Industrialization of Abundant Natural Resources: Absorbing Efficiencies

The conceptualization of primary industries, wherein natural resources are transformed into commodities, as engineered for efficiency and isolated from extrinsic systems, has in recent history led to the depreciation of the role of architectural and landscape design in the development of these industrial operations.

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The fish markets, mining, warehouses, and mill programs that were once generators of architectural or urban monuments have followed the path of the 1970's containerization movement and become hidden away in anonymous corrugated sheds set apart from urban environments. In this transition, there is an underlying notion that production quotas and global markets subsume local contextual forces, and therefore the value of design with local context is a burden to and not a factor in industrial systems.

Ledoux's Salt works of Chaux, begun in 1775, exemplifies a now historic model of architecturally merging and making legible primary industrial process through the translation of timber and subterranean brine into the commodity of salt, into the urban form, architecture, and landscapes of a production oriented town. The surrounding forests of Chaux were cut down to feed furnaces that heated evaporation ponds filled with brine pumped to the site from underground springs. Housing, gardens, and chapels radiate from the central operations building, managers' office and production halls. From one perspective, the urban development is a nuanced and formalized expression of co-dependence between natural landscape and urbanism within industrial process. On the other hand, the static formality of this expression predicts the eventual decline and abandonment of this industrial operation, as advancements in rail transport connected the inland regions of France to more naturally efficient coastal salt production landscapes. A simultaneous success and failure of the design was deep embedment of industrial process with local contextual systems -both natural and urban. However, despite relatively short lived industrial processes at Chaux, the architectural value of the urban form, now as a UNESCO World Heritage Site, has persisted long after its' industrial operations have ceased.

Missing in the contemporary practice of detaching industrial process from urban landscapes is the recognition that the contemporary state of global resource extraction is in fact highly tuned to the specificities of local conditions, arguably

more than ever before. Wherein the oceans were once vast barriers that limited access to resource environments, over the last few hundred years, transportation infrastructure has evolved to reposition the oceans as a unifying and buoyant medium of trade. This switch is mirrored in the advancement of communication systems which encompass the globe in a growing body of wavelength transmissions. The unification of once divided natural resources has geographically liberated the exchange and efficiency of material extraction. Wherein industry was once relegated to operate within geographically limited confines, today the purveyors of landscape industrialization have their pick of a litter of global environmental and cultural climates. Wherein the Salt works of Chaux were forced to expend great energy and resources to extract products from a relatively limited local landscape, in-land France today is networked across land and sea with hyper-efficient production environments. The fundamental goal of industry in these environments is not to impose industrial process in the landscape, but to forge as seamless a marriage as possible with local productive capacities of these geographies.

This paper does not debate the environmental and cultural merits of a local versus distributed production and consumption model. Instead, it investigates the varied dimensions through which the industrialization of natural resources become embedded within specific natural and cultural systems. Industries and their operations, though highly impactful on populated environments, are difficult typologies for architectural design to address because they are non-physically contained nor bounded. Industries are as much defined by processes as physical characteristics. Unlike other urban types, housing, offices, that have relatively bounded footprints and predictable impacts, there are multiple scales, mediums, and dimensions at play - for instance- the medium of tangible building structures and landscapes, kinetic systems of vehicle routes and material stockpiles, or the perceptual space of process legibility. However, if we understand how industrial processes become embedded in natural and cultural systems there can be a launching point to determine new means, methods, and mediums for re-engaging active industrial operations with urban environments through architectural and landscape design.

For this study, it is critical to distinguish between two types of industrialized primary natural resources- scarce and abundant. Of recent, petroleum resources, such as LPG, LNG, and coal, have garnered much attention. These are non-renewable, naturally deposited resources that occur in relatively confined and specific deposits in the world. Other such resources include lithium, copper, gold, nickel, and other metals. The influence that such rare, naturally derived commodities have had on contemporary design discourse has relegated the role of designers in the realm of resource extraction to be reactionaries. The logics governing the extraction of such resources are shaped first and foremost by their scarcity. In order to exploit these resources, governments and private entities will subjugate all other efficiencies presented by productive human ecologies. In this context, the role of design is confined at best to reactionary models of minimizing negative impacts, designing a process that is as frictionless and disengaged with local systems of human ecology as possible, or designing and/or re-envisioning the post-industrialized landscape once the resource is depleted.

