ELK COAST INSTITUTE

FOR MINDFUL SUSTAINABLE INNOVATION

Energy Equity Summit

Technology Group

A draft document prepared by Deepak Divan for discussion purposes

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Background:

We are at an inflection point in the transition from a fossil fuel-powered world to one supplied by clean renewable energy. Previous transformations, especially in the energy sector, have been driven by those who could afford the benefits and luxuries of new products, technologies, and services. Wider adoption of electricity only came from policy and regulations that guaranteed universal access. However, in many developing countries, grid extension continued to be impractical and expensive as a mechanism to serve the more impoverished communities.

The unfettered use of fossil fuels over the last 400 years to power the global economy has resulted in greenhouse gas (GHG) emissions that have been the root cause of anthropogenic climate change. Over the last 20+ years, efforts to force mankind to confront climate change by reigning in GHG emissions have had mixed results. The choice has been positioned as one between enjoying the privileges and luxuries that come from access to as much affordable carbon-emitting energy as one wants and using a much more expensive form of energy that provides fewer emissions but may reduce levels of an 'invisible gas that may or may not be able to reverse the effects of climate change in a timely manner' Further, for emerging economies that had little to do with creating the current GHG levels, there would be a substantial penalty on their ability to grow their economies. It is not surprising that few countries have adhered to the limits prescribed by COP, at least until now.

Viewed in traditional terms of rolling out new technologies - with winners and losers and haves and have-nots – this battle to reduce CO2 levels would have been long and protracted (as others have been). As recently as 2004, the IEA was projecting less than 4% penetration of renewables by 2030. With a resurgence of fracking, peak oil was no longer a concern, and the oil industry had dug in for sustained dominance. Coordinated and concerted action against climate change was viewed as aspirational and not very practical – especially for the poorer nations, where talk of reduced carbon emissions came hand in hand with slower growth and increased poverty. However, most predictions in this area, even by leading pundits and organizations, have proven spectacularly wrong.

Over the last 20 years, the world today has become a different place. Renewable energy is much cheaper than fossil fuel. Electric vehicles cost much less over the vehicle's life cycle and will soon have a first cost below the mature and very much cost-reduced gasoline car. Coal plants are in retreat, and gas plants that should have been base generation are running as peaker plants with inferior capacity factors. Utilities are struggling to accommodate increasing levels of poor capacity factor renewables on the grid and are having to build more transmission to integrate it with the grid – all operating at even lower utilization factors than today's grid. The traditional paradigm of a centralized grid sees limits to how well it can integrate distributed resources. Digitalization also increases the threat of cyberattacks, which can be especially crippling for large centralized systems.

Overview:

Globally, we have an extremely tight timeline to reign in carbon emissions and move towards a sustainable society that will require unparalleled global mobilization to avoid the devastation and to manage the needed adaptation that will come from catastrophic climate change. In this journey, it is important that all people be included and have an opportunity to become a productive part of modern society. If the push for equity comes from philanthropy and the adoption of services that do not have a viable economic model, the initiatives are not scalable. In fact, the modular nature of many of the new technologies, together with the more equitable distribution of the inputs required to generate energy, i.e., sun/wind, hydrogen from water, and carbon from the air, can create positive alignment between the need to address the climate threat and improve energy equity. Increased energy equity is a necessary condition to address the climate threat in a timely manner - it is not a cost. If it is done right, addressing the climate threat will not involve sacrifice and reduction in human development, with its associated difficulty in achieving consensus and enforcing the measures. A different strategy is called for and made possible by the new emerging technologies that align people's interests with societal interests, using technology, policy, and access to finance as enablers that can accelerate the emergence of a new prosperous and sustainable era. Some of these enablers are discussed next.

