Configuring the Urban Smart Grid

Transitions, Experimentation, and Governance

Anthony M. Levenda

ASU School for the Future of Innovation in Society
Arizona State University

Lifestyles, Buildings and Technologies: What Matters Most?

Loren Lutzenhiser, Huafen Hu, Mithra Moezzi, Anthony Levenda, and James Woods
Portland State University

ABSTRACT

There is considerable variation across households in energy use, even within similar climates and housing styles. There is also considerable variation in energy savings following upgrades of housing and appliances. We combine empirical data on household consumption with advanced simulation modeling techniques to investigate just how much behavior matters in determining consumption levels—compared to weather, technology and building characteristics. We explore several new concepts, including the BETA (building, environment, technology, activity) Model of household energy use, a *habitation zone* approach that can be used to differentiate BETA effects, and a hybrid (simulation/ statistical) end-use consumption analysis approach. For illustrative purposes, we report the consumption dynamics within three representative dwelling types, located in four different California climate zones, and occupied by a range of households. We also consider energy saving potentials from building retrofits and appliance replacement under different occupancy/activity conditions. We conclude with a discussion of the implications for energy efficiency policies and programs of our findings that behavior may determine up to 2/3 of typical home energy use, or more depending on heating and cooling requirements and environmental conditions.

Introduction

In this paper, we investigate the sources of energy use in the residential sector and their contributions to variation in energy use across households. Our fundamental question is “How much do each of the most likely factors—building characteristics, weather, energy-using devices, and consumer behaviors—influence natural gas and electricity demands in homes?” A related policy question relevant to next-generation energy efficiency programs is “How can we design home efficiency upgrades to optimize the interactions among these factors?”

These questions are not new, and we are not attempting to reinvent decades of analysis focused on energy savings potentials and efficiency program design and impacts. A good deal is known about various energy end-uses, and a number of conventional policy instruments—ranging from demand forecasting systems to building simulation models, deemed savings databases, and consumer education initiatives—commonly rely upon estimates of “typical” energy demands for various residential energy uses. There would seem to be an established base minimal baseline, we can estimate an environmental effect that is assigned to all of the prototypes.

This lays the groundwork for an analysis of the effects of occupancy and activity, which was also a multi-stage process. It is necessary to acknowledge again that our "T" (technology) term is impossible to differentiate as a contributor to demand on its own and independent of human activity and control. However, with *efficiency upgrades* (considered below), changes in T can be important contributors to energy *reduction*. In the building and environmental effects analysis, both technology and activity were intentionally excluded. They were introduced into the analysis via the 9500 *EnergyPlus* model runs that varied a range of activity and technology parameters for each housing type and climate zone. These inputs included HVAC control set-points and schedules, lighting schedules, equipment efficiencies, building leakage rates, heat loads from appliances and people, and thermal contributions of a set of energy uses involving refrigeration and home electronics.[11] Again, the model runs covered a range of both low occupancy patterns and high occupancy patterns. They also included low and high appliance usage and lighting, as well as lower efficiency HVAC, leakage and insulation, along with retrofit runs that improved the efficiency of all of these.

Table 6. Estimating BETA Factor Proportions

	Total Demand (MJ/yr)	**Building Design Effect (%)**	**Climate/ Weather Effect (%)**	**HVAC Activity Effect (%)**	**Other Activity Effect (%)**
Eichler Fresno	97,378	6	13	32	49
Riverside	80,924	7	4	31	58
San Diego	73,697	2	0	34	64
South Bay	92,642	5	3	41	51
Ranch Fresno	130,852	3	10	52	36
Riverside	111,405	2	3	52	42
San Diego	94,672	1	0	49	50
South Bay	110,492	2	2	53	43
Title 24 Fresno	105,984	0	12	43	45
Riverside	91,260	0	3	45	52
San Diego	80,963	0	0	42	58
South Bay	94,380	0	3	47	50

By determining the ranges of all runs for each housing type and climate zone combination, we were able to gauge the extremes in demand for each prototype. Estimates of energy use for non-modeled appliances and devices (e.g., hot water heating, cooking, laundry, home electronics, etc.) were then brought into the analysis alongside of the thermal/HVAC modeling results. Selecting the mid point value in the ranges for both activity/behaviorally driven

"For one thing, the Other Activity (non-HVAC) effect is surprisingly large—as much as 1/3 to 2/3 of total household energy use." p. 2-268.

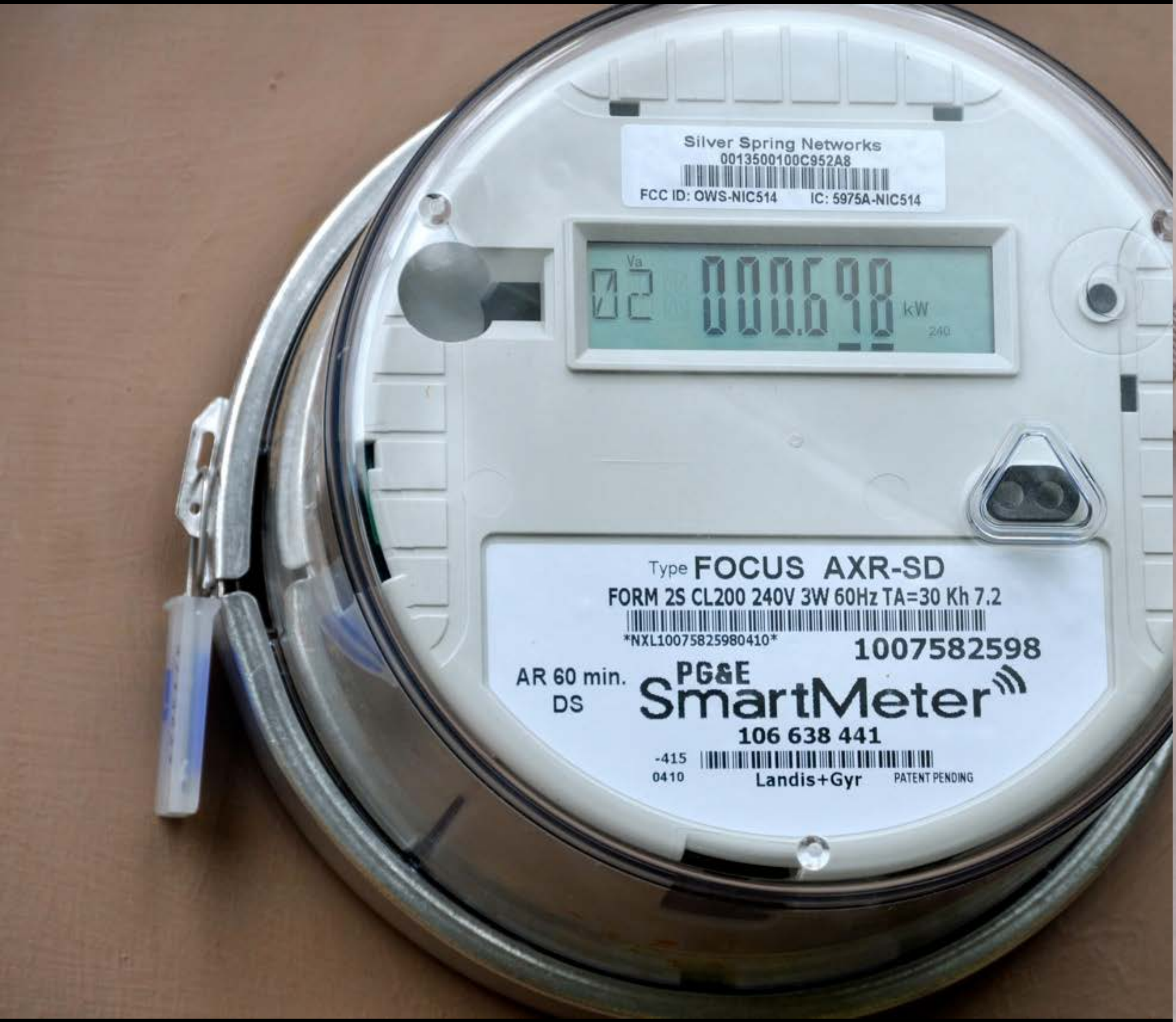
minimal baseline, we can estimate an environmental effect that is assigned to all of the prototypes.

This lays the groundwork for an analysis of the effects of occupancy and activity, which was also a multi-stage process. It is necessary to acknowledge again that our "T" (technology) term is impossible to differentiate as a contributor to demand on its own and independent of human activity and control. However, with *efficiency upgrades* (considered below), changes in T can be important contributors to energy *reduction*. In the building and environmental effects analysis, both technology and activity were intentionally excluded. They were introduced into the analysis via the 9500 *EnergyPlus* model runs that varied a range of activity and technology parameters for each housing type and climate zone. These inputs included HVAC control set-points and schedules, lighting schedules, equipment efficiencies, building leakage rates, heat loads from appliances and people, and thermal contributions of a set of energy uses involving refrigeration and home electronics.[11] Again, the model runs covered a range of both low occupancy patterns and high occupancy patterns. They also included low and high appliance usage and lighting, as well as lower efficiency HVAC, leakage and insulation, along with retrofit runs that improved the efficiency of all of these.

Table 6. Estimating BETA Factor Proportions

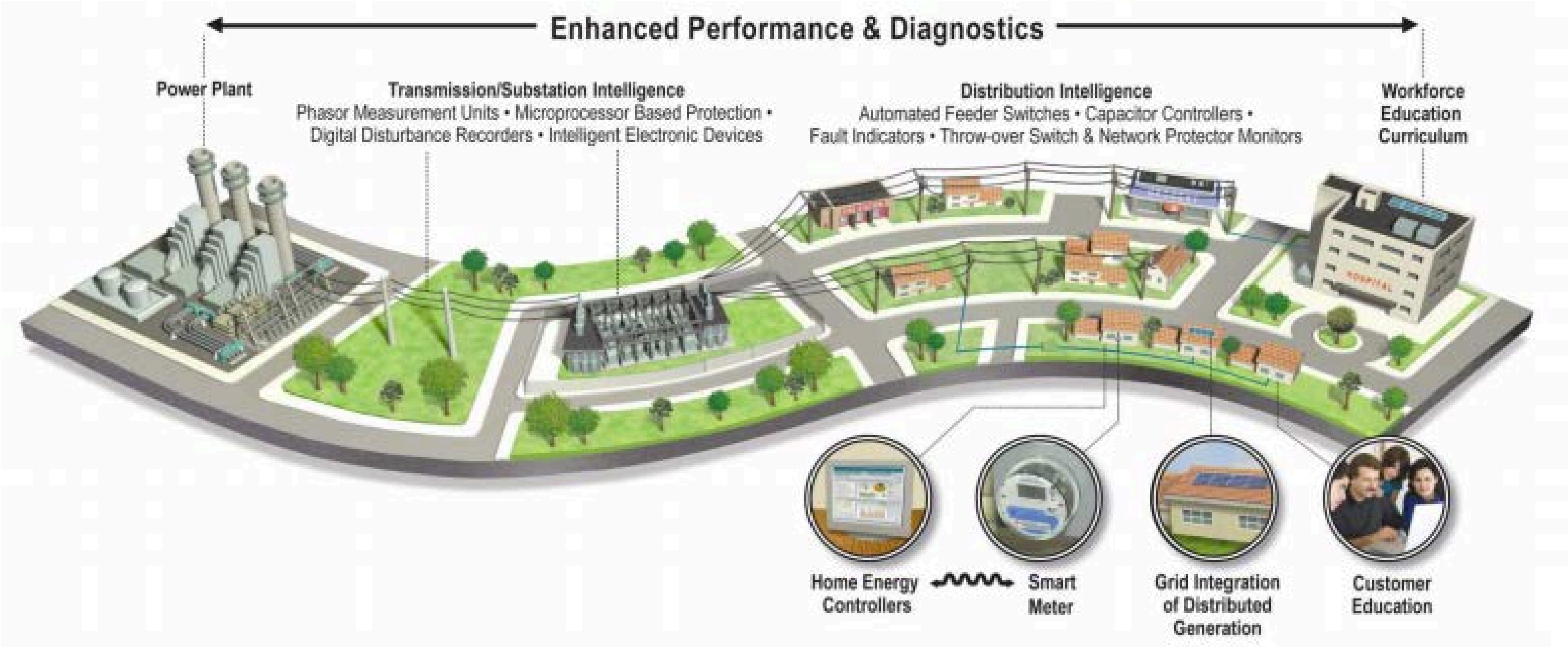
	Total Demand (MJ/yr)	Building Design Effect (%)	Climate/ Weather Effect (%)	HVAC Activity Effect (%)	Other Activity Effect (%)
Eichler					
Fresno	97,378	6	13	32	49
Riverside	80,92[illegible]	7	4	31	58
San Diego	73,69[illegible]	[illegible]	0	34	64
South Bay	92,642	5	3	41	51
Ranch					
Fresno	130,852	3	10	52	36
Riverside	111,405	2	3	52	42
San Diego	94,672	1	0	49	50
South Bay	110,492	2	2	53	43
Title 24					
Fresno	105,984	0	12	43	45
Riverside	91,260	0	3	45	52
San Diego	80,963	0	0	42	58
South Bay	94,380	0	3	47	50

By determining the ranges of all runs for each housing type and climate zone combination, we were able to gauge the extremes in demand for each prototype. Estimates of energy use for non-modeled appliances and devices (e.g., hot water heating, cooking, laundry, home electronics, etc.) were then brought into the analysis alongside of the thermal/HVAC modeling results. Selecting the mid point value in the ranges for both activity/behaviorally driven


Silver Spring Networks
0013500100C952A8
FCC ID: OWS-NIC514 IC: 5975A-NIC514
000.698 kW
Type FOCUS AXR-SD
FORM 2S CL200 240V 3W 60Hz TA=30 Kh 7.2
NXL10075825980410
1007582598
AR 60 min.
DS
PG&E
SmartMeter
106 638 441
-415
0410
Landis+Gyr
PATENT PENDING

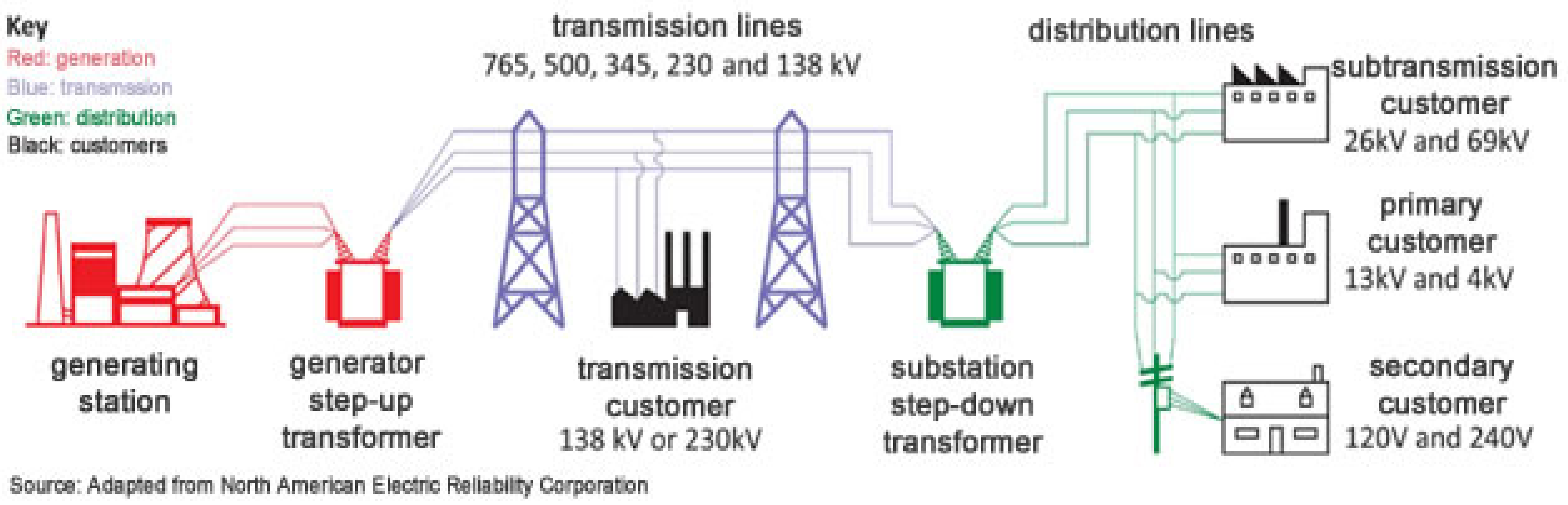

GENERAL ELECTRIC
KILOWATTHOURS
CL 200
TYPE I-60-S
SINGLE STATOR
FM 2S
WATTHOUR METER
TA 30
240V 3W
CAT. NO. 720X1G1
Kh 7.2
60~
397128
44 617 187
MADE IN U.S.A.

