RE-ENERGIZED:
A New Model for Suburban Housing
Through Infrastructural Remediation
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ABSTRACT

Isolated houses within secluded subdivisions have been
dominating the American landscape for decades. Commonly
criticized as energy and resource wasteful, financially vulnerable,
and socially unresponsive, few have provided constructive ideas for
new methods of development. The goal of this thesis is to provide
an alternative model of urbanization by redefining the relationship
between infrastructure and urban form. By rethinking the dynamics
of this relationship, the thesis will introduce a framework that has the
dexterity to address more complex patterns of urban development, a
characteristic which is severely lacking in the current model of the
American “suburb.”

This type of urbanization has reached a tipping point at
which local governments lack implementable strategies for meeting
the demands of their growing populations that are both sustainable
and economically viable. Focusing on Denton, Texas, the proposal
aims to repurpose oil and gas extraction sites for new housing
subdivisions. Taking advantage of the Extraterritorial Jurisdiction
Zone (ETJ) in one of the fastest growing regions in the country,
these new designs will be allowed to experiment in future growth
areas that do not abide by conventional regulations of municipal
governments and have the flexibility to support more complex
forces. By converting resource extraction rights and infrastructures
to cleaner energy sources of wind and solar, this new dynamic of
development capitalizes on the diversity of a dispersed network while
accommodating both economic and environmental expansion in a
more sustainable system.
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I. INTRODUCTION
Introduction

As populations moved to more affordable cities away from legacy cities of the Northeast and Midwest, large portions of land have been annexed in order to keep pace with population growth. Municipalities have adopted aggressive annexation policies in order to collect taxes in the process of development, primarily from residential subdivisions in the outskirts of their political boundaries. While local governments rely on private developers to provide housing for their thriving populations, they don’t always have complete control over where and how development happens. Annexation, and therefore zoning and land use, typically follows development. The aggressive construction of residential developments has not coincided with an ample provision of housing options or amenities. Concurrently, affordable housing for low-income groups has been overlooked in these areas. These issues are exacerbated by the fact that federal support is not keeping up with the pace of population growth in these areas (Urban Institute).

Much of the development in the fastest growing regions of the country is driven by speculative markets in anticipation of future residents. Sprawling housing developments have dominated the American landscape, creating a patchwork of isolated and repetitive urban forms while local governments have taken a back seat to real estate
developers in determining the scope and location of housing. The expansion of the suburban subdivision as the primary unit of urbanization has left future generations with very limited options. These development strategies have been practiced unequivocally by local governments who have not considered or foreseen the negative repercussions; however, if they continue to depend entirely on the private market to drive development and neglect to plan for future growth, then serious ramifications are likely.
This thesis spawned from a desire to tackle this glaringly underappreciated subject head-on and seek alternatives to its development. While the urban-suburban dichotomy dates back to the practices of synocesim in ancient Greece and Rome (Hilberseimer 1955), the proliferation of suburban development in modern times is unprecedented. With over 75% of the urban population inhabiting suburban areas in the United States, there is still a reluctance to...
embrace suburban models of development within the field of Urban Design. There is an insistent demand for innovative development approaches of this type. As populations continue to expand into previously uninhabited areas, the irreversible process of urbanization has posed challenges in managing higher levels of complexity in shaping urban form.
The aim of this thesis is to expose potential “layers” to include in a regionally consciousness about the environment, ecology, and energy while developing housing projects in unregulated zones that are susceptible to growth. This thesis proposes a new model of urbanization in locations where oil and gas extraction advancements have created an impervious barrier to residential expansion. It begins to address more complex patterns of urban development which have been previously unnavigable within the rubric of the suburban subdivision. In order to foster the decoupling of eco-economic expansion, new layers of complexity need to be incorporated into this restrictive model which has survived relatively unchanged for almost a century. By freeing the bounds of this system to other uses and forms of inhabitation, it may be possible to create new values for the suburban subdivision that have yet to be considered.
Introduction

