Energy Systems for a Sustainable Future

Wind, water, solar provide energy for the future: together they form a distributed energy system. In order to accurately fill in the details, there must be a corresponding business model that collects payments for the energy provided and compensates providers for building, installing, operating, delivering, and maintaining the system. The future is reliable, resilient systems that operate across decades. The new economic model must be based on the fundamental principles of this new reality.

The current business model for energy systems is driving towards an unsustainable future because it fails to recognize its effects on society, ecosystems, and climate: it excludes costs like air and water pollution, political conflict, and climate destruction. With accurate accounting of the real costs, fossil fuels are not part of a sustainable future.

Optimizing the performance of wind, water, solar, is the primary requirement of a new business model. An energy system based on these renewables will be significantly more reliable, resilient, and cheaper than the current one. But it will work differently from a system using fossil fuels. The generation and distribution process as well as the demand can be optimized to take advantage of the benefits. To build this future requires changing the economics to match the characteristics of these systems. It also needs an operational approach that maximizes the value in these systems.

There are powerful new tools available to support a more suitable business model:

- Distributed computing and communication that puts control at every point in the network,
- Low-cost sensors to monitor environmental and system status,
- Low-cost secure communication,
- Global weather data – historical, real-time, and predicted,
- System models for planning and managing demand and response,
- Electrical energy storage can be placed at any point in the system.

Completing the transition to distributed, renewable energy will be an iterative, interactive process. Generation, storage, and demand will be built and managed in different ways and adjusted based on experiences. Finding the appropriate scale and location of generation, size and location of storage, and management of demand can be solved using models and tools to evaluate choices, monitor results, and deliver a system that is lower cost, more reliable, and more resilient than the current situation.

Electrify Everything!

Electricity from wind, water, solar is the easiest and lowest cost way to generate zero emission power, so electricity will be used for a much wider variety of uses than historical practice.

Some of these will be shifting existing use cases away from other energy sources. Building heating using oil or gas will be replaced with heat pumps. Electric vehicles will no longer require gasoline or diesel. Many industrial processes are currently being reimagined to use electricity.

This transition will change the dynamics of many of these use cases. Instead of driving vehicles to dedicated gas stations, charge points will migrate to places where cars are parked at home or at work. This changes the load profile from "I need the energy transferred, now!", to "The vehicle needs to be charged by 7:30 am tomorrow morning." This type of transformation, dynamically adjusting the amount of energy and the time of delivery will occur across many parts of the energy system.

As the transition accelerates and moves closer to 100% renewables, new demand models will be developed that are optimized for the properties of the new systems. Solar and wind have predictable, cyclic power delivery, creating new patterns for optimizing demand management. Electric energy storage at points of generation and/or use enhances that management.

Why isn't the current model adequate? Can we just update it?

The existing business model has evolved around the world since 1882 when electricity was first generated and delivered as a service. There are differences among the many providers, but the common theme is centralized generation that delivers power over transmission and distribution lines with billing based on energy delivered. The revenue collected for energy and other fees is split between fuel providers, generators, and distribution networks. Demand is managed by limiting the capacity of the interconnection to the grid and supplying the real-time load using projections based on historical usage.

This historic model has no mechanism for managing real-time demand/response. Since fuels can be stored locally, system balancing has been largely managed from the supply side. There is no direct connection between modeling the behavior of the system and operating it. The one-dimensional price signals it generates do not have enough information to make rational decisions. Even worse, these price signals arrive far too late to drive a practical response. A new approach is called for that provides all of the information required, when and where it is needed.

Areas that need improvement:

- Reliability – Planning and parameters for reliability must be designed into the system at the grid level, as well as for regions, neighborhoods, and individual buildings.

- Resiliency – Additional planning is required for exceptional events that may negatively impact the system. This includes exceptional weather events (of which more are expected due to climate change), as well as equipment failures of different types.
- Unrecognized externalities – Currently unrecognized externalities must be brought into the system to accurately compare and manage costs. One example is a Carbon tax to recognize the cost of climate change. Similar taxes for air pollution, water pollution, and other types of environmental degradation are essential to build a properly functioning system.
- Operational data – Since accurate modeling of the complete system is essential, detailed real-time and long-term data must be captured and made available to all interested parties.
- Demand control – A new approach to demand management is required. The right level of localized control, and aggregated external signals will enable a stable system that can grow with minimal overhead.
- Location and weather data – Weather data today is excellent and reliable, but it can and must be improved in detail, time resolution, and localization.
- Energy efficiency – Reducing energy demand is functionally equivalent to increased generation. It must be included in the modeling and valued at the same level as the energy that is now not required to generate..
- Management of and access to capital – Many of the desired changes, like adding renewables and improving energy efficiency are capital intensive. A new approach is required to manage capital and to make sure capital is available when and where needed to optimize the system.

What does the future look like?

The future of energy is wind, water, solar, plus storage. These are the core low-cost, reliable components of a distributed energy system that simply harvest energy from natural sources. The configuration and operation of the system will be very different from the existing grid. Key differences are:

- Distributed – Components for generating, storing, and consuming power are placed at locations that optimize the performance of the system;
- Smart – Every component in the system has sensors and communication. These provide data for real-time monitoring and control, as well as long term planning and design. This enables control systems that maximize the immediate user experience, predict the future operation, and provide actionable data for improvement.

The organization of the system will be a grid of grids: microgrids containing nanogrids linked into regional structures. Operation will be local, with communication to facilitate interaction with other grids. The configuration of the system will be developed to meet the goals of the communities that are served by the energy.

TREO's areas of focus:

- Scalable secure transaction systems and system management
- Renewable energy system design with storage and local autonomous operation
- High-speed flywheels for energy storage

TREO is looking for partners to further the energy transition based on these principles.

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Appendix A – Updating Concepts

Many organizations around the world have recognized the issues with the current models for energy systems. Here are a few examples of work in this area. Some of these are specific to energy while others address a larger context.

***Transactive Energy* –** A view of electric power delivery that moves beyond the idea that all electrons are the same by adding concepts like the time and location of delivery to the transaction.

https://en.wikipedia.org/wiki/Transactive_energy

RethinkX - The RethinkX team has done important modeling work on optimizing the combination of renewable energy sources and storage. They also explore some of the unique benefits that can be exploited by rethinking the design of energy demand.

https://rethinkdisruption.com/how-to-achieve-rapid-cheap-energy-decarbonization-using-the-rethinkx-clean-energy-u-curve/

***Doughnut Economics* –** Kate Raworth's seminal work on reimagining of economics with a broader, more inclusive view of value. Many of the gaps identified above are included. It provides a framework for thinking about value as contributing in multi-faceted ways.

https://en.wikipedia.org/wiki/Doughnut_(economic_model)

https://doughnuteconomics.org/

SuperchargeMe - Eric Lonergan and Corinne Sawers have focused on specific economic policies that will accelerate the transition to renewable energy. The book isn't released yet, but the initial blog post has some significant ideas about the form that the economic side of the transition needs to take.

https://www.philosophyofmoney.net/the-wrong-chapter-of-the-textbook/