Figure 1. Smart grid technologies are being applied across the electricity system, including transmission, distribution and customer-based systems

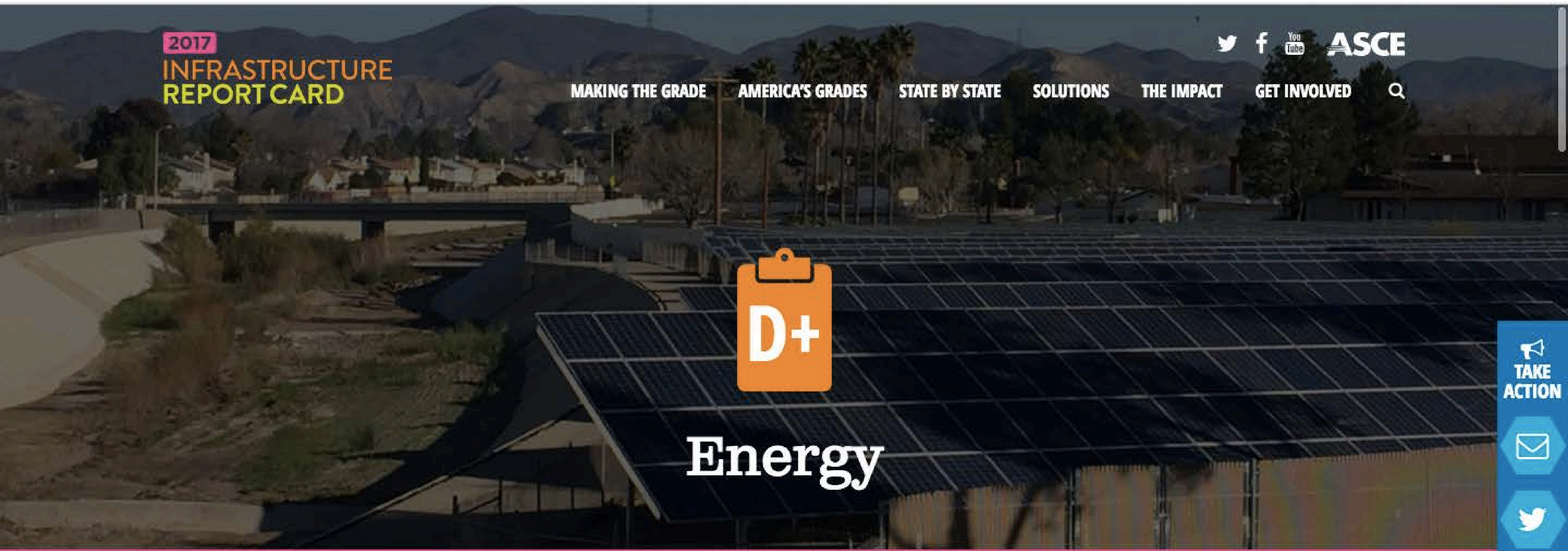


Source: US DOE 2014 Smart Grid System Report to Congress.

The "Dumb" Grid



Source: http://www.eia.gov/energy_in_brief/power_grid.cfm .



D+

Energy

TAKE ACTION

BACK TO CATEGORIES

Overview

Much of the U.S. energy system predates the turn of the 21st century. Most electric transmission and distribution lines were constructed in the 1950s and 1960s with a 50-year life expectancy, and the more than 640,000 miles of high-voltage transmission lines in the lower 48 states' power grids are at full capacity. Energy infrastructure is undergoing increased investment to ensure long-term capacity and sustainability; in 2015, 40% of additional power generation came from natural gas and renewable systems. Without greater attention

On average,
oil refineries have operated at over
90% capacity
SINCE 1985,

“The modern grid will utilize telecommunications and information technology infrastructure to enhance the reliability and efficiency of the electric delivery system. The smart grid will meet the growing electricity needs of our digital economy more effectively.

Together with new digital smart meters—which provide two-way communication between customers and their electric companies—the modern grid **will allow customers to better understand their electricity usage and to manage their electric bills more effectively**.”

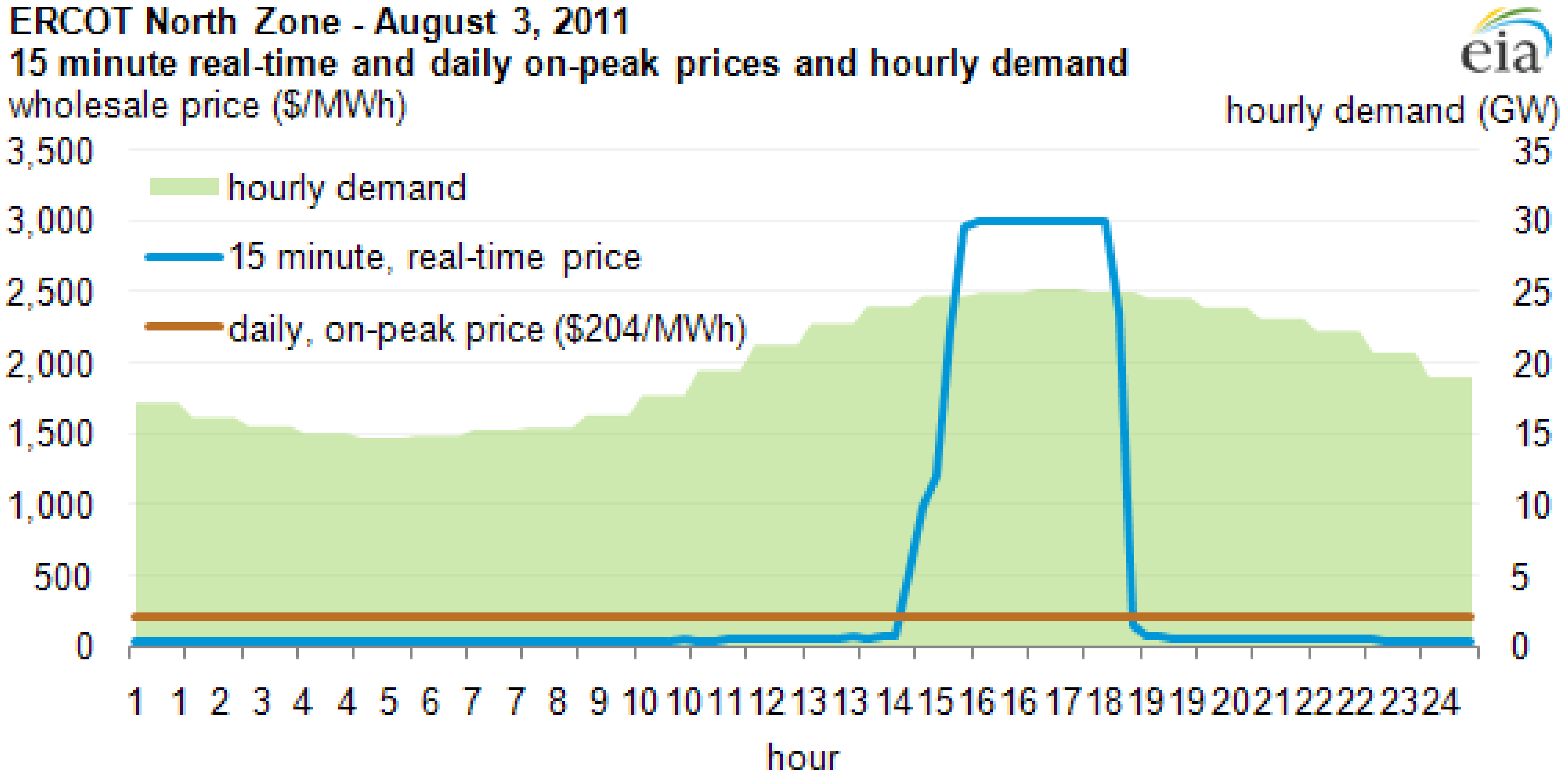
Edison Electric Institute, 2016.

SMARTGRID.GOV

Initiatives that catalyze the industry to modernize the grid.

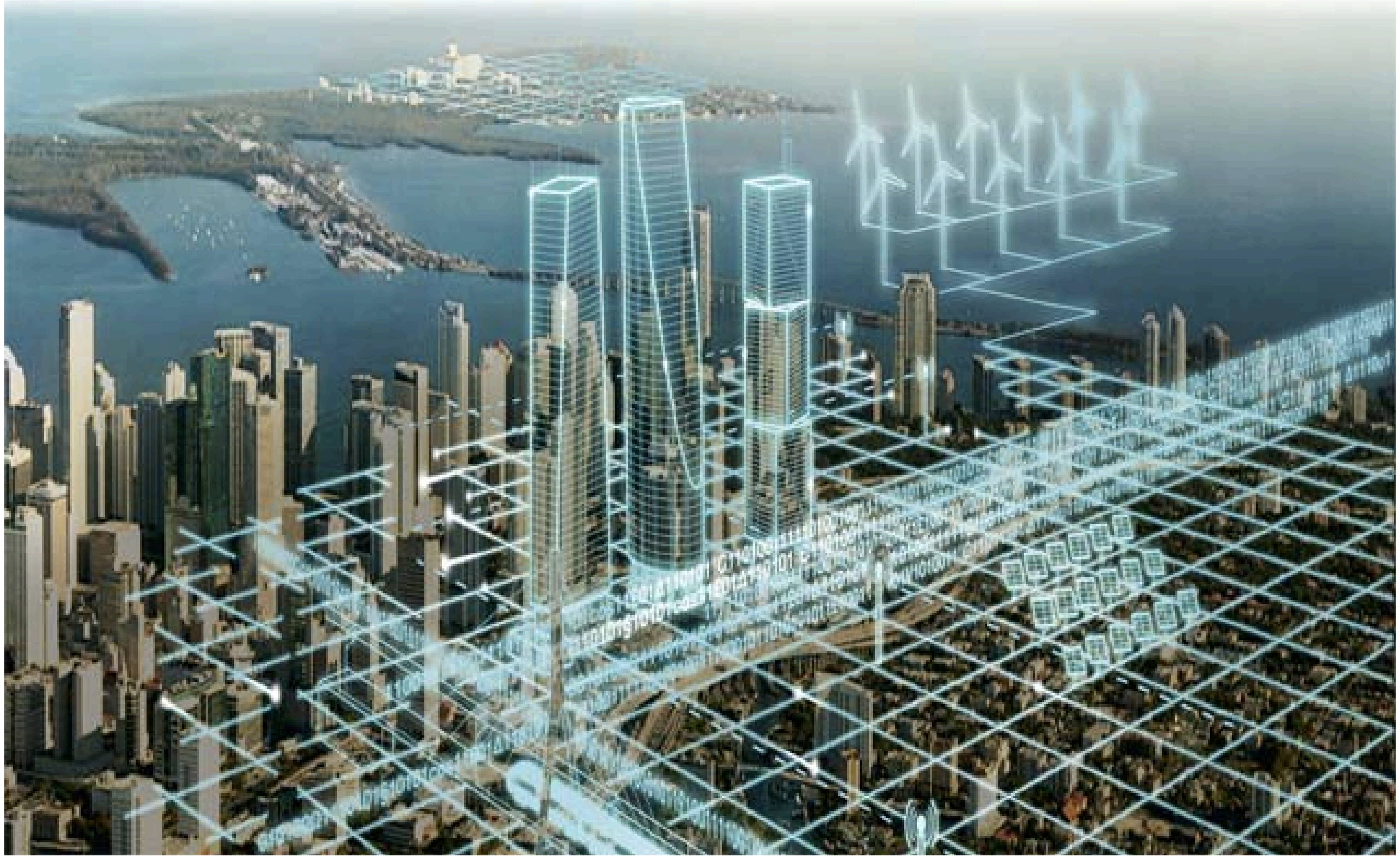
“Smart Grid Investment Grant (SGIG) projects that deployed advanced metering infrastructure (AMI), direct load control programs, time-based rate programs, and consumer information and control technologies, such as in-home displays, web portals, and programmable communicating thermostats to **affect the timing and magnitude of the consumption of electricity by customers. The key analysis question concerned how, and to what extent, these devices and programs resulted in reductions and/or shifts in peak demand and reductions in overall levels of electricity consumption?”**

Smartgrid,gov, 2016.



Source: U.S. Energy Information Administration, based on [Electric Reliability Council of Texas (ERCOT)](#).