3.
Fracking near residential neighborhoods in Denton, TX
2. INCLUSIVE FRAMEWORKS
Within the debate of suburbanization, a consistent attitude emerges regarding how we perceive and identify dominant forms of development. There is a generalization that separates centralized urban development from what is occurring most rapidly at the periphery. Simply designating “urban” vs “sub-urban” becomes problematic due to its inherent exclusive nature or implied linguistic hierarchy of primary and “sub” importance. This desire to challenge the myopic attitude toward urban space is not merely generated by fairness of inclusion. As many critics have noted, suburb and city have become more and more similar as both continue to evolve. In “Get Out of Town,” Nicholas Lehmann suggests that, “cities and suburbs have started to seem less like fundamental opposites, and more like points on a continuum”. Our perception of what constitutes an area as urban or suburban begins to dissipate in contemporary context. As our built environment changes, we have to constantly evolve our criteria to be more inclusive of new forms urban complexity. Roger Keil offers a definition of suburbanization as, “the combination of an increase in non-central city population and economic activity as well as urban spatial expansion” (Keil...
2010). This expansion has led to entirely new relationships between our built form and the context within which we develop. Thus, it is critical that we find constructive frameworks for anticipating the future growth of our cities.

Tracing the subdivision morphology, we can identify two major phase shifts in housing form and infrastructure: 1) from the bounded urbanism of the early American settlements to the unbounded expansion of the industrial city, and 2) from a centralized focus of urban form to the decentralized organization of the developer-driven subdivision. While the expansion of infrastructural networks afforded the industrial city spaces for production and distribution in a growing economy, the simultaneous dispersal of housing has led to an entirely new type of enclosure. The various conventions used to determine the formal organization of the suburban subdivision have gradually assisted a complete compartmentalization of living. Enclaves of suburban houses delimit pockets of socioeconomic uniformity. Disengaged from their surroundings not only by farther distances but further formal exclusion the house has become a pure
commodity, limiting the social capacity of housing. The proliferation of this type of urbanization has reached a tipping point. As Americans continue to inhabit the periphery of cities, the subdivision remains as the pervasive unit of urbanization and setting for contemporary living. New layers of complexity need to be incorporated into this restrictive model which has survived relatively unchanged for almost a century. By freeing the bounds of this system to other uses and forms of inhabitation, it may be possible to create new values for the suburban subdivision that have yet to be considered.

Throughout American history, infrastructure and urban form have oscillated between extremes. Infrastructure has both helped to connect disparate cities and separate local communities. Urban form has shifted from a centralized organization towards a dominantly decentralized configuration. Viewed in combination, the relationship between infrastructure and urban form have contributed to three dominant phases of urbanization:
Theoretical Framework
2.1 CENTRALIZED BOUNDED (1680s-1830s)

From the initial colonization of the Americas to the early 19th century, the pervasive model of urbanization was characterized by a centralized form bounded by a clear infrastructural border. Whether initiated by colonial powers, religious groups, or merchant communities, these pre-industrial towns shared a common pattern. They were designed as ideal, pre-determined urban developments and followed a very particular series of development rules. Typically, settlements were established along the major transportation corridors of rivers or coastal ports. First, public squares were delineated as the civic center of the community. Then, streets were laid out in regular intervals perpendicular to principal streets intersecting the square and terminated at a clear perimeter. The civic amenities surrounded the central community space and housing grew symmetrically from the center to fill out the gridded plots over time. These towns were deployed as holding grounds for a single community through urban form that represented a symbolic whole.
Main Forces & Conditions that Advanced this Model:

- Colonization, religious freedom, and frontierism
- Naval infrastructure
- Trade & agriculture
- Social unity, ideal communities sharing a single ideal
- Lack of diverse models, methods of planning borrowed from Renaissance methods
- Environmentally located near ports or rivers, a resource approach to the environment
2.2 CENTRALIZED UNBOUNDED (1830s-1930s)

Beginning in the mid-19th century, the extension of railroad infrastructure led to a higher level of connectivity between the established centers. No longer isolated as single entities or closed systems, the emerging urbanization expanded from its center to accommodate industrialization and serve a booming population. Urban form followed as an outgrowth of the exiting pre-industrial town, branching off from the civic core in an expanded grid pattern. Planning was incapable of keeping up with the pace of urbanization, so a “system”, rather than a comprehensive “plan” was implemented. Speculation from private enterprise gave rise to entirely new towns along the rail system, adopting similar conventions of the ideal towns. In an effort to adhere to a familiar urban form, grids anchored by larger public squares extended in all directions.
Main Forces & Conditions that Advanced this Model:

- Economic development, private speculation, and frontierism
- Railroad infrastructure
- Trade & industrial production
- Capitalist expansion
- Continuation of the previous model, expanded and evolved into a systematic application
- Environmentally extending for the industrial machine, lack of a clear response to the environment other than to shift the grid pattern where geological boundaries presented themselves as topographically inept
2.3 DECENTRALIZED BOUNDED (1930s - 2030s)

In 1934, the Federal Housing Act introduced new patterns of urbanization focused on a decentralized urban form in the American suburbs. While the expansion of infrastructural networks afforded the industrial city spaces for production and distribution in a growing economy, the simultaneous dispersal of housing led to an entirely different enclosure on the periphery. The provision of mortgages for individual households, war-amplified industrial production, and automobile proliferation encouraged a dominance of isolated housing communities. The subsequent highway infrastructure developed in response to post-war atomic fear solidified the decentralized form as the prevailing unit of urbanization until the present day. The various conventions used to determine the formal organization of the suburban subdivision gradually assisted in creating a complete compartmentalization of living. Enclaves of suburban houses delimit pockets of socioeconomic uniformity. Disengaged from their surroundings not only by farther distances but further formal exclusion, the house has become a pure commodity, limiting the social capacity of housing in the urban fringe.
Main Forces & Conditions that Advanced this Model:

- War, individual opportunity, federal actions
- Highway infrastructure
- Industrial production & tertiary economic corporations
- Mass consumption of goods
- Planned unit developments, suburban neighborhood planning, corporate campuses
- Environmentally disengaged while creating “leap-frog” development fragmenting ecological and environmental systems. Visual response to surrounding environment, topographic consideration for streets as an economic benefit for developers, lacks a larger scale sensitivity to surrounding environmental context.
2.4 DECENTRALIZED UNBOUNDED (2030s - )

As Americans continue to inhabit the periphery of cities, the suburban subdivision will remain as the pervasive unit of development and setting for contemporary living. While this model has survived relatively unchanged for almost a century, its deficiencies illuminate the opportunity for innovation. In the same way that the ideal American towns were released from their bounded configurations to create new forms of urbanization, can the suburb untangle itself to create forms of urbanization that have yet to be considered? With digital infrastructures becoming more imperative to commerce and communication, what effects will their improvements have on urban form? Are there social innovations that could add value to our housing developments beyond the financial models currently in place? What is the next paradigm shift in the relationship between infrastructure and urban form? Can an unbounded infrastructure of dispersed form define the future of the American suburb?
Main Forces & Conditions that Advanced this Model:

- Lax government controls
- Digital infrastructure
- Tertiary economic corporations and entrepreneurial ventures
- Mass customization of goods and sharing of information
- Private-public shared unit developments
- Environmentally sensitive to local resources and regional ecological patterns

Vision for incorporating environmental strategies into future development models
3. SITE
SITE

3.1 FRAMEWORK

Located in one of the fastest growing regions in the country, Denton, Texas has experienced a sequence of urban transformations similar to that of many other American cities. The original plan of Denton was established on a grid, covering a footprint of roughly 100 acres. In the early stages of growth, the downtown maintained a vibrant urban fabric of retail and mixed use development along more compact streets and blocks in a centralized configuration. Later, Denton expanded to over 2,000 acres to accommodate industrial production, extending its infrastructural networks from the main downtown area. As the post-war era put pressure on the market to provide housing, private builders took control of greenfield sites outside the city limits. Development began to take on a more mono-programmatic nature, covering even larger lots on the fringe.
Urban morphology of Denton, TX
3.2 HISTORY

Established as a trade and agricultural hub in the mid-19th century, Denton experienced gradual growth for almost a hundred years. Despite its close proximity to Dallas and Fort Worth, the city never industrialized at the scale of its neighbors, establishing academic institutions, light industry, and commercial centers instead. It wasn’t until the 1960s that Denton began to participate in a regional growth pattern. When Interstate 35 was constructed, connecting to Dallas and Fort Worth, Denton experienced an increase in population.
growth. Growing from a population of just over 10,000 in the
1940s to just below 40,000 by 1970, the city began aggressive
annexation of the surrounding territory. The pattern continued
in rings around the central core and along major roads.