Findings:

1. New technologies such as PV solar, wind, energy storage, nuclear, electrolysis, and direct air capture, carbon conversion, and hydrogen to synthetic hydrocarbons provide the core capability for the energy transformation needed. Their effective implementation is enabled by a host of other developments in digital computing, communications, power electronics, battery energy storage, novel synthetic materials, sensing, IoT and new additive manufacturing – all follow steep learning curves that persist for decades, leading to continued improvement in performance and reduction in cost. PV solar, for instance, has seen a 21% learning rate for over 50 years and does not show signs of easing up. Such 'exponential' technologies are at the heart of technologies that will enable an era of affordable and abundant energy for all. A significant finding is that many of these technologies will achieve economic viability at volumes that represent a tiny fraction of the capacity needed to meet the demand created by the conversion of our industrial ecology to a renewable and sustainable basis – a key requirement to address the threat of climate change.
2. For example, PV solar and wind, paired with 4 hours of energy storage to make it dispatchable, is already well below grid parity at utility-scale and is projected to get down to as low as $10/MWHr for solar and $15/MWhr for solar plus storage. The building blocks for these systems are modular and can rapidly be integrated to achieve utility-scale. This also enables the use of these distributed modules as

building blocks that can be located at a smaller scale along the grid edge. Distributed generation technologies that can be deployed at the edge, such as dispatchable carbon-neutral or carbon-negative power generation, are already cost-competitive with the grid or have the potential to reach that point in a few years. The creation of a distributed synthetic fuel and closed carbon cycle economy will be enabled by cheap energy and will experience an enhanced rate of cost reduction enabled by the need to develop the needed capacity rapidly.

3. The technologies for integrating and managing such decentralized systems are also being proven in the market and promise to provide the easy to use, flexible, scalable systems that are needed.
4. PV, wind, and battery storage are examples of 'exponential technologies' which exhibit strong and persistent learning curves. The rapid growth of these new marketswas initiated by a forward-leaning policy in the form of incentives, applied when the technology was approaching and had a clear line of sight to price parity. Continued price declines and performance improvement allow access to broader markets with time. PV solar, wind, electric vehicles, and grid-scale energy storage are prime examples of such a strategy. These examples show that viable candidate technologies are available today that are already at or are a reasonable distance away from price and performance points that would make them feasible at scale.
5. For a complex energy system such as the grid to work, a wide range of standard, abnormal, and fault conditions must be anticipated and managed – including loss of communications and cyberattacks. Such a system cannot be operated easily with only purely variable renewable generation. Dispatchable generation is needed in the mix that can be provided by nuclear energy and synthetic clean liquid fuels made from hydrogen and carbon from the air using low-cost renewable energy. Such a system may also require dynamic control that can route power along desired paths, avoid congestion and manage the grid. This technology is not widely deployed on the current grid, and its absence makes grid integration of renewables very challenging and expensive. In fact, the lower cost of renewable energy also reduces the cost of the materials used to produce.
6. This is an example of how the broad range of technological advances that are underway will have positive feedback between them that will allow many of them to become economically viable and adopted faster. This is also part of a more general finding that there will be a transition period where we still need to use our existing capacity and technologies, but in a way that helps address the threat of climate change. At the same time, we are scaling the new technologies. Most notable of

these is the use of natural gas, where technologies are being developed to create carbon-negative power plants.

7. Penalties and taxes against GHG emitters have not proven to be very successful. A better approach is possible because of new technologies that have shown steep learning rates and can become economically viable and outperform existing technologies when at scale. Incentives and subsidies that temporarily help technologies on the cusp of economic viability and sustainable scaling can be very effective, especially to address the well-known valley of death faced by all emerging technologies. The climate threat requires that we help accelerate deploying those solutions that have desirable attributes at an appropriate scale. At the same time, this should not encourage monopolies nor limit the implementation to only the advanced economies. It is also important to make sure that life cycle costs, including disposal and recycling at end of life are included to avoid a replay of a GHG type scenario, and a further abrogation of the rights of future generations.
8. The biggest challenge will be to provide equitable energy access to the almost 1 billion people who live off-grid and the 3 billion who live in extreme energy poverty. Grid extension as a means of bringing them into modern society is very expensive and not scalable. For example, 95% of utilities in sub-Saharan Africa cannot meet their capital or operating costs. Yet, the preferred approach followed by national governments and the World Bank has primarily been grid extension. There has been increasing interest in microgrids, but they have not been able to sustain themselves because load growth, the key to their survival, does not occur at the pace that is needed for viability.
9. With income levels of less than $1.90/day, the challenge is not to give them energy access – they do not have the ability to use the energy or to pay for it, but to help them improve their livelihood. Their energy needs do not only include lights and electronic devices but also cooking, cooling, transportation, agriculture, and energy to support a small business. Sophisticated systems that need skilled technical support cannot be installed and maintained in these communities – both because of cost and level of skills needed. Yet, companies with technology and product capability do not have a viable business model for achieving scale in energy access markets. Any metrics that assess equity should address typical use cases, such as those defined by SE4ALL for energy access as Tier 1 at 100 WHr/day, Tier 2 at 1 kWHr/day, and Tier 3 at 10 kWHr/day – levels of use which translate into specific utilization for the energy delivered. The application of new modular technologies