For reasons related to scarcity and difficulty of extraction, these resources typically have only played a significant role in industrialization for a few hundred years, and with many of them it is well predicted that our consumption may only last for a few hundred more. If this means that the resource is only animated

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Figure 1: ATACAMA DESERT
Salar Surface
Open pit salt mine
Conveying salt from shore
Conveying salt to ship

for five hundred years or so, it will be a relative anomaly in geologic history, though the consequences may persist throughout time. Our momentarily intense affair with these resources should not preclude the industrialization of natural resources as a site of architectural design.

EFFICIENCIES OF ABUNDANCE

The primary focus of this paper is instead on a second type of resources which exist in relative global abundance and have been central to societal evolution for thousands of years. Such resources include silica (quartz), water, fertile soil, timber, and salt. The industrialization of these materials is governed by different logics from the resources described above, and thereby different design potentials may emerge based on an inherent flexibility to choreograph the relationship between industrial, natural, and human systems.

In contrast to a reactionary model, this paper posits that there is an altogether different model of efficiency which is absorbed from highly variable intrinsic conditions. In this second model of efficiency the designer regains significant agency through a role of choreographing industrial processes in tandem with local environmental and cultural systems.

The methodology of this investigation is an analysis of industrialization of a single resource across varied geographies to unearth the dimensions and mediums through which an industrial process is influenced by contextual factors. As a starting point, it has been assumed that each of the industrial landscapes documented and visited are efficient in some dimension if they are operating in the world of markets. Through first-hand observation and background research it will be possible to pin-point the varied global and local, tangible and intangible dimensions that influence the industrial operations.

From a collection of industrialized landscapes that I have visited over the last decade, I have selected four cases that can each be identified for absorbing a different environmental efficiency. By arranging these cases into comparative pairs, the aim is to study how even seemingly contradictory efficiencies of industrial practice can be neutralized by environmental context, or vice-versa.

INDUSTRIALIZATION OF SALT

Salt is a nearly ubiquitous material in world geography, occurring across nearly every climate and eco-region. In general, it is relatively low cost in proportion to its weight. There is no realistic threat of global salt depletion even though it has been consumed throughout human existence, and owing to our own internal human chemistry, we will continue to be dependent on salt for the entirety of human existence. In spite of all this, the material is highly metamorphic, and any exposure to moisture in the air will keep it in a constant state of phase change. Across diverse landscapes the changing nature of salt has resulted in equally variable harvesting methods. These differences have propagated regional distinctions in social and cultural structures surrounding the industry.

Due to the abundance of salt and its relative chemical consistency, it serves well as a control to gauge contextual variables that shape industrial efficiency.

CLIMATIC & GEOGRAPHIC EFFICIENCIES: THE ATACAMA DESERT & BELFAST LOUGH

The Atacama Desert eco-region in Chile is an environment of extremes, as both the driest and longest continually arid desert on earth, though located just twenty seven kilometers from the Pacific Ocean. This unique combination of

aridity and adjacency to an ocean is the result of a unique climatic effect called a rain shadow, in which moist air from the Pacific is deflected away from the landscape by the rapid topographic ascent of the coastal Andes mountains[1]. The Atacama Desert lies in the shadow of this diversion and never receives the rain typically anticipated in a coastal landscape. The salt deposits here are located immediately on the surface of the earth in salars. Though surrounded by sediment and mineral rich mountains and hills, due to the lack of water-borne erosion or intermixing of sediments, the salt is pure enough for both industrial and food consumption directly out of the ground. Operating in open pit mines at the surface of the earth, salt is simply broken from the ground through blasting. Then it is crushed and shipped over roads (paved in salt) to an ocean port merely a thirty minute truck ride away. From this privileged coastal location, salt is loaded 50,000 tons at a time in Panamax vessels for global trade across the seas.