Beginning in the 21st century, control over this pattern
began to dissipate. Reaching a population growth rate of
40.8% in 2010, the city’s physical growth boundary became
haphazard, dispersed, and disconnected.
3.3 GROWTH

The city has designated a 5-mile boundary outside its limits commonly known as an Extraterritorial Jurisdiction (ETJ) in an effort to secure land for future development. While the area is claimed by the city, it does not abide by the same legal restrictions as the city proper. By allowing market forces to dictate how and where new development would occur in these areas, the city has put itself in a vulnerable position. Large housing developers continued taking control of cheap land on the urban periphery and the municipality followed with retroactive land use and zoning regulations once ready for annexation.

The aggressive expansion of residential construction away from the downtown core has limited access to amenities and basic services. Without established zoning laws or incentives to provide living options for residents, developers continue to build market rate housing away from regulated zones, primarily within the typology of the single family detached home. In the process, developers must secure utilities for their subdivisions, which are provided by the City of Denton or county Fresh Water Districts. As the pace of development increases, more and more pressure will be put on local governments to provide infrastructure for residences at further distances and in greater volume.
Map of future growth boundaries
Recently, Denton City adopted a plan to guide their expected growth for the next twenty years. The plan will focus on combating sprawl and focus on urban in-fill projects. According to the Denton’s redevelopment plan, the city will grow by 94,000 residents by the year 2030, requiring 37,000 new housing units. The preference for growth calls for more compact development, shifting to “more mixed use development, bringing together compatible residential, commercial, office, institutional, or other uses for increased pedestrian activity, reduce car trips, and expand housing choices” (DP2030).

While it has recognized the fault of unregulated growth, Denton plans to continue supporting a market-driven development strategy targeting middle to high income groups. The plan in place ignores the fact that patterns of development follow cheap land in surrounding unincorporated land where county restrictions for development are looser than within the city limits. The zoning and land use regulations are powerful mechanisms for controlling development within the city limits, but these and other limited mechanisms are not enough for guiding growth in the ETJ. In lieu of allowing speculative markets to dictate growth, and subsequently shaping zoning requirements and the like as areas become annexed, city governments should promote simultaneous planned
Sec. 232.001. PLAT REQUIRED.

(a) The owner of a tract of land located outside the limits of a municipality must have a plat of the subdivision prepared if the owner divides the tract into two or more parts to lay out:

(1) a subdivision of the tract, including an addition;

(2) lots; or

(3) streets, alleys, squares, parks, or other parts of the tract intended to be dedicated to public use or for the use of purchasers or owners of lots fronting on or adjacent to the streets, alleys, squares, parks, or other parts.

Diagram showing the requirements and process of development of subdivisions in the ETJ.
development with future populations in mind. These zones will inevitably become a part of a regional urban fabric which can be strategically developed to include local resources and regional ecological patterns, a paramount solution which will impact the future of the city.

3.4 FRACKING
As the foreclosure crisis was sweeping the nation, new technologies in the shale gas industry nurtured a rapid increase in natural gas extraction in the metropolitan area of Denton County. Due to four relatively new advancements in hydraulic fracking, these sites multiplied across Denton’s periphery in a few short years. Located above the Barnett Shale formation, Denton’s rural landscape is prime for the development of gas pads, sites excavated to aid the process of gas extraction. Miles and miles of pipeline have already been laid to facilitate the gas extraction process. The proliferation of gas pads in the area and their subsequent volume of activity have expanded to the point that they have started to impede on suburban residents.
12. Typical gas pad, site of natural gas extraction
Vacant lots in the wake of the foreclosure crisis.
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Currently, many of the gas well pads that have been drilled are dormant due to the high cost of the fracking process and low price of natural gas. As housing demand increases in conjunction with the economic recovery expected in the coming years, these two incompatible conditions will have to be reconciled. Conventional gas drilling has been common practice in the United States since 1947, with a total of more than 1.4 million gas and oil wells drilled; however, the combination of directional drilling, high fluid volume, chemical additives, and multiple-well pads in the extraction process is a relatively new practice (Ingraffea). Many of the external effects of these technologies on local water supply and regional environment are still being debated. Denton’s residents responded to this fledgling practice by issuing the first fracking ban in the country. While the ban has since been lifted, the desire remains, with the citizen of Denton, to find alternatives to this development practice. Turning the attention toward cleaner sources of energy production could alleviate tension between these two groups. For instance, with Texas’ high potential for wind and solar production, many residents have already started searching for innovative trade-offs in the speculative pursuits of private fossil fuel companies and residential expansion.
Fracking fluid pumped into the ground