and advanced digitalization can offer an unprecedented opportunity for these communities to leapfrog the advanced economies.

Recommendations:

1. Climate change and energy poverty can be addressed, not through taxation and barriers, but through establishing incentives and policies for enabling a move by the market towards a more desirable future energy and industrial ecosystem that meets our societal energy need for clean, cheap, abundant and sustainable energy and materials for all. All the technology elements exist today to achieve that outcome and show trajectories that promise the ability to achieve impact at scale over the next 20 years.
2. To achieve scale in the desired timeframe, the preferred technologies are distributed and utilize inputs that are universally available, ensuring equitable access. This will also help to ensure that addressing the threat of climate change most effectively will also improve energy equity. Increased energy equity is a necessary condition to address the climate threat in a timely and sustainable manner.
3. Many of the promising technologies have made the leap from science to market and are following steep learning curves primarily driven by continuing advances in basic science, new materials, engineering, and manufacturing processes (not just economies of production scale). This calls into question the wisdom of building extensive, centralized infrastructure that becomes obsolete and too expensive even before it is built and is often vulnerable to catastrophic weather events or cyber-physical attacks. Industry has adopted this approach up until this point. A better strategy is a more flexible modular adaptive approach based on plug-n-play building blocks that can be easily integrated into central or distributed locations and assembled, operated, and maintained without a highly skilled technical workforce. With appropriate design, such modular systems can achieve interoperability across multiple vendors and technology generations (e.g., Bluetooth and 5G) while preserving the security and proprietary IP that individual companies may have.
4. There is clearly a strong interest at the government and policy level to achieve the above goals. However, to achieve scale rapidly over the next critical 20 years, it is important that interoperability between vendors be a key objective. Standards are a time-consuming process and problematic in fast-moving technology areas – a better

strategy is to direct public funding towards those companies and entities that will support the development of independent competing solutions that are still interoperable and flexible. This can be achieved through consortia, partly funded by the governments, that coordinate and demonstrate the technical viability through field trials and pilots, ensuring that issues of interoperability and IP sharing are also addressed. High-level technology-agnostic metrics can be established to ensure that compliance is achieved. Further financial incentives and specific captive markets can also be targeted towards compliant solutions to get them to start moving along the learning curve.

5. A modular approach to building energy infrastructure will fundamentally change the way such smart, complex and dynamic systems are built and operated. Much as a cellphone user does not need to know how it operates or the massive infrastructure that supports it, so will the future energy ecosystem operate. This will also trigger a massive new jobs boom, both in the factories that design and build the modules but also a more significant wave of jobs in the field where the distributed ecosystem is deployed and operated. Thus, a major effort in education and training of local workforces is necessary, which of course in turn creates a positive feedback loop by creating greater demand which will drive the costs down and enhance the rate of adoption.
6. If Edison were to build a new grid today, it would likely be a modular and decentralized cluster of interconnected microgrids. Off-grid communities have an opportunity to leapfrog the traditional grid extension model and to develop resilient energy communities where advanced attributes such as load diversity, dynamic balancing of generation and load, advanced protection and implementation of a simultaneous transactive and physical control of the grid can be intrinsically designed and built into the system – at a much lower cost than a traditional grid could be built. With proper design, this could be built such that any future grid extension, if and when it were to occur, would integrate with the existing microgrid.
7. The question of carbon-neutral fuels cannot be ignored – both liquid and gaseous. The use of advanced catalysts and novel materials that allow efficient extraction of hydrogen and carbon (or other organic feedstock) from the air or from natural gas is now in commercial production along equally steep learning curves. These liquid fuels can also address issues of dense energy mediums or applications such as cooking in rural low-income off-grid areas. Making a true carbon-neutral fuel by using renewable energy to power electrolysis to produce hydrogen and carbon