Smart Energy Transition



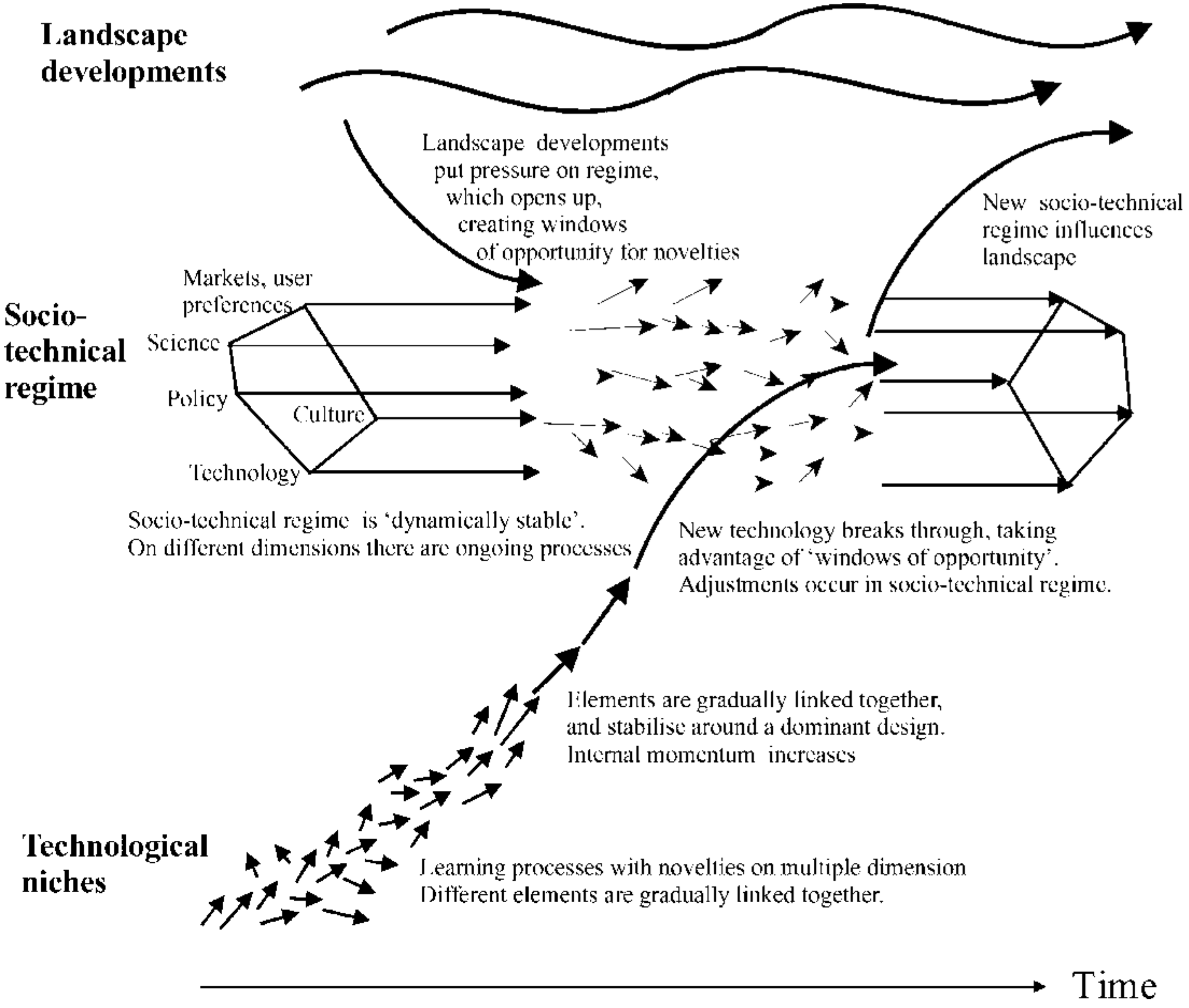
Siemens Smart Grid Solutions

Research questions

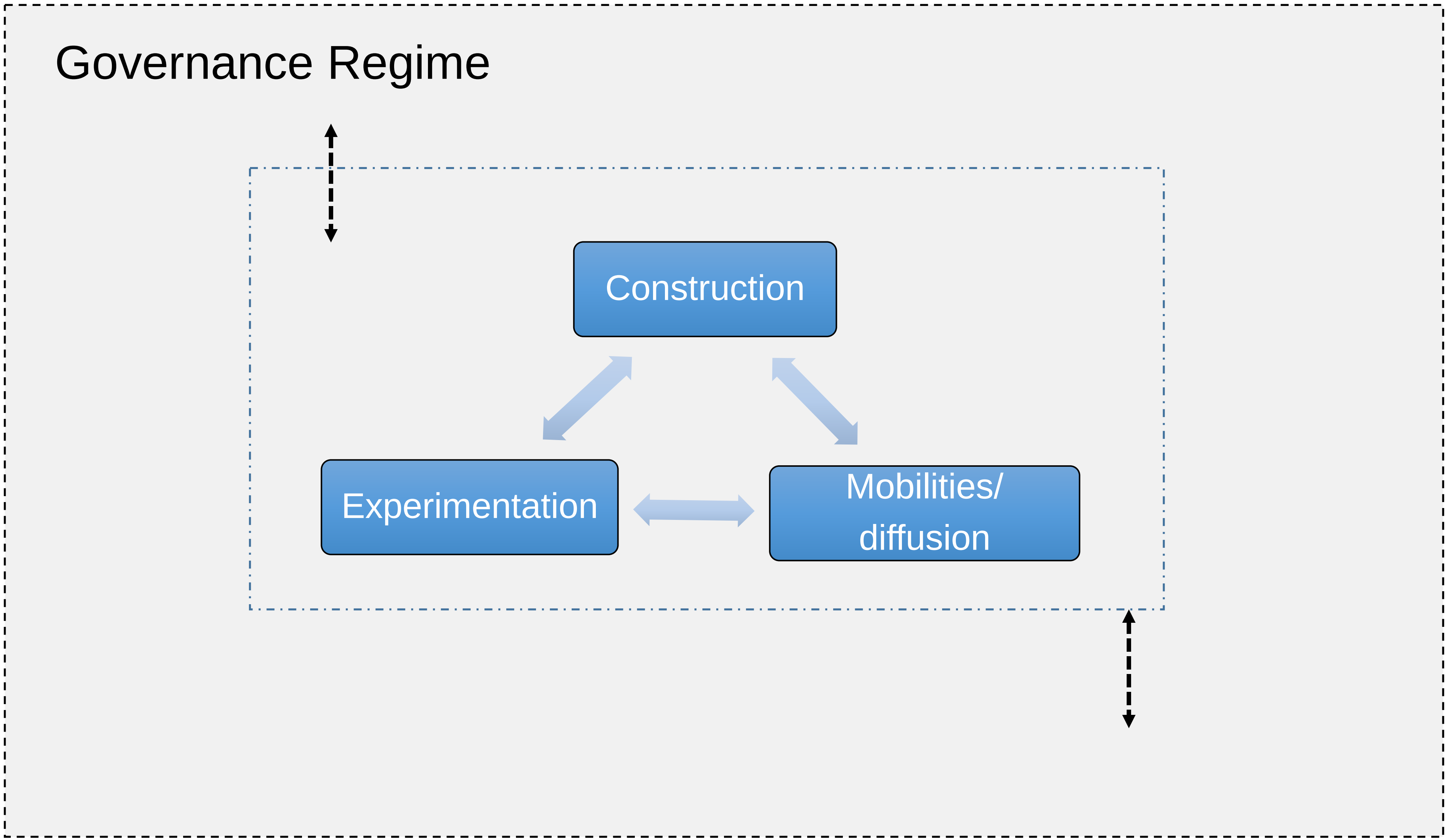
1. How are smart grids constructed in discourse? What problems do they address?
2. How are smart grid programs implemented in urban contexts and with what results?
3. How do different cities learn about smart grid technologies? How do associated policy models and knowledge move from one place to another, and with what implications and limitations?

Social Science Research on Smart Grids

- The grid is a sociotechnical system, that is composed not only of technologies, but also institutions, rules, laws, culture, markets, and everyday practices (cf Hughes 1983; Nye 1990; Geels 2014).
- The smart grid seeks to transform this sociotechnical system, thus reshaping and reconfiguring both social and technical elements.
- Most social science research tends to focus on visions and imaginaries, in some “proximate future” (cf Ballo 2015; Engels and Munch 2015).
- Other studies perform STEEP analysis to address barriers to implementation or the multi-level perspective to examine transitions (cf Mah et al 2012, 2013; Stephens et al 2014,2015).



Source: Geels (2005, 452).