In contrast, in Carrickfergus, located on Belfast Lough in Northern Ireland, which receives rainfall nearly fifty percent of days[2], salt has been mined for centuries in underground rooms and pillar mines. Here, unlike the simple physical mining efficiency of the Atacama Desert, workers carve salt out of the ground one thousand feet underground. To support the earth above, nearly fifty percent of the salt deposits are left in place as structural pillars to support the excavated rooms. The salt emerging from the three mile journey on an underground conveyor belt has trace amounts of soil captured in the salt, making it suitable only for road deicing. Emerging from the mine shaft the salt continues by conveyor directly out into Belfast Lough, an inlet connected to the Atlantic Ocean[3].

The environments of these two regions are dramatically dissimilar, yet the industrialization of natural resources is capitalizing on shared characteristics. Both the Atacama salars and Carrickfergus salt deposits are remnants of prehistoric lakes evaporated millions of years ago, today located close to ocean coasts. Likewise, the industrial operations, processes, machinery, and number of human laborers at each of these locations is nearly identical- Salt is dislodged from the ground by explosives, processed through a conveying crushing plant and loaded by pier mounted conveyors onto awaiting ships. Yet the efficiency of production of the two facilities is vastly divergent. The mining of one thousand feet deep subterranean salt in Carrickfergus introduces layers of operational complexities for ventilation, conveying, access for workers, safety, and earth stabilization that are avoided in the open pit mining practices of the Atacama Desert. Further, the unique climatic conditions of the Atacama create a pristine environmental context for salt pure from contaminants. However, despite this operational imbalance wherein one landscape is essentially ideal for salt harvesting, versus a competing climate which is nearly antithetical to salt harvesting, both of these landscapes have been producing salt for centuries, and for several decades been competitively providing road salt to the east coast of the United States.

A neutralizing factor for this climatic discrepancy is the geographic position on earth of each salt deposit. While salt from the Atacama makes the long journeys to Asia and to the east coast of the United States, Carrickfergus is neighbored by the cold climates of the United Kingdom to the east and the east coast of the United States a relatively short trip across the Atlantic to the West.

In addition to this geographic discrepancy, the Panama Canal is perhaps the greatest counterbalance between the Atacama and Carrickfergus. The toll for transporting a 50,000 ton cargo of salt from Chile through the Panama Canal is roughly 250,000 USD, a fee avoided on the relatively quick passage across the Atlantic between Carrickfergus and ports in Boston and New York[4].

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Figure 2: BELFAST LOUGH
Mine surface
Room and pillar mine
Conveying salt from shore
Conveying salt to ship

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Figure 3: ILE DE RE
Evaporation ponds
Mud berms and water channels
Salt Worker
Brand Image
Fleur de Sel

This contrast unearths the vast global reach and diversity of scales that can influence the operations of the industrialization of natural resources. Geologic processes latent in the landscape, climatic conditions shaped by the convergence of oceans and mountain ranges, and the construction and operations of international infrastructures in other continents, shape the industrialization of resources and the operating efficiencies of landscapes half a world away as much as any specific local condition of the industry and its immediate context.

BRAND & CULTURAL EFFICIENCIES- ILE DE RE & SAMBHAR LAKE

Ile de Re is an island surrounded by shallow sandy waters located in the Atlantic Ocean just off the west coast of France. Encased within the middle of the island are a collection of shallow salt water evaporation lagoons. The island is today a high end vacation location famous for a perfectly comfortable summer climate of sun and breezes, and picturesque historic architecture and urban fabric.

