REIs: Renewable Energy Infrastructures

Designers address problems outside of themselves and therefore are engaged in a form of applied research. Furthermore, designers have historically played a role as technological innovators. As such, our research / design team is applying its collective design thinking skills to a problem that involves energy production, energy transmission, and urban living. We believe a Renewable Energy Infrastructure (REI) will solve this problem.

An REI is an idea for the generation and transmission of renewable megawatts (MW) to end users in high population areas. An REI generates renewable energy MWs at an industrial scale through the simultaneous harnessing of wind, solar, and geothermal resources within an integrated, holistic, and free-standing facility positioned on an urban site. An REI is not a retrofit of a pre-existing architectural condition, but rather is conceived as a new typology to be owned and operated by an electrical utility.

We believe we are in an advantageous position to consider this design problem and are assessing the full design requirements involved in such a proposal. We would assess pre-existing and emerging industrial-scale power technologies and would generate multiple plausible design options for hybridizing these solar, wind, geotechnical and (if applicable) hydrological technologies into a single, holistic, infrastructural entity. Our project deliverables yielded would require working with various public and private power districts in the design of (3) site-specific, technically-plausible REI solutions of escalating scale for municipalities located in the American Midwest -- Lincoln NE (population 251,624), Kansas City MO (population 451,572) and Chicago IL (population 2,853,114).

We are finding our preliminary WPA 2.0 design to have the technological potential of generating 124 MW of renewable energy.
A composite ideogram identifying issues related to an REI: Renewable Energy Infrastructure. Design issues in play include; the concentration of industrial-scale renewable energy technologies in rural areas, the exclusivity of technologies found in these rural areas, assessing the measurable rates of electrical energy loss over the transmission length to end users in urban areas, and the recognition of favorable climatic conditions for a hybridized renewable energy infrastructure type in the American Midwest.

The following five axiomatic truths serve as the condition from which our REI investigation is based:

01. Due to the Greenhouse Effect caused by carbon dioxide emissions from fossil fuels, there is a need to invent and deploy more environmentally-mindful modes of electrical production to meet an increased demand by modern society.

02. On a per square mile basis, urban areas have significantly more demand for electrical energy than rural areas.

03. Current modes of renewable energy production, such as wind farms and solar arrays, are typically located in rural areas due largely to social and political forces.

04. Due to the physical properties of our current electrical grid system, there are measurable falloff rates of MW from their originating power sources (in rural areas) along the transfer length to the end user (in urban areas).

05. Transfer efficiency can be increased by collapsing the physical distance between original renewable energy power source (in an urban area) to the end user (in an urban area).

Considering these axiomatic truths, is it possible then to design a free-standing, renewable energy infrastructure for an urban environment that holistically considers energy-producing agents such as wind, solar, geotechnical, (and if applicable, hydro technologies) into one holistically-designed entity? If so, then what are the tangible, measurable benefits of this new infrastructure typology in the face of an established status quo?

We recognize that some buildings in urban areas have been / are being retrofitted with renewable energy technologies, such as vertical axis wind turbines and photovoltaic panel systems. However, these retrofits are the result of negotiated circumstances where the private and public stakeholders involved possess a range of various short- and long-term interests. An REI is not a retrofit, but rather an intentional and deliberate free-standing electrical infrastructure. Our interest is in the creation of a single renewable energy powerplant that shall be owned and operated by an electric utility and shall produce renewable energy MW at industrial scales.

We believe the innovative value of our investigation lies in:

• the bringing together of multiple renewable energy technologies on a single urban site in a deliberate, hybridized, and technologically unbiased way.

• its willingness to engage non-rural, densely populated sites for generating renewable energy.

• its means of sharply reducing MW loss during transmission.

• the circumvention of the need for new long-span transmission technologies.

• its scalable implementation over time. As new REIs are constructed, existing types of electrical production (such as coal-fired electrical plants) can be decommissioned.
The US Department of Energy identifies the State of Nebraska as 6th in raw wind energy potential. Despite this climatological benefit, Nebraska surprisingly ranks only 24th in actual wind energy production at a total rate of 153.2 MW. Of the 153.2 MW produced, 10%-15% of this amount will be lost along the length of transmission from rural areas of production to urban areas of end use. If all renewable energy MWs currently generated in Nebraska were directed to Lincoln NE, they would travel over 906 miles of transmission line length, which is a loss of 15.3 - 23.0 MW. These losses are due to measurable degradation rates along electrical transmission lines and loss during electrical load step-down at transformers.