Governance Regime
Construction
Experimentation
Mobilities/
diffusion

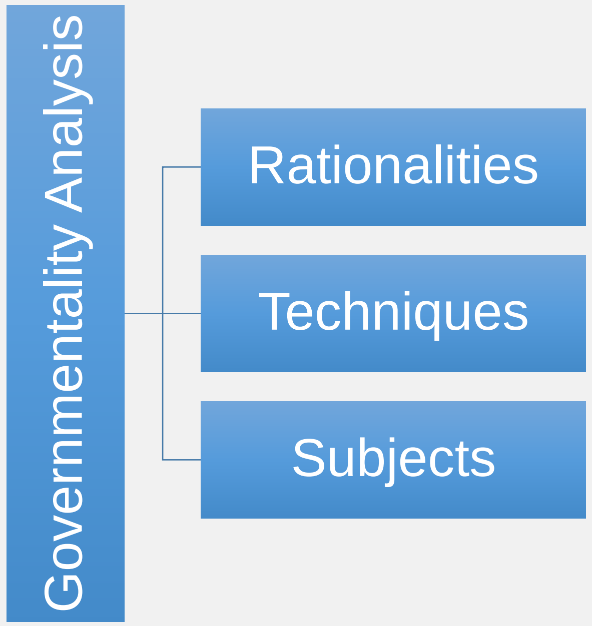
Governance Regime

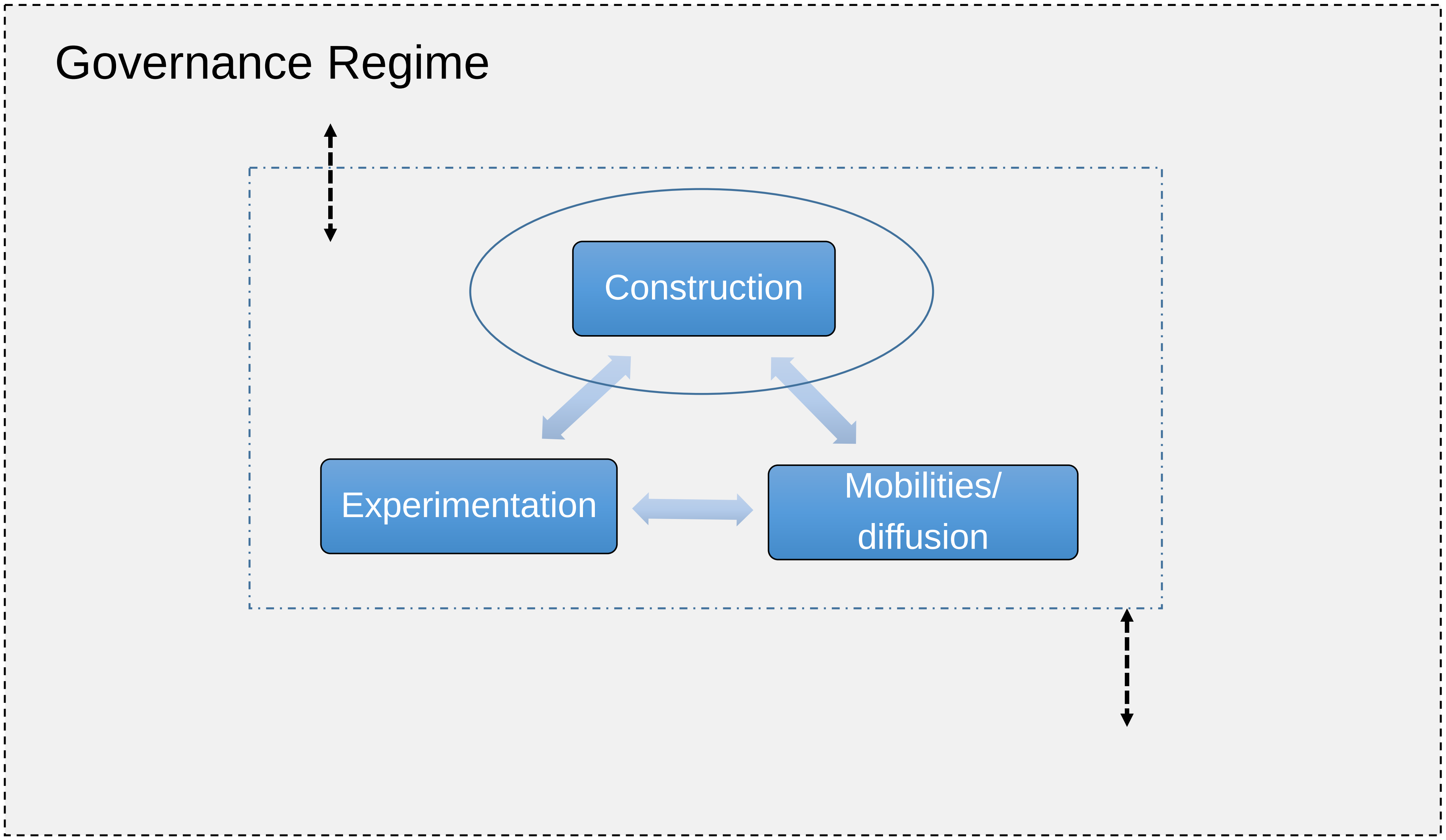
STS/MLP

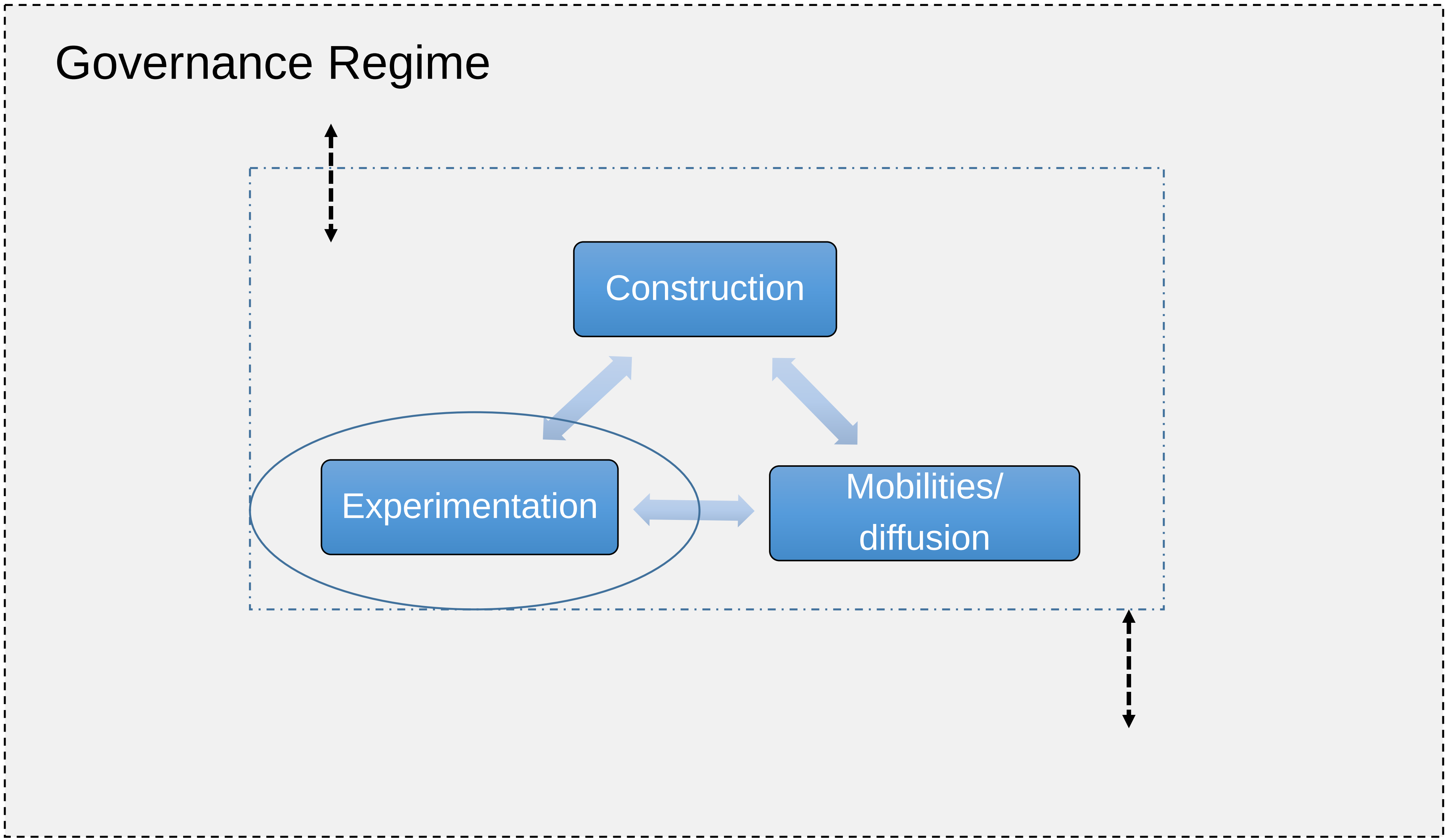
Sociotechnical regime:

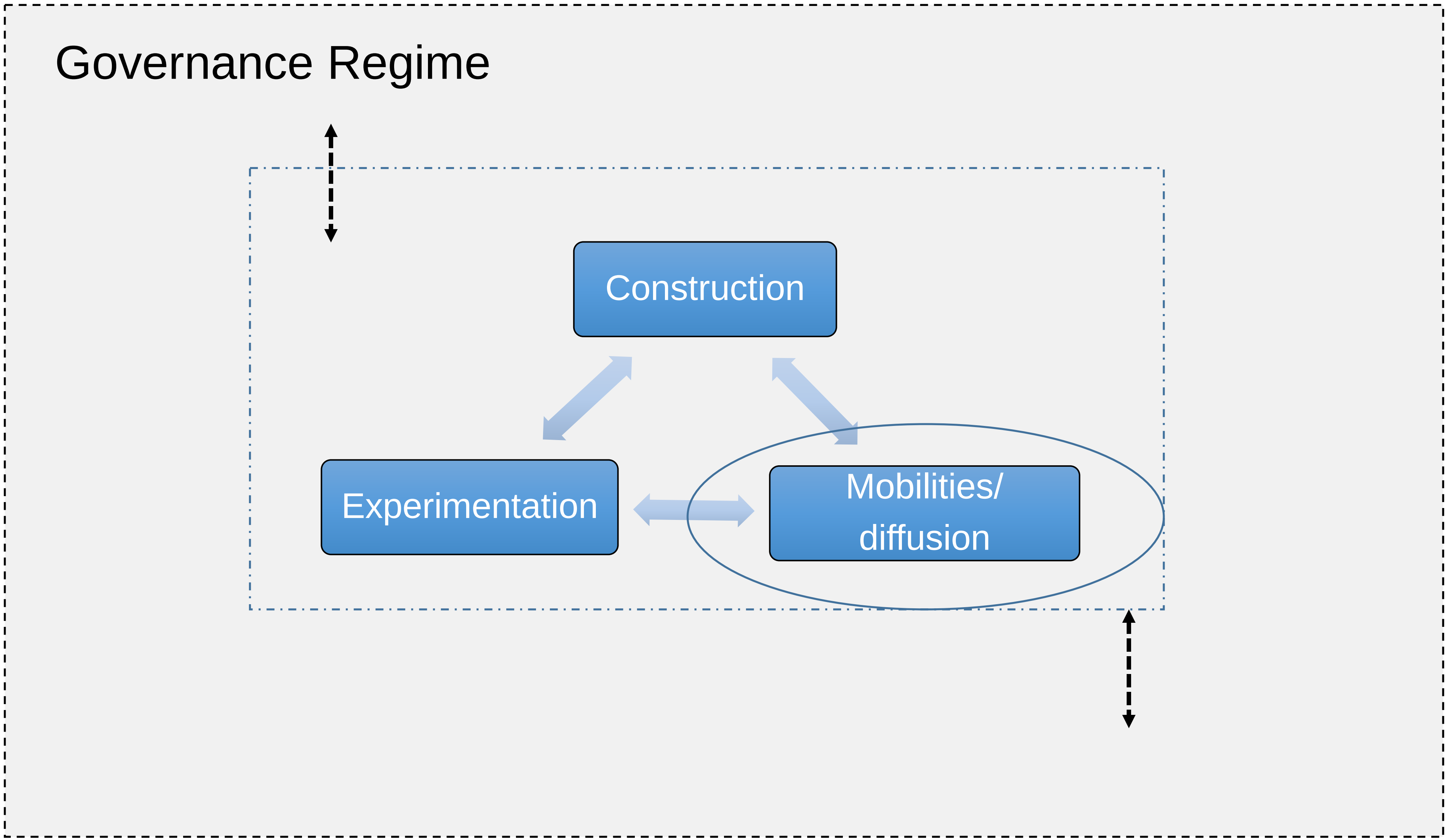
“the deep-structural rules that coordinate and guide actor’s perceptions and actions” which are embedded in institutions and infrastructures (Geels 2012, 473; Rip and Kemp 1998) .

Governmentality




Governance Regime
Construction
Experimentation
Mobilities/
diffusion


Governance Regime
Construction
Experimentation
Mobilities/
diffusion

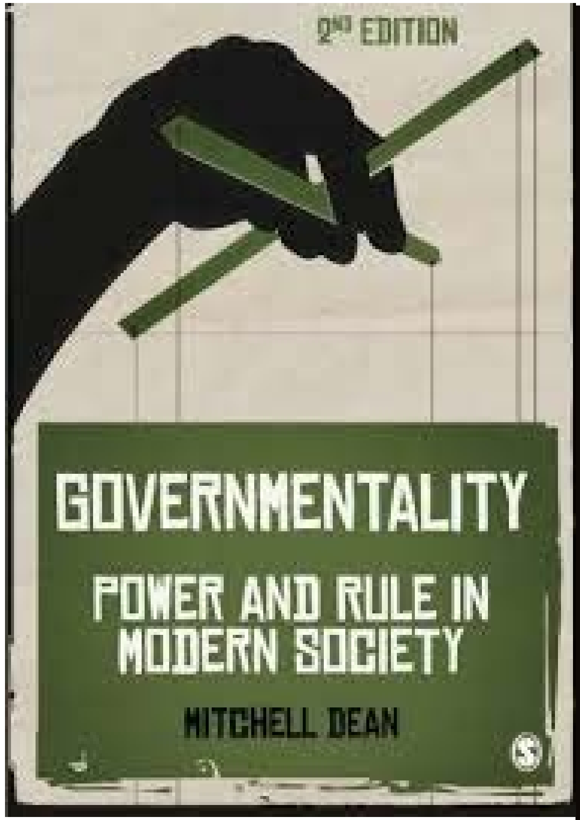

Governance Regime
Construction
Experimentation
Mobilities/
diffusion

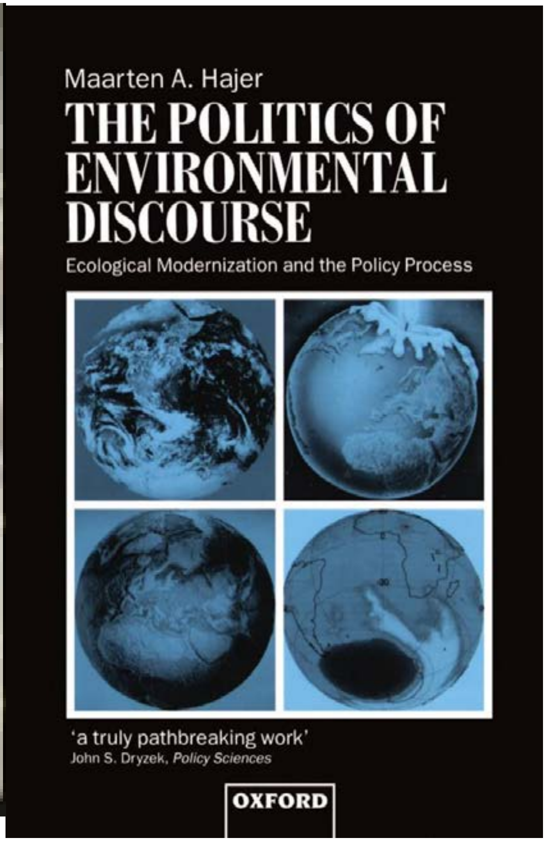
Methodology

Critical discourse analysis and case study approach

Critical discourse analysis (CDA)

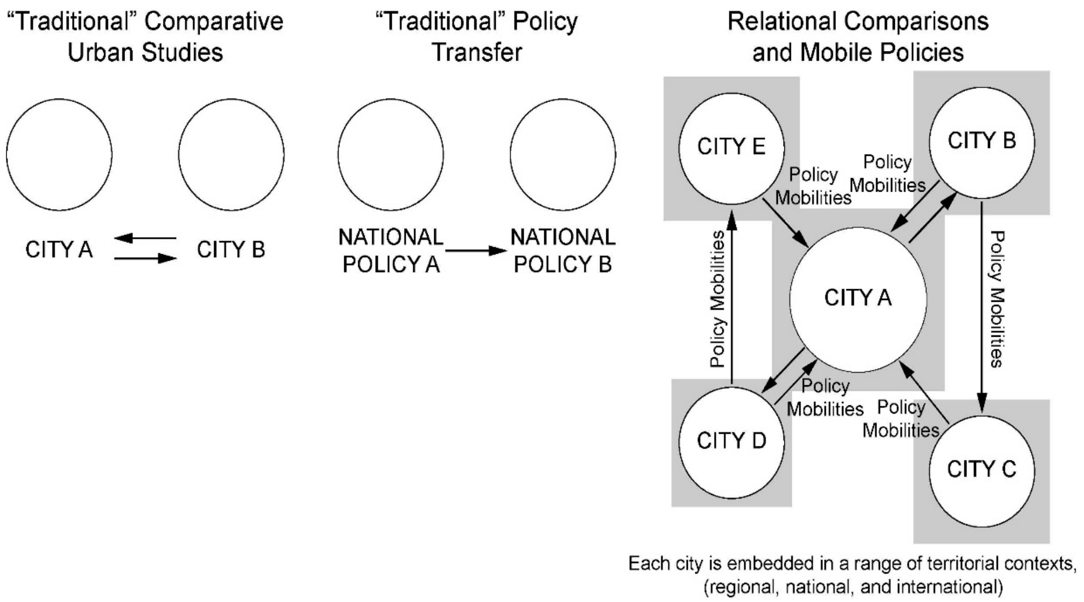
- Discourse is “a specific ensemble of ideas, concepts, and categorizations that is produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities” (Hajer 1995, 60).
- Central to studies of governmentality (Dean 1999).





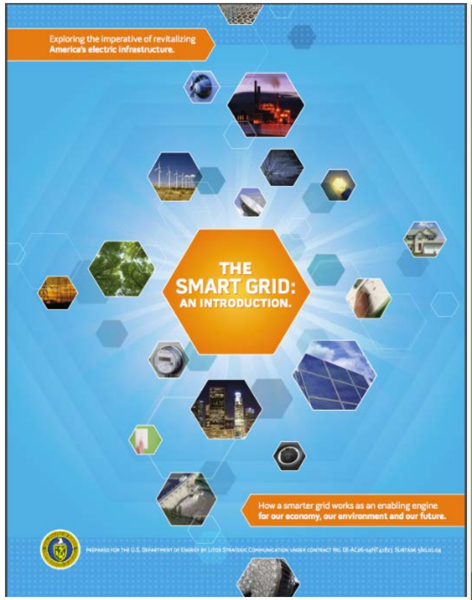
Case Study Approach

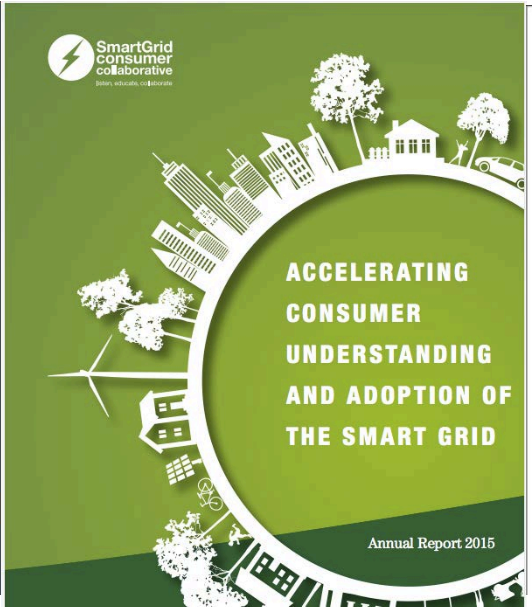
- Key case of Austin (cf Yin 2003, Flyvbjerg 2006).
- Exploratory, relational comparative cases of Oak Park, Fort Collins, and Boulder (cf, Peck and Theodore 2012,2013; Ward 2008, 2010; McCann and Ward 2011).



Data Collection

- Database of documents.
- Semi-structured interviews with key informants across 4 sites (44 total, 34 recorded and transcribed).
- Participant observation and field notes at: events community and city council meetings, technology showcases.