The industrialization of the landscape in Ile de Re produces an internationally acclaimed salt product known as Fleur de sel (flower of salt). Through evaporation, salt begins to separate from sea water when trapped in the inland lagoons. Heavy salt crystals (Gros sel) separate from the water, and settle at the bottom of the evaporation ponds. If air flow and temperature at the waters' surface is favorable, salt will also begin to crystallize across the surface of the water. These fragile crystals, akin in appearance to snow-flakes, are the Fleur.

The Fleur and Gros sel are the end-product of a careful manipulation of the soils of the shallow inland lagoons to shape a micro-topography of berms, waterway channels, and clay bed evaporation ponds. The constructed network of clay berms is calibrated to allow water of varied salinity levels to flow by gravity through a sequence of ponds of subtly varied elevation. The landscape is so sensitively and precisely tuned that the simple removal of a single cedar shake dam from between the berms sets the landscape in motion, cycling the hypersalinated waters by gravity alone; a petroleum-less production process.

Against the backdrop of the ocean horizon and vivid fields of grasses, as the Fleur and Gros sel form in the final pond stages, a barefoot worker rakes and gathers the salts into small piles using a wooden plank mounted at the end of a slender wooden pole. Skimming the crystals off of the surface of water is a delicate process.

The inherently slow and labor intensive process of production embeds the material with added value through the marketing and pricing of the Fleur de sel brand. The brand absorbs an idealized vision of a working landscape translated through the image of the Saunier (pond tender). The resulting product is a luxury culinary salt, sold internationally at premium prices. While the salt from Chile costs 50USD per ton, the Fleur is 1USD per ounce. The embodied image of the working landscape and brand value built around designed inefficiencies increases the material value by a factor of 60. Even more interesting, the image of the Fleur de sel working landscape and the Saunier has attracted a new type of culinary tourist to Ile de Re, who can take part in the experience of raking the salt from the earth alongside a Saunier. Here, industrial processes have been transferred with cultural value. Today the salt industry of Ile de Re is a multi-faceted industry coupling production and tourism capitalizing on the legibility of integrated industrial and natural process.

The same symbol of the salt worker coupled with a nearly identical extraction process can also lead to a dramatically different result when undertaken in a

different cultural context. It is through this example that we can see the dramatic power that specific cultural contexts can have on shaping even the most globalized industrial productions.

In India, salt is harvested from numerous coastal and inland landscapes, including the salt lake of Sambhar, and along the eastern shoreline of Mumbai, sandwiched between large areas of informal settlements and dense mangrove colonies where there are hundreds of acres of salt evaporation ponds. In Mumbai, similar to the salt evaporation ponds of Ile de Re, the same hand labor based process of salt raking is systematically undertaken to extract crystallizing salts from evaporation ponds formed out of a calibrated micro-topography of canals and ponds sculpted from local clay based soils. At the Sambhar Lake of Rajasthan, a dam built across the lake controls water flow into an area of approximately eighty square kilometers. Thousands of migrant workers organized in family units of husband and wife work by hand to rake and collect salt to be transported to a central bagging plant where it is inspected for impurities by hand, and bagged by hand. Each step of the process is labor intensive.

In this context the labor of the worker and process of the industry does not imbue the salt with luxury status. Here, the industrialization of natural process has wholly different cultural symbolism and value. If the Saunier is a cultural symbol of the salt of Ile de Re, perhaps a poignant juxtaposition of symbolism in India is the image captured on April 05, 1930 of Mahatma Gandhi bending down to collect salt at the conclusion of the Salt Satyagraha at Dandi. This image memorializes the symbolic action of Gandhi, defying British colonial laws by harvesting evaporated salt. This simple action was a statement against taxation with powerful conceptual undertones. Salt is a mineral fundamental to human existence and survival, akin to oxygen and water, and bountiful in quantities to even the most impoverished of peoples. Through this imposed regulation and simple protest, salt absorbed tremendous cultural significance for a national independence movement. This situation highlights the tremendous ramifications entailed by the conversion of a natural resource to an industrialized commodity. Once extracted from the earth, the resource becomes susceptible to regulation and ownership. Through a modest action, Gandhi highlighted this complexity. Without machines, technology, or even significant labor, he crossed this regulated threshold of landscape industrialization, and his following arrest highlighted the degree to which those regulations on industrial process become consequential to basic human needs for survival. This calculated use of a material that so precipitously teeters in identity between industrial commodity and natural right has also forever imbued the materiality of salt with powerful symbolism for India and beyond.