Fracking ban initiated by local residents
TYPICAL GAS PAD SITES
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EXTRACTION PROCESS

Geological section through a 150 acre site
Step 1: Secure water from either the municipality or a local water source for mixing.

Step 2: Drill well into shale formation.

Step 3: Frack shale formation to release natural gas and begin process of extraction.
4. PROPOSAL
4.1 STRATEGY

Taking advantage of the extensive pipeline and water infrastructure used in the gas extraction process, there is a potential to repurpose the existing systems of the gas industry for new housing development. This new dynamic would also allow for a reinterpretation of many of the current urban forms, adopting an additive strategy to development and shifting the hierarchy of the development processes. Instead of relying on the municipality to bring infrastructure to the housing in the periphery of the city, housing could potentially follow the systems in place. By converting gas well pads to nodes of development, this new model of housing capitalizes on a dispersed network which balances clean energy production of wind and solar to power a diversity of neighborhoods.
Existing infrastructure from the gas and oil industry, Denton County
FROM SUBDIVISION TO SPACING

160 ACRE SPACING

320 ACRE SPACING

80 ACRE SPACING

640 ACRE SPACING

10 ACRE SPACING

40 ACRE SPACING
Example sites
Existing gas well pads, 160 acres
Potential conversion, 160 acres
ADDING TO EXISTING INFRASTRUCTURE

ISOLATED

NEAR HIGHWAY INFRASTRUCTURE

ALONG PREVAILING WIND DIRECTIONS

NEAR WATER SOURCES

ADJACENT TO AGRICULTURE
ECOLOGICAL AND REMEDIARY ZONES

SOFT ROAD INFRASTRUCTURE

NEW ENERGY TYPOLOGIES

TOPOGRAPHY

CONVERTED PIPELINE INFRASTRUCTURE

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4.2 A NEW MODEL

Throughout the thesis, I have argued for larger-scale design strategies as a potential focus for future planners and designers. In her article “Environmental Planning and Management of the Peri-Urban Interface,” Adriana Allen discusses the environmental planning dynamics of urban, rural, and regional areas and highlights a potential for the environment to be a crucial unifying factor. Unfortunately, the incentive to act in this regional-benefitting manner with respect to the environment has been largely in response to crisis. While it can be argued that there is much to gain from systems or strategies that are sensitive to the broader region of a given area, the logistics of creating those systems and implementing those strategies are less clear. The incentives to act responsibly to neighboring areas are even less apparent. Where would this even happen and why?

Denton’s gas and residential dilemma could offer new criteria for determining the nature of development. This thesis poses a shift toward an energy-focused agenda by allocating programs and land use based on energy potential. In the process of remediation and conversion of gas well sites, civic amenities and collective programs form infrastructural nodes, dispersing various programs across a connected network. Local energy production would dictate the volume of housing provided in a neighborhood given its own carrying
capacity. By diversifying neighborhood quality and program, this new model of housing also capitalizes on a dispersed strategy to collect energy in down times. For example, a solar neighborhood in peak production times might produce energy for a wind neighborhood experiencing lulls in wind power, and vice versa.
Future Land Use Map based on a diversity of regional resources.
Section showing the benefits of an unbounded decentralized system that does not depend on a central provision of services
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[Diagram showing various elements related to housing and infrastructure.]
NEIGHBORHOOD COMBINATIONS
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4.3 Example Neighborhood
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Perspective of solar neighborhood
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Civic and Infrastructural Gathering Node
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4.4 PHASING
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Bibliography