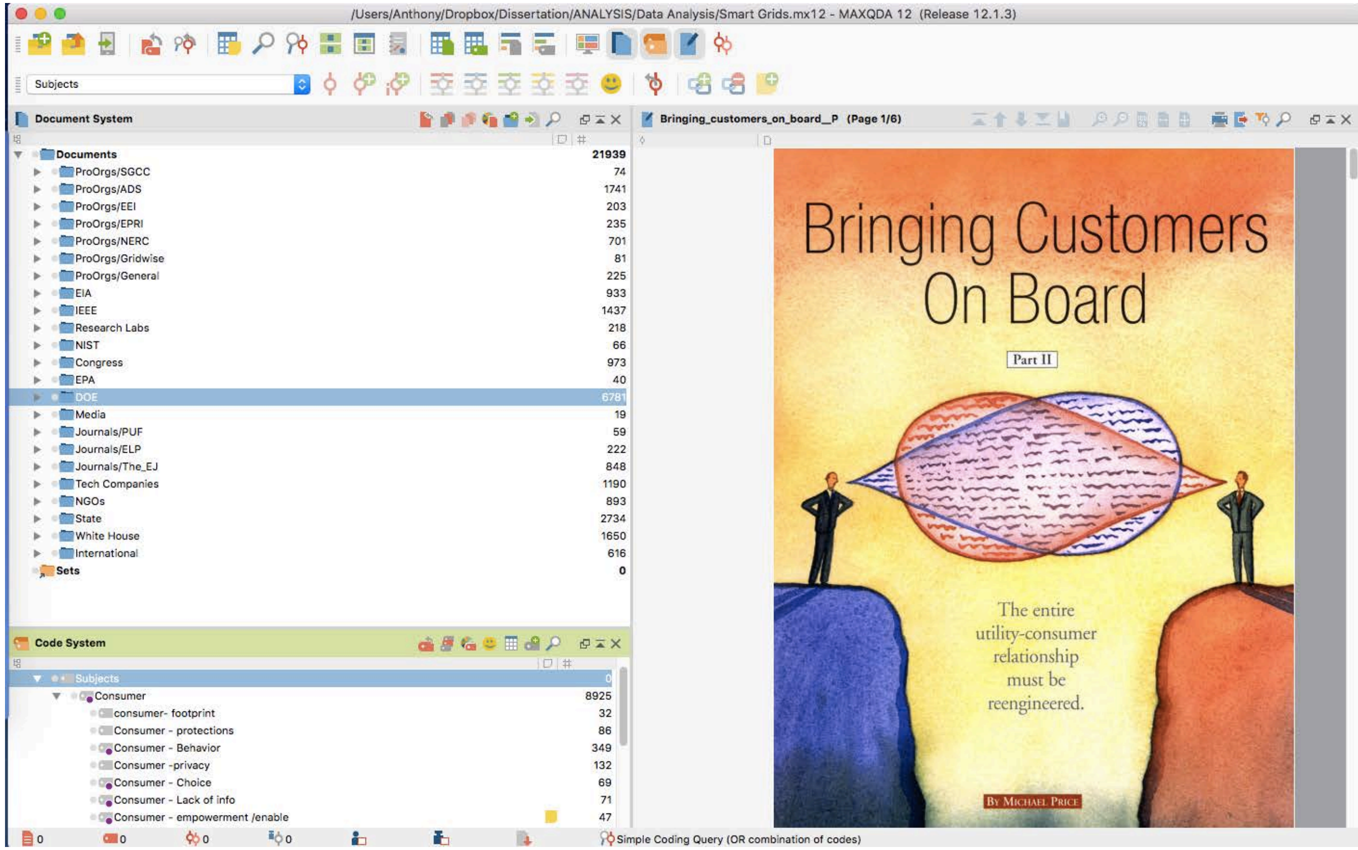



Energy

Experimental and data collection methods for a large-scale smart grid deployment: Methods and first results

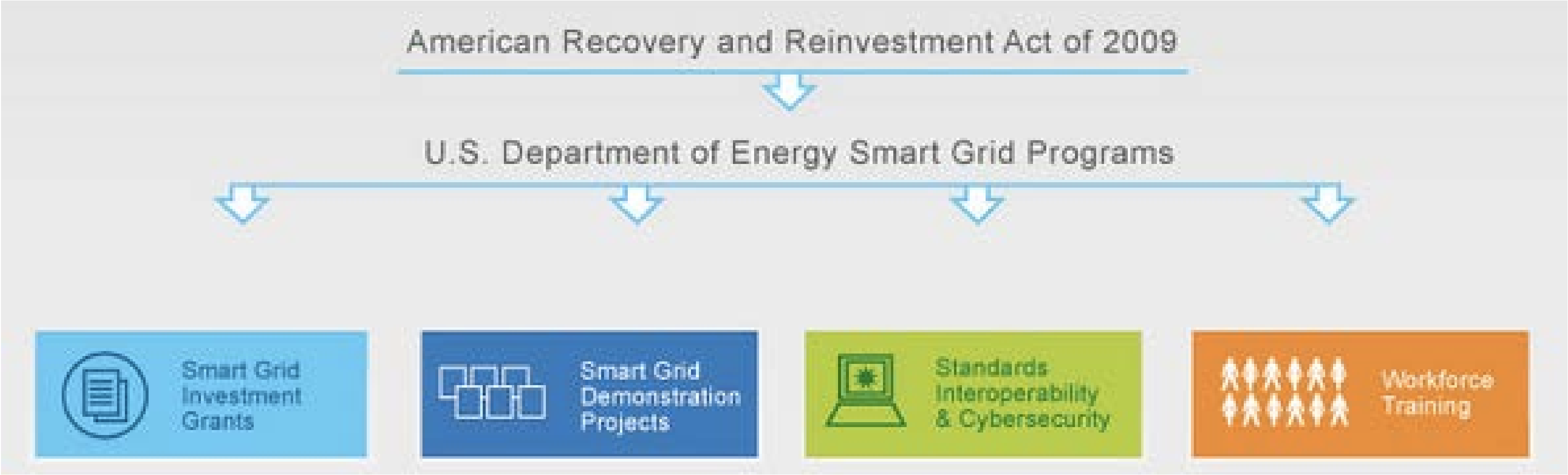
Data Analysis

- Open coding then analytical coding on both documents and interview transcripts.
- Developed coding scheme through iterative process.
- Critical discourse analysis (Hajer 1995, Waitt 2005).



Experimentation

How are smart grids implemented in urban contexts and with what results?


American Recovery and Reinvestment Act of 2009
U.S. Department of Energy Smart Grid Programs
Smart Grid Investment Grants
Smart Grid Demonstration Projects
Standards Interoperability & Cybersecurity
Workforce Training


Smart Grid Demonstration Projects.
Total Value of $1.5 Billion.
Energy Storage
Regional Demonstrations
16 projects
$648,404,497
16 projects
$874,354,924

We're not trying to solve all the world's challenges. Just the two biggest ones.

Water and energy are two of the planet's greatest challenges, and they are inextricably connected. Addressing one requires addressing the other. And solving them both will grow the economy, improve people's lives and protect our natural resources and climate.

Unlike any other organization, Pecan Street is focused on advancing university research and accelerating innovation in water and energy. We provide utilities, technology companies and university researchers access to the world's best data on consumer energy and water consumption behavior, testing and verification of technology solutions, and commercialization services to help them bring their innovations to market faster. We help prepare technically-focused students for careers with industry, and we help them conduct research that will change the world.

In Partnership With:

ROUND ROCK, TEXAS
PURPOSE. PASSION. PROSPERITY.

Green Mountain Energy®

In The News

Pecan Street Seeks Systems Architect/Programmer

Pecan Street Inc. seeks a systems architect/programmer to be part of its award-winning team innovating solutions for intelligent energy management …

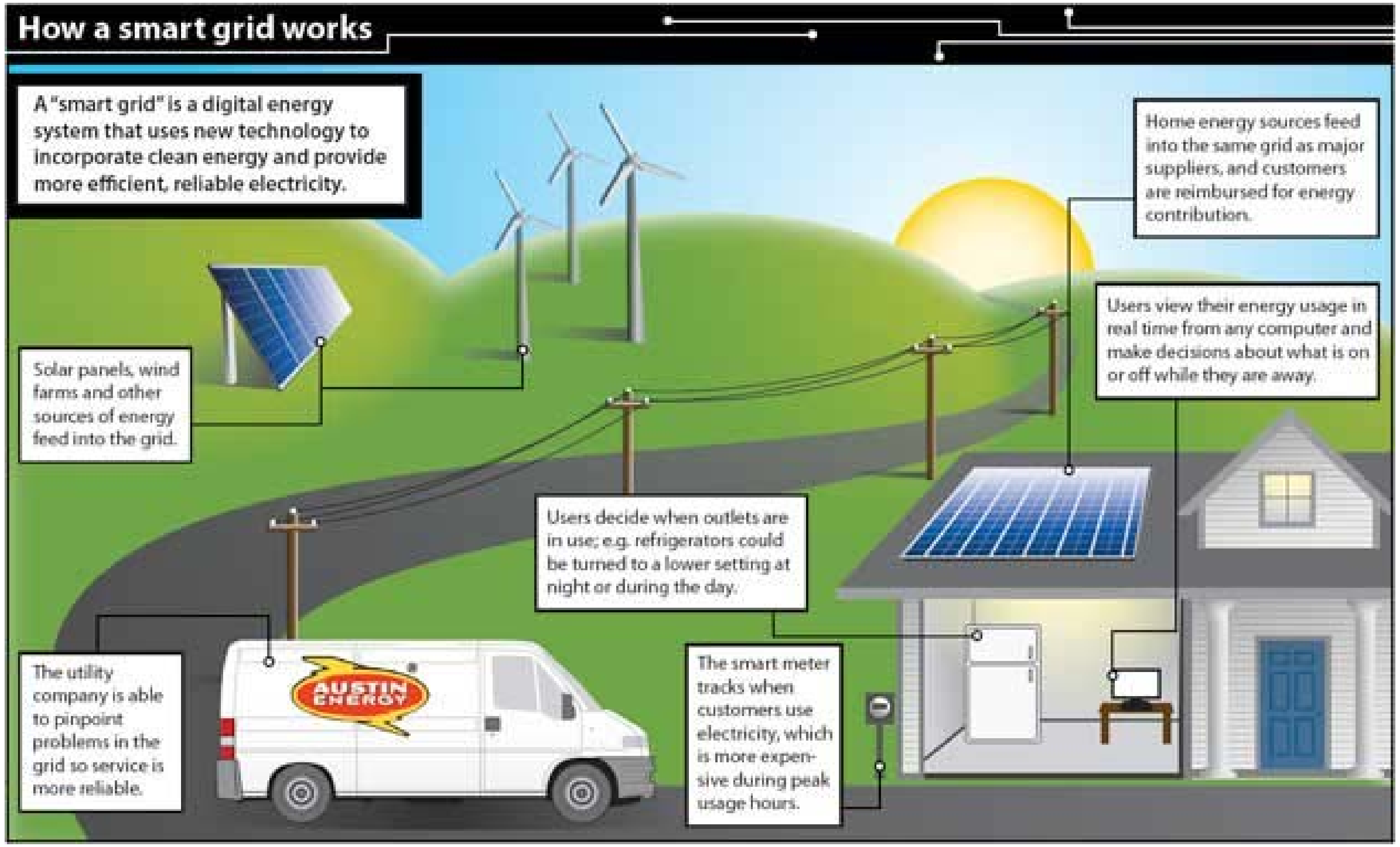
TxTrib: Researchers,

MANOR RD.
AIRPORT BLVD.
SINGLE FAMILY
BERKMAN DR.
TOWN CENTER
MUELLER BLVD.
DELL CHILDREN'S MEDICAL CENTER
I-35
H-E-B
AUSTIN STUDIOS
51ST ST.

A “living” laboratory

“Mueller neighborhood, the locus of Pecan Street, is a laboratory of ideas and technologies that will move the nation’s $1.3 trillion electricity market toward a future in which energy is cheap, abundant and clean. If Pecan Street is successful, every neighborhood in America will look like it in 20 years.”

Pecan Street and test-bedding the city



Pecan Street and test-bedding the city

"There's no other place in the world where companies can go and study how human behavior interacts with energy... Pecan Street can give its ‘Good Housekeeping Seal of Approval’ before a product or service is introduced into the nation's households.”

Co-founder of Pecan Street, Director of Austin Technology Incubator, 2014.

“Any technology now, is what... **my targets are less solar panel manufacturers and more people creating efficiency.** So, like, anyone who is doing battery, software, hardware integration to support communications between utilities and residents, etcetera... there is a lot of software engineers here, there is a lot of people who know how to analyze data. Austin is a good fit for those companies. This is a natural place for them to be. ... **[Clean tech] is going towards devices that communicate to create efficiencies. Austin is very good at this, we have a lot of software engineers, and there is an incredible quality of life. You’ve got the Pecan Street Project where companies can test their sensors.** You’ve got a very progressive utility, you know, who is more or less open to adopting new things and trying new things, and they’re changing their generation mix to look very green, and, so..."

Chamber of Commerce Representative, Interview, November 2015.

LIVING

Is This America's Smartest City?

Bryan Walsh @bryanrwalsh | June 26, 2014

Smart consumer engagement

- Smart grid experiments suggest a reconfiguration of consumer – utility relationships.
  - From passive to active consumer.
  - Rational actors, individual decision makers, economizers.
- Some engineers and others suggested smart, rational consumers don’t exist and current smart grid programs won’t work. Instead, they advocate for home and appliance automation or default set-backs.

“ it’s a very wonky subject, its [energy] not necessarily the most interesting conversation material for a lot of people so one barrier is just peoples interest levels. **There is a statistic that is widely quoted that people think about their energy bills and electricity six minutes a year... for most people its not something that you choose to focus on. One barrier for scaling up demand response and smart technology and that sort of thing is just generating interest**... I’ve talked to representatives of utilities. I feel like demand response is pretty well received... but I guess there is a barrier in the way its designed... getting the design of these programs right so that customers have a positive experience, that’s one of the current barriers for it to catch...**even if they don’t think about it that much, they think about ways to save money, if something is a no-brainer, then you make that choice.”**

EDF Representative Interview, October 2015.

“In terms of energy efficiency and smart grid and how they are related, its just sort of the next evolution, its using machines and technology that doesn’t have the human error element, or the human interest level, **you have these items programmed to be more efficient and at scale that will take a lot of the human element of being more efficient with energy out of the equation... and so its just the next evolution of it. It just makes it easier for humans to act with the environment in mind.** I mean, humans might want to act with the environment in mind, but they have their priorities and they have a lot of other things to do that day, and some things slip through the cracks, and if you want to be a good environmentalist but that’s a low priority for you that can slip through the cracks and the technology can make it a lot easier.”

EDF Representative, Interview, October 2015.