Just as society has accepted large-scale infrastructure such as grain elevators, wastewater digestors and electrical substations because of their performative benefit, then so too does an REI need to establish credibility through its physical performance to challenge restrictive urban zoning policies, provoke NIMBY attitudes and induce market transformation.

The site selected for our preliminary REI study is located in downtown Lincoln NE, immediately south of the historic Haymarket District. The site is owned by the City of Lincoln, but is leased to the local electrical utility as an electrical transformer site. Our REI site is the airspace above this existing electrical infrastructure.

When site conditions allow, REIs would typically be positioned on existing industrial sites with operating transformer equipment, thereby occupying electrical transformer airspace and tapping into an existing electrical distribution network without increasing project costs.

SCHEME A
Photovoltaic arrays are sloped to optimize yearly solar angles, but are also arranged to deflect air currents to double the air velocity moving through the vertical axis turbines. Wind = 34%, Solar = 13%, Geothermal = 13%.

SCHEME B
Schemes incorporating wind technology need to occupy the highest elevations that municipal zoning regulation will allow. This scheme explores the incorporation of (6) horizontal axis turbines covered with a photovoltaic fuselage skin. Wind = 50%, Solar = 25%, Geothermal = 25%.

SCHEME C
Whereas Scheme A & B sought an aesthetic informed by scientific determinism, Scheme C explores composition for its own sake. What interest it may gain in composition, it loses credibility in energy performance. Wind = 25%, Solar = 25%, Geothermal = 50%.

SCHEME D
This scheme is informed by attributes of each of the first three schemes. It is not self-conscious about its own aesthetic, but rather reflects a scientifically deterministic aesthetic that maximizes electrical production from wind, solar and geothermal resources. Scheme "D" has been selected for further development.
SCHEME D v1.5

Description

This scheme for Lincoln NE assumes a maximum allowable REI zoning height at 400’-0” which is equal in height to the Nebraska State Capitol building by Bertram Goodhue (1932).

To maximize this likely height restriction, this REI provides (8) stacked tiers of integrated wind / solar modules each set every 40’-0” in infrastructure height.

Energy Production -- Wind

Equipped with quietRevolution qr5 v1.3 Vertical Axis Wind Turbines. (22) turbines per floor with (8) floors = 176 qr5 turbines. 1 qr5 turbine = 2.74 kW @ 12 m/s. Seasonal wind data for Lincoln NE suggests that these turbines can likely generate: Jan thru Mar = 563 kW, Apr thru Jun = 1.056 MW, Jul thru Sept = 1.144 MW, Oct thru Dec = 528 kW.

Energy Production -- Solar

Equipped with custom-shaped Schott ASE-250-DGF photovoltaic panels. 187,220 sq. ft. of PV panel per floor with (9) floors = 1,684,980 sq. ft. PV panel area. 1 sq. ft. of Schott PV produces .012kW x 1,684,980 sq. ft. = 20.22 MW generated.

Energy Production -- Geothermal

The NREL (Golden CO) has published that the State of Nebraska has access to internal core temperatures of 100 to 200 degrees Celsius.

MAX POTENTIAL = 124.609 MW
An REI design assumes a phased construction schedule where a smaller fraction of a fully engineered REI can become operational, and would then yield higher amounts of MW when completed to meet the original planned scope. It is our expectation that an REI would have upgradeable, hot-swappable technological components to both maximize life expectancy and design against expiration due to technological obsolescence. By combining vertical axis wind turbines and photovoltaic arrays on the same site, we take advantage of multiple climatic conditions. Furthermore, we challenge the current trend of proprietary system design by companies that exclude other renewable energy types due to specificity in their business model / expertise.

We expect the final (3) REI designs to have a transformational affect upon our nation’s energy problem. Because an REI conceptually emerges from an intersection of energy production, energy transmission, and urban living, it therefore suggests that energy solutions can originate outside of traditional disciplinary boundaries and speaks to the validity of cross-disciplinary, research-based design. While the REI is looking to establish credibility through generating quantifiable electrical yields at industrial scales, it also addresses other multiple aspects of our nation’s energy problem (political, economic, carbon emissions, technical) while having some collateral benefit to non-energy areas (commerce, design, engineering).

Left: Perspective looking east toward the State of Nebraska Capitol building by Bertram Goodhue.
Top: Perspective looking west with the “O” Street bridge in foreground.
Mid: Walkways are provided at every floor for servicing the vertical-axis turbines and PV arrays.
Bottom: View of REI at ground level from South 7th Street.
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