capture from the air can play an important role in enabling existing hydrocarbon infrastructure to be used to help address the threat of climate change.

8. It is likely that the next 20 years will see many competing technologies, each clamoring for a piece of the market – each claiming to have overcome the challenges, and each looking for public monies to move them beyond the 'valley of death'. At such time, the focus needs to be on a holistic assessment of the specifications for the new energy and industrial ecosystem, including problems that these technologies will leave behind for future generations to resolve. Public resources should only be given to those entities and to support the development and deployment of those technologies that are sustainable, minimize externalities, and include the impact on future generations in their life cycle cost assessment.

9. It will be noticed that there are no recommendations regarding phasing out old technologies. Implementing carbon taxes or a carbon market will help move the process along at a faster rate needed to avoid catastrophic climate change. Still, an important distinction is that it is not important that the new system be at a lower cost today than the system it replaces. It is critical that the learning curves show a clear path to economic viability at volume levels that are a low fraction of the total estimated market. To stimulate demand and growth, incentives can be applied to large users of energy or emitters of CO2 – e.g., generation, steel, aluminum, cement, fertilizer, and organic feedstock industries. The ability to sustainably reduce emissions should be incentivized, but only after a holistic assessment. The costs of lingering long-term issues, such as toxic ash from coal plants, or radioactive waste disposal from nuclear plants, or phosphorus-rich waste flow into rivers and oceans – these are all externalities that may have been difficult to avoid at one time but are now easy to measure and track, and must be addressed.

The Role of Intellectual Property and Standards Setting in Energy Equity

By Hanna Madbak

Energy equity cannot be accomplished without ensuring global access to the energy solution(s), without technological, economic or legal barriers. Once the solutions are identified and proven, technological barriers can be overcome by ensuring that a solution is the product of a modular and interoperable system. A plug-and-play system that does not require the user to have any particular training or expertise to operate the system (much like how a user can sync and use a Bluetooth device without knowing anything about how the device operates). Such a plug-and-play model requires the active engagement of all stakeholders in the development of standards that govern the operation of the technical solution(s).

Intellectual Property (IP) rights and Standard Essential Patents (SEPs) are often falsely accused of impeding or delaying innovation. This is rarely the case and only true when IP rights are abused by those who wish to extract from their IP more than what they are entitled to, which is virtually always counterproductive. There are those who believe that IP rights should not attach to life-saving and globally-needed innovations. I respectfully disagree. IP rights encourage and reward innovation. Innovations are protected by granting the innovator a patent, which grants a monopoly for a couple of decades. This monopoly gives the innovator a commercial competitive edge when applied to a limited market. In such a limited market, a commercial entity has an incentive to exclude its competition in order to access and profit from as much as possible of the market. However, in a virtually unlimited market (such as the energy market) monopolies do not make commercial sense, because no individual company can address the whole market. Instead, what matters the most for the commercial success of the technology is universal adoption. This is the role of Standard Setting Organizations (SSO).

An SSO manages the development of the standards surrounding the technology and encourages transparency among all stakeholders. Setting standards facilitates universal accessibility and adoption by guaranteeing the right for any market participant to obtain a license on a Fair Reasonable and Non-Discriminatory (FRAND) basis. FRAND rates are generally relatively very low compared to the average industry rate, making them accessible to virtually any commercial entity. FRAND licensing does not require extensive negotiation between licensors and licensees, because generally the licensing rate is set by the SSO.