Experimentation: key findings

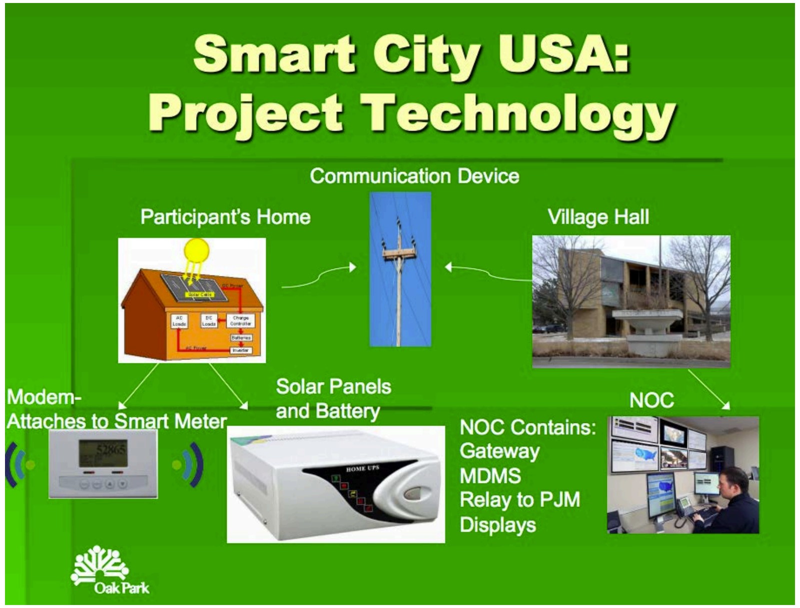
- Living laboratory concept is utilized to facilitate “test-bed” approach to experimentation.
- “Smart” consumer engagement is a necessary strategy to enact the smart grid and realize its presumed benefits.
  - Automation and limits of the active consumer.
- Discursive construction influences types and forms of experimentation.

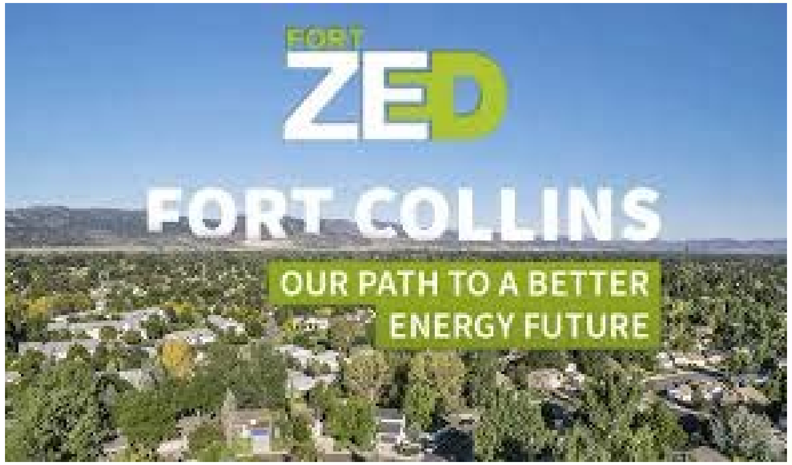
Experimentation: key findings

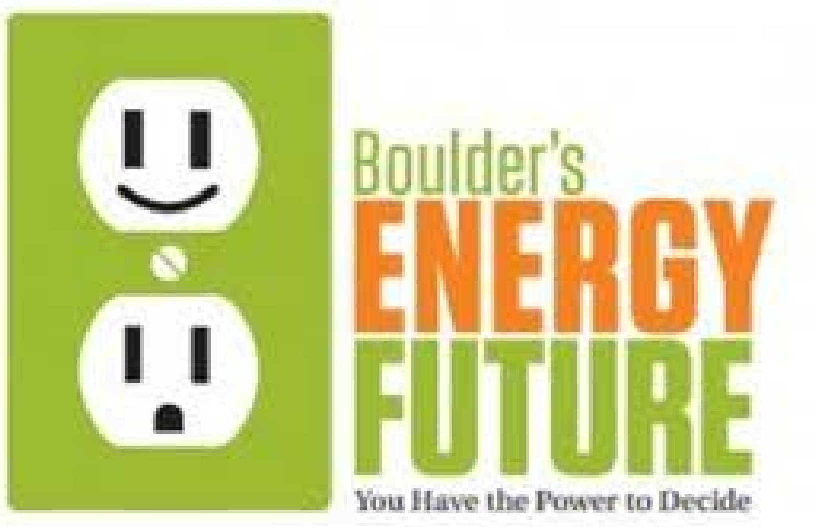
- Living laboratory concept is utilized to facilitate "test-bed" approach to experimentation.
- "Smart" consumer engagement is a necessary strategy to enact the smart grid and realize its presumed benefits.
  - Automation and limits of the active consumer.
- Discursive construction influences types and forms of experimentation.

Experimentation: key findings

- Living laboratory concept is utilized to facilitate “test-bed” approach to experimentation.
- “Smart” consumer engagement is a necessary strategy to enact the smart grid and realize its presumed benefits.
  - Automation and limits of the active consumer.
- Discursive construction influences types and forms of experimentation.





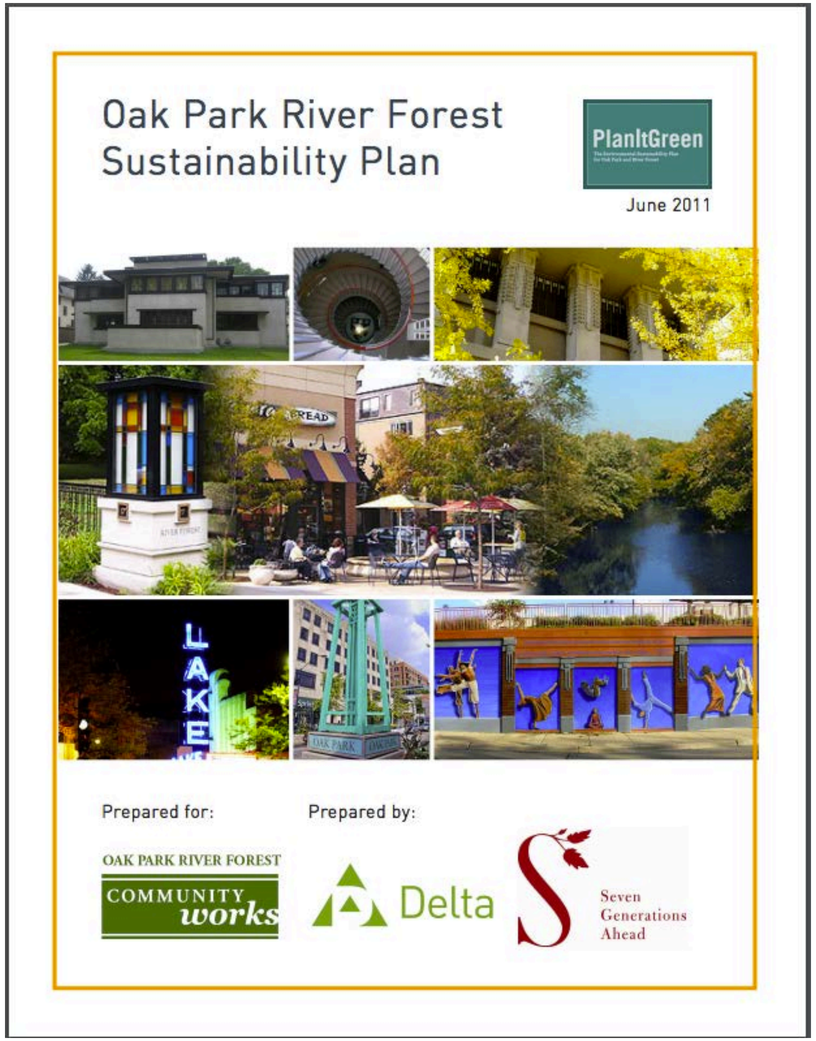


Mobilities/Diffusion

How do different cities learn about smart grid technologies? How do associated policy models and knowledge move from one place to another, and with what implications and limitations?

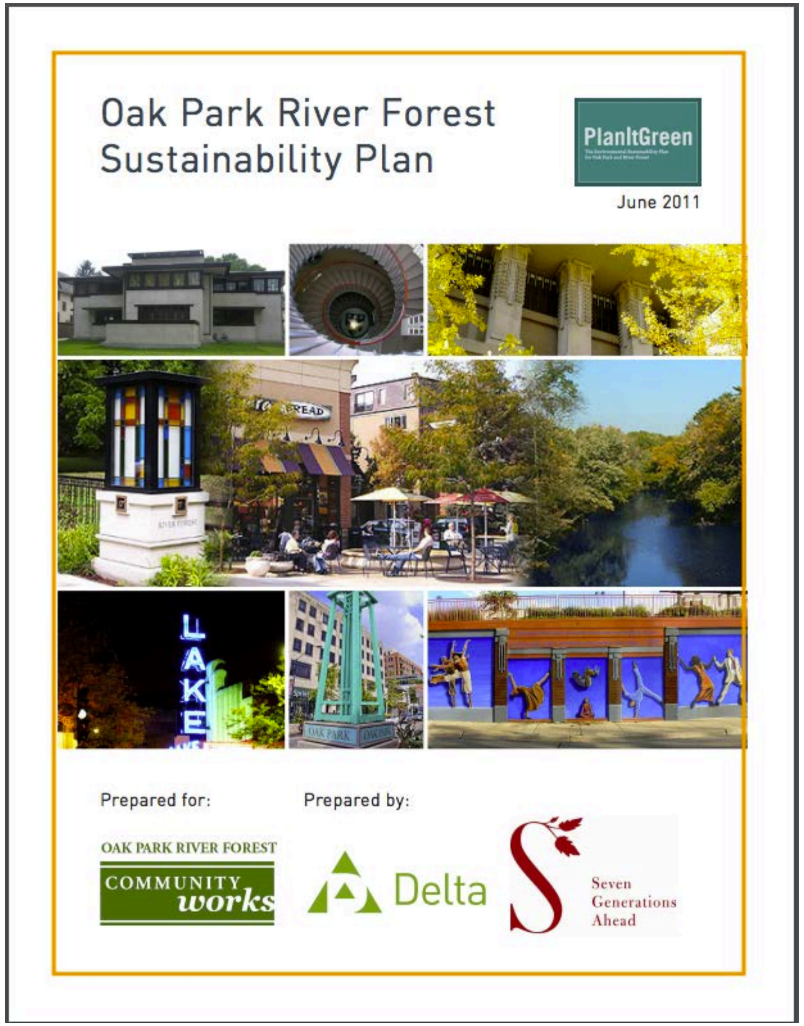
Oak Park SmartCityUSA Project

- Existing sustainability plan (Planit Green) with neighboring municipalities.
- Community choice aggregation.
  - Investor owned utility, ComEd, regulated by state PUC.
- International and state level support.



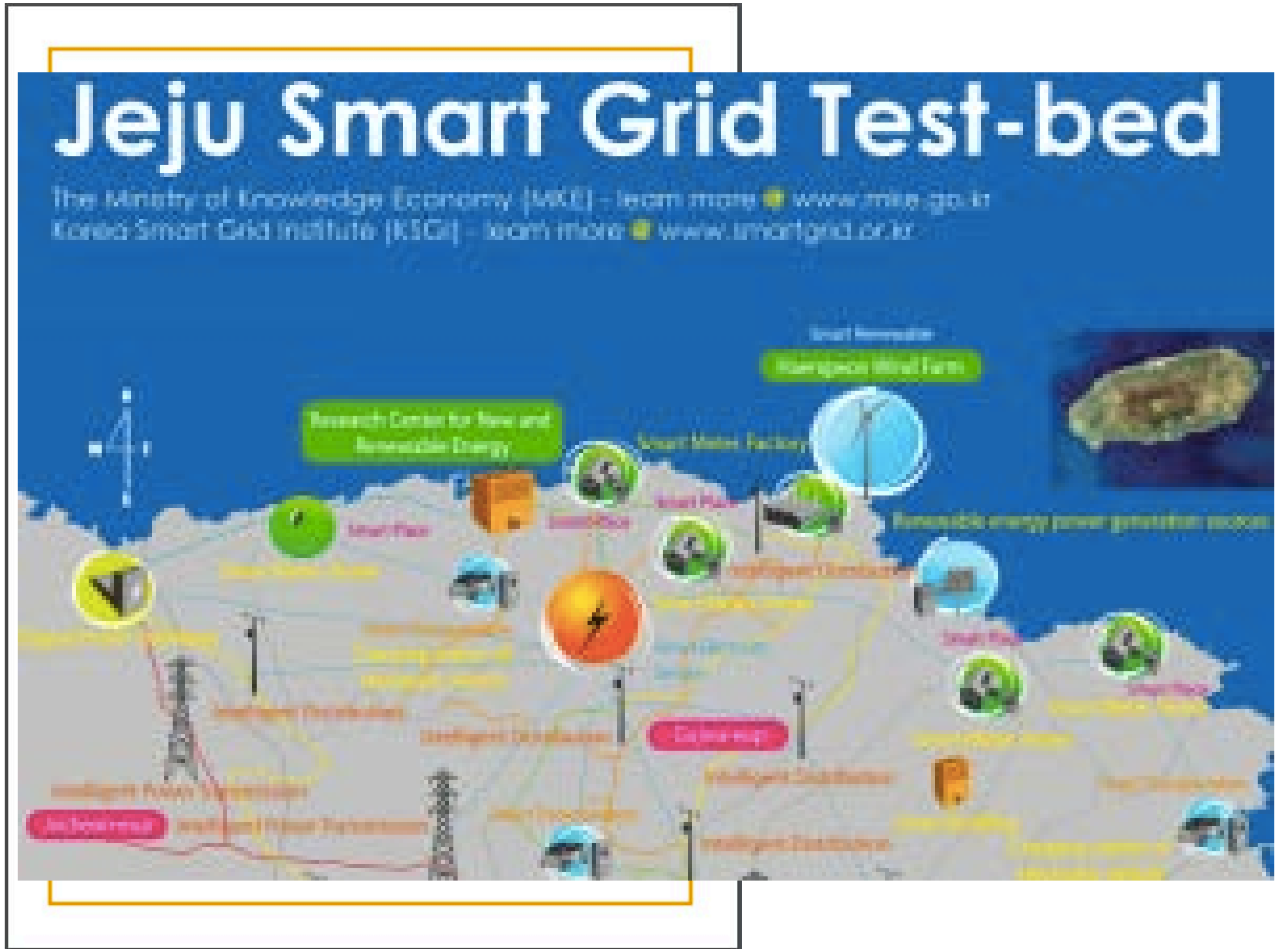
Oak Park SmartCityUSA Project

- Existing sustainability plan (Planit Green) with neighboring municipalities.
- Community choice aggregation.
  - Investor owned utility, ComEd, regulated by state PUC.
- International and state level support.