In Ile de Re, the Fleur de sel reveals the potential of the industrialization of natural resources to not only achieve a sensitive balance with landscape systems and imagery but also how a resource can absorb additional cultural and economic value from its landscape heritage and cultural context. The contrast of the salt of Ile de Re to that of India indicates that similar industrialization processes can manifest an entirely different product with vastly different monetary and cultural valuations, depending on the cultural environment in which the industry occurs. The salt works of Sambhar Lake, for example, are principally owned and operated by the government, utilizing infrastructure built by the British during colonization. A principal product is salt rations, distributed to people across India through government run nutrition programs.

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Figure 4: INDIA
Evaporation ponds
Mud berms and water channels
Salt Worker
Gandhi at Dandi[5]
Sambhar salt rations

The salt workers of India are highly impoverished. Yet still today, any threat to the independence of salt workers and individuals to harvest salt from the natural environment or discussion to upgrade salt harvesting with mechanization or technological advancement is met with significant communal opposition. This was evidenced recently when Unicef and the WHO led efforts alongside the creation of legislation to enforce iodization of salt to prevent iodine deficiency. Two years after the enactment of these regulations, they were overturned under protest that the iodization requirement threatened the independence of small scale salt pond tenders. The headline in the New York Times on November 2, 2000 read "Gandhi's Spirit Hovers as India Debates Iodized Salt"[6].

In India, the image of a barefoot worker is not synonymous with luxury or picturesque vision of the working landscape, and there are no tourists visiting the salt ponds to rake alongside the workers. Though for other reasons, and forever memorialized in a choreographed act of non-violent protest that directly engaged the operations of landscape industrialization to challenge the boundaries between free nature and regulated industry, salt has absorbed an immutable cultural value.

ARCHITECTURE OF NATURAL RESOURCE INDUSTRIALIZATION

For these industrial operations the relationship and absorption of environmental contexts is the very condition that makes the industry viable, competitive, and sustainable in a world of markets. The aim of the pairings organized above is to unearth varied environmental contexts that influence industrial process and the varied dimensions through which industrial developments inherit from their context as territories of design. While none of the examples are taken to be designed in the conventional sense, they unlock the latent variability within an industrial system as an opportunity to envision a new role for designers of urban and landscape systems to act within the global industrial framework and question the relationship of industrial systems with specific contexts.

ENDNOTES

1. *Burton, Kathleen, Anderson, Robert, Guadaupe, Dias, Licenciada, 'Mars-like Atacama Desert could explain Viking 'No Life' results'. NASA Ames Research Center, Moffett Field, California, November 7, 2003. http://www.nasa.gov/centers/ames/news/releases/2003/03_87AR.html*
2. *Northern Ireland climate reporting, recovered from Met Office http://www.metoffice.gov.uk/climate/uk/ni/ on 09/15/14*
3. *Dimensions and details about mining operations acquired through interview with mine manager of the Irish Salt Mining and Exploration Company in 2005*
4. *Toll through the Panama Canal based on calculations made using the 2013 approved canal tariff for a dry bulk carrier Provided by the Panama Canal Authority*
5. *Photograph of Gandhi at Dandi, South Gujarat, picking salt on the beach at the end of the Salt March, April 5, 1930, photographer unknown.*
6. *Dugger, Celia W. 'Gandhi's Spirit Hovers as India Debates Iodized Salt', The New York Times, November 2, 2000*