.
10. Assure that indigenous forest inhabitants have meaningful work that arises from their values, and their relationship to the land. Assure that there are specific avenues for the wisdom of these communities to permeate our atomized civil societies.
11. Encourage down to earth dialogue among faith communities and civil society on the subject of environmental market mechanisms which, like any other tool, can be used either for good or ill, remaining mindful that the Economy is a subset of Nature, and not the other way around.
12. Support governments in crafting policies and laws which reflect our moral and spiritual obligations to each other and to Nature, as they translate into physical and material obligations.
13. Work to establish local and national commitments to use-inspired basic research, required for sustainable energy and water systems and valuing forests. Research and innovation is a vital tool in implementing the

Encyclical, will foster beneficent new technologies, narrow the gap between Nature and technology, and allow people and Nature again to "extend a friendly hand to one another."

14. We need a change of heart; we need to increase tenderness towards each other and the environment, and the way we will get there is not built solely on greater analytical insights and new policy, but also moving aesthetic experiences that raise our minds, hearts, and souls towards the good the transcendental, and the holy.
15. Diets of those consuming industrially produced meat, notably cattle, require a disproportionate amount of arable land, and water. This extravagant inequity highlights that, as with what we purchase, what we eat is a moral choice. Nature's bounty can be sufficient for all needs, but not all greed.
16. Engage the spiritual infrastructure of our world geographically, and include georeligious dynamics in dialogues about environmental programs and policy. Keep the spirit of *Laudato Si'* alive, repeated, and deeply ingrained in communities of faith through communications media, actionable geography-relevant materials (like maps with guided land-use and land/facility maintenance suggestions for various dioceses), and through scientific, and NGO partnerships.
17. Disseminate a central lesson of *Laudato Si'*: that we bear moral responsibility for the full lifecycle of activity resulting from our individual economic actions. We each have personal responsibility for the environmental harm caused by the energy we use or the food we eat, any inequity or injustice in the product supply chains that provide us goods and services, and the byproducts and waste we create.
18. Operationally capitalize on and expand the commonalities between religions, communities, and beliefs around the planet, a shared language that can build understanding and cooperation to support sustainability.
19. *Laudato Si'*, explicitly and implicitly, grounds our material reality in a cosmological view of interrelatedness - in the tradition of St. Francis, Teilhard de Chardin, Thomas Berry, among others - proclaiming the Universe a "communion of subjects," and not "a collection of objects."