Oak Park SmartCityUSA Project

- Existing sustainability plan (Planit Green) with neighboring municipalities.
- Community choice aggregation.
  - Investor owned utility, ComEd, regulated by state PUC.
- International and state level support.



Oak Park SmartCityUSA Project

Having the demonstrated knowledge, experience and expertise in getting smart grid projects up and running is a major step toward achieving our goal of keeping Oak Park a leader in environmental initiatives. [...] With Pecan Street’s assistance, we can move closer to implementing a project that will underscore the Village’s commitment to environmental sustainability.

Village President, 2014

Oak Park Testbed

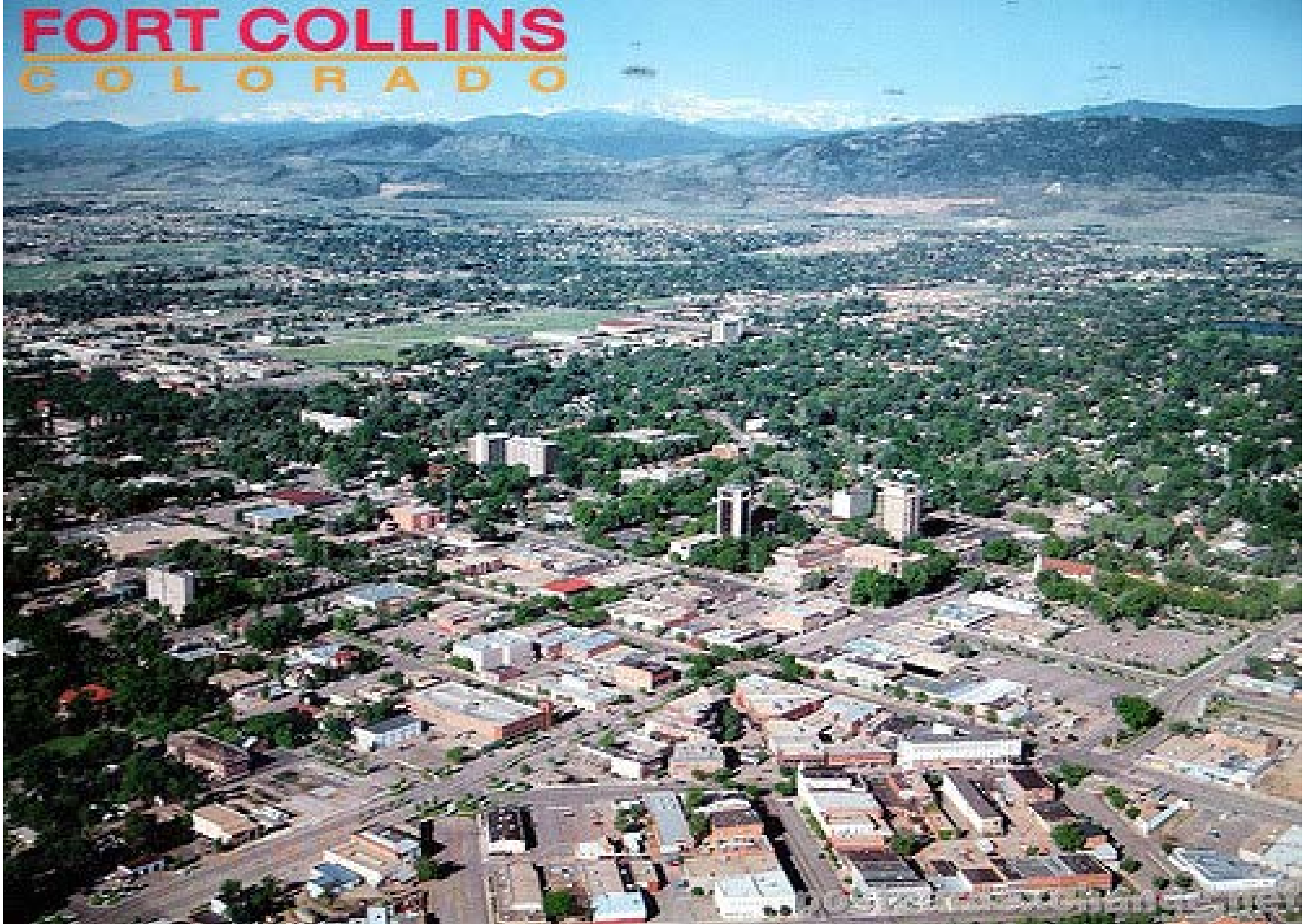
- The test-bed concept was recommended in State policy for utilities, but city officials wanted the focus on Oak Park and their goals.
- Austin’s model smart grid experiment served as an “inspiration” for Oak Park’s project.

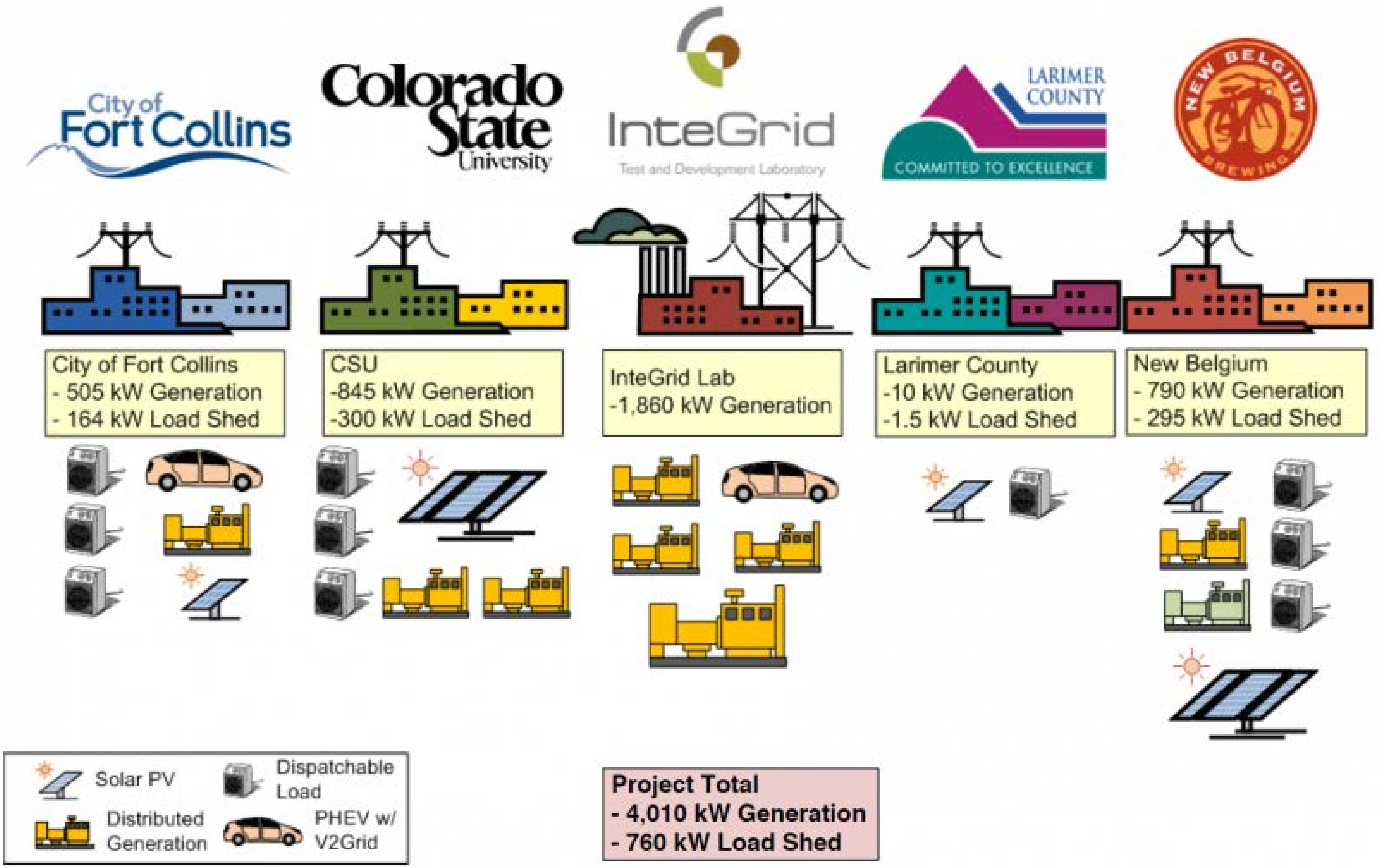
Oak Park Testbed

- The test-bed concept was recommended in State policy for utilities, but city officials wanted the focus on Oak Park and their goals.
- Austin’s model smart grid experiment served as an “inspiration” for Oak Park’s project.

“We wanted to work with Pecan Street to really give us sort of the playlist of how we can do smart city. ... they have done and exceptional job and delivered to the Village really the kind of project ready to go.”

Village Manager, Interview, October 2015


FORT COLLINS
COLORADO



City of Fort Collins
- 505 kW Generation
- 164 kW Load Shed
CSU
-845 kW Generation
-300 kW Load Shed
InteGrid Lab
-1,860 kW Generation
Larimer County
-10 kW Generation
-1.5 kW Load Shed
New Belgium
- 790 kW Generation
- 295 kW Load Shed
Solar PV
Dispatchable Load
Distributed Generation
PHEV w/ V2Grid
Project Total
- 4,010 kW Generation
- 760 kW Load Shed

FortZED: Power to the Community

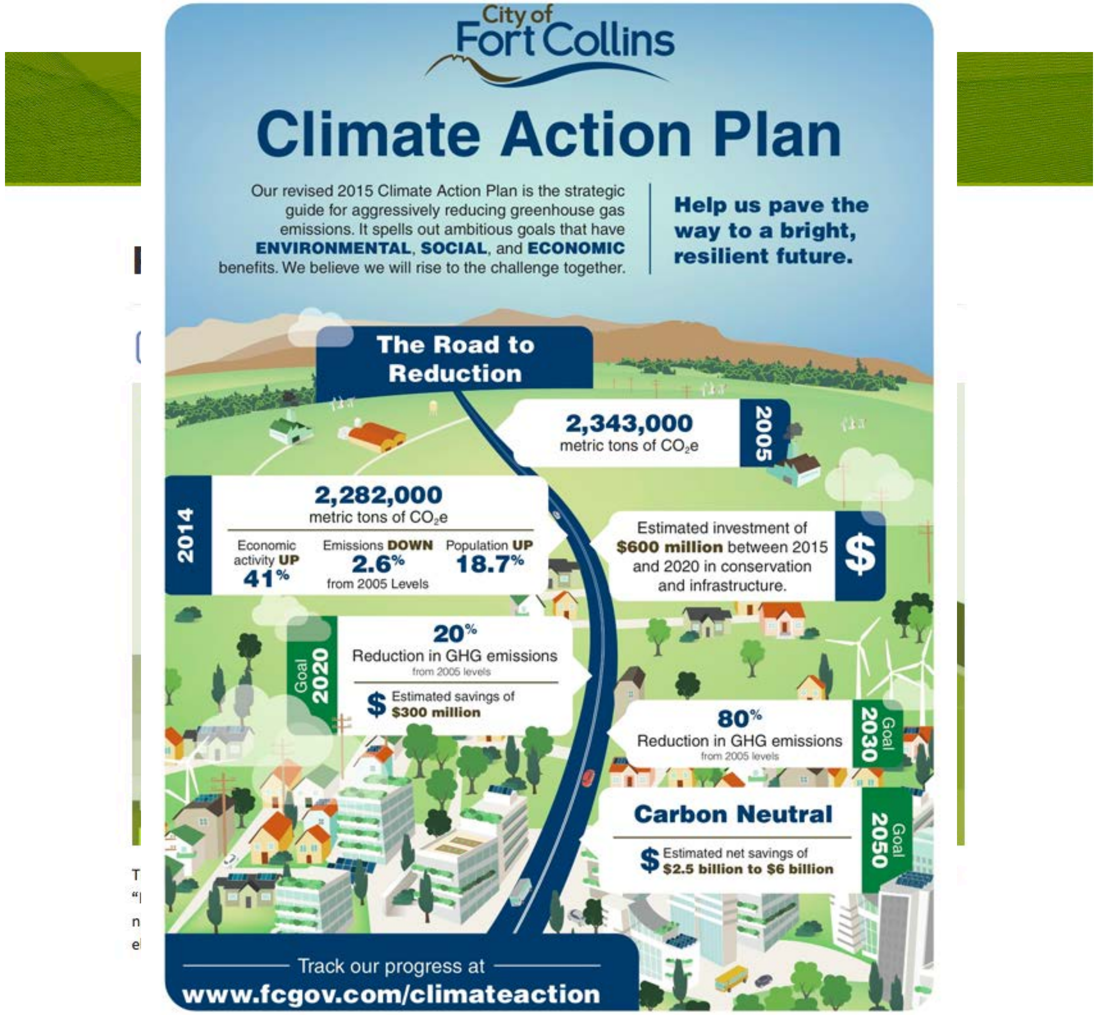
A Public-Private Grassroots Effort

City of Fort Collins

Fort Collins FortZED Project

- Zero Energy District concept.
- Municipal utility overseen by city council.
- Climate Action Plan has aggressive goals for carbon reduction.

Fort Collins FortZED Project

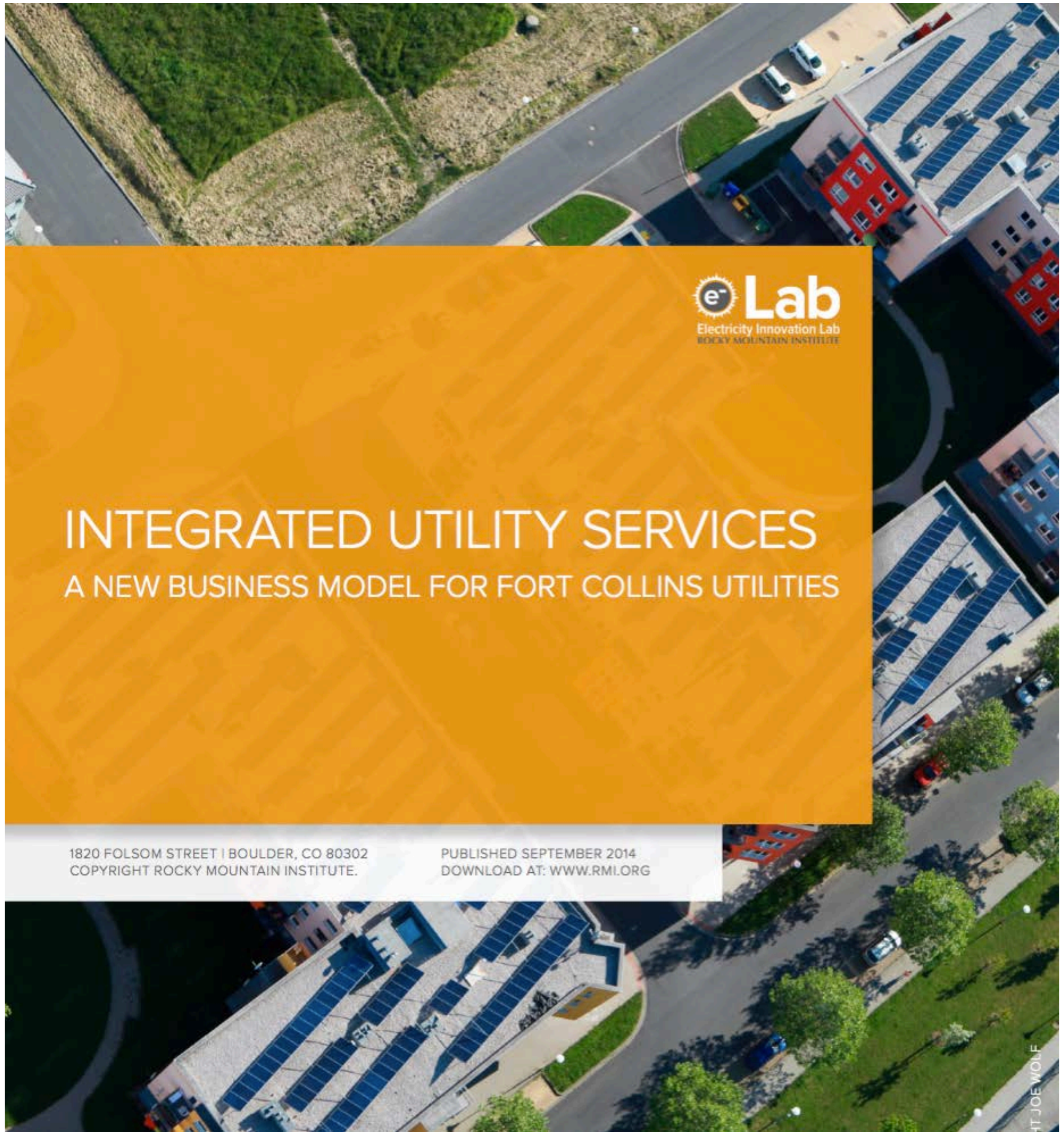


- Zero Energy District concept.
- Municipal utility overseen by city council.
- Climate Action Plan has aggressive goals for carbon reduction.

“[local companies] were able to modify their technologies, they work on control systems, platforms for software, they were able to develop their next generation platform based on some of the outcomes of RDSI phase one study. [...] The city had a tremendous amount of PR out of it. So that part was very successful, however it was very hard to convey to the public. It was very engineering-focused, very technical.”

City of Fort Collins Representative, Interview, November 2015

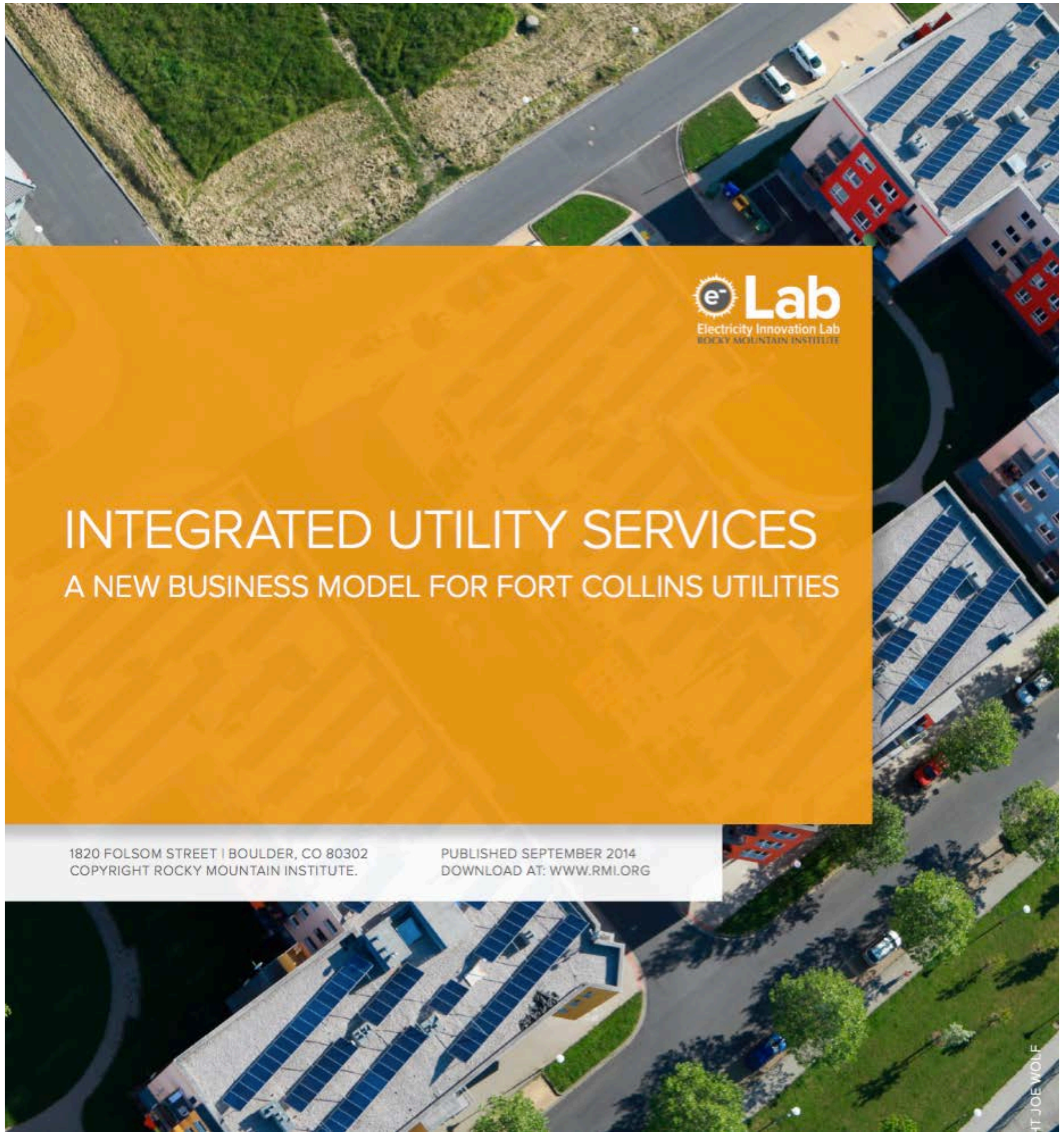
Fort Collins Testbed



Fort Collins Testbed

“the pilot will provide a model for other utilities and cities around the nation interested in providing clean, reliable electricity to their customers while stabilizing their own utility business models.”

RMI, 2014.



Mobilities: key findings

- Context still matters for the way policies move and get implemented.
  - Oak Park replication and transmission, but failed to materialize.
  - FortZED is an example of policy mutation, and local and national impacts.
- Policy ideas and models may fail to materialize in “actually existing” projects.
- Even singular non-governmental actors are important influencers.
- Sociotechnical systems change, and specifically urban energy transitions, needs to better account for learning, referencing, and mobility (not just construction) of knowledge.

Mobilities: key findings

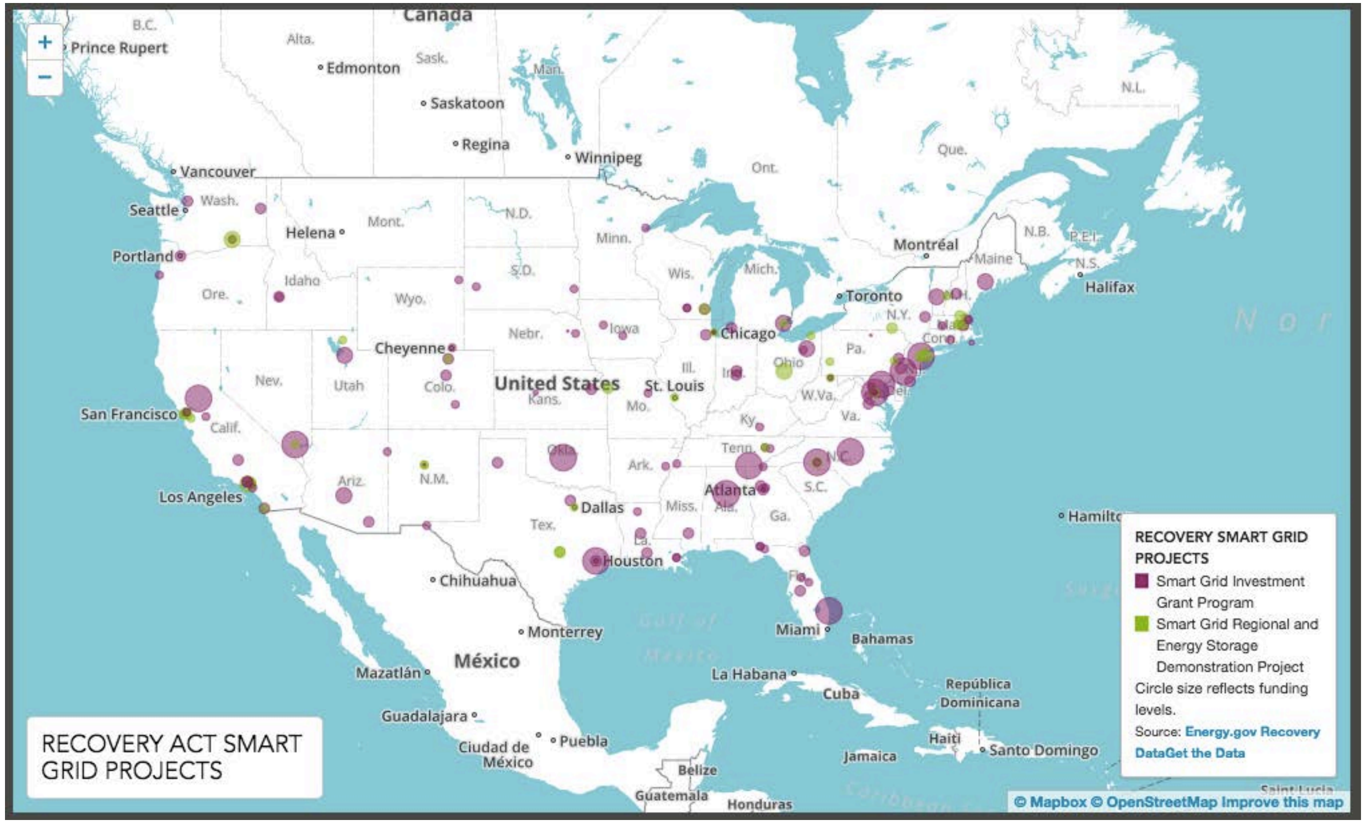
- Context still matters for the way policies move and get implemented.
  - Oak Park replication and transmission, but failed to materialize.
  - FortZED is an example of policy mutation, and local and national impacts.
- Policy ideas and models may fail to materialize in “actually existing” projects.
- Even singular non-governmental actors are important influencers.
- Sociotechnical systems change, and specifically urban energy transitions, needs to better account for learning, referencing, and mobility (not just construction) of knowledge.

Thank you!

anthonylevenda@gmail.com
alevenda@asu.edu
amlevenda.com
@amlevenda

Limitations

- Geography.
- Cost.
- Time.
- Breadth and depth of discourse.



Policy/Technology Transfer Issues

- Policy moves from one place to another.
  - But this is political and shapes (and is shaped by) the city of implementation.
- Technology is developed in laboratory an implemented into a market.
  - But requires testing, and especially with “consumer” oriented tech, testing in real-world contexts where user experiences are shaped by typical conditions.

CHECK PRICES. SHIFT USAGE. REDUCE ELECTRICITY BILL.

We’re always happy to exchange information with people. It really helps that we are a non-profit. ... I talk to cities, I talk to for-profit companies, you know. We meet with them and they say, what have you learned, and I’ll be happy to tell the for-profit company that is trying to build a product that this is what we’ve learned, this is what’s failed, and this is what’s succeeded. **You know... we’re happy to show off our work, even though our work is in beta, and you would think that like oh we shouldn’t show off our secrets before... but I’m happy to say like look, this is the cool stuff we are making right now. ... my job is to make sure we can get as much data as possible to give to people so they can utilize it and learn from it.**

Pecan Street representative, Interview, October 2015

Governing by experiment?

- **Policy experiments**
  - Especially as cities attempt to respond to climate change.
  - We see this in the context of “eco-state restructuring” around logics of carbon-control and re-scaling of political authority of state and non-state actors
- **Niches (ST transitions)/demonstrations**
  - Protected spaces for testing technologies and influencing regime change
- **Living laboratories or test-beds?**
  - **Using the city as a space to test out sociotechnical interventions in the “real-world”**
  - Produce an exemplar that is repeatable and reproducible

Why the (smart) city?

- The city might best be seen as an ideological project, a concept that mediates everyday experience, and one that profoundly influences social imaginaries and visions of urban futures that help structure and legitimate particular forms of social and political order.
- City as a laboratory for conducting experiments and generating new knowledge about how urbanization processes can best be managed for sustainable, resilient, just outcomes.
- The smart, super instrumented city for data collection, analysis, and “improved” decision-making

Governing by experiment?

- **Policy experiments**
  - Especially as cities attempt to respond to climate change.
  - We see this in the context of “eco-state restructuring” around logics of carbon-control and re-scaling of political authority of state and non-state actors
- **Niches (ST transitions)/demonstrations**
  - Protected spaces for testing technologies and influencing regime change
- **Living laboratories or test-beds?**
  - **Using the city as a space to test out sociotechnical interventions in the “real-world”**
  - Produce an exemplar that is repeatable and reproducible

Governing by experiment: beyond institutions towards governmentalities

- Situated in and enacted through a heterogenous network of artefacts, practices, knowledge, etc.
- Foucault posited that power was about “governing the forms of self-government, structuring and shaping **the field of possible action of subjects”** (Lemke, 2002: 50), or in other words, the “conduct of conduct”
- The living lab concept not only provides structured spaces of intervention (for governance) but also for producing knowledge that circulates to create new norms, techniques, and practices

Governing through “smart” subjects

- Smart grid experiments reconfigure, or suggest a reconfiguration, of consumer – utility relationships
  - From passive to active consumer
  - Rational actors, decision makers, economizers
- Neoliberalism is a form of governmentality that subjects all aspects of social and political spheres to an economic rationality
  - People manage their households as an “enterprise” endlessly improving conditions and economizing functions
- Although these smart grid experiments assume these interventions will work, appealing to economic rationality, they do not consider the context of demand (social practice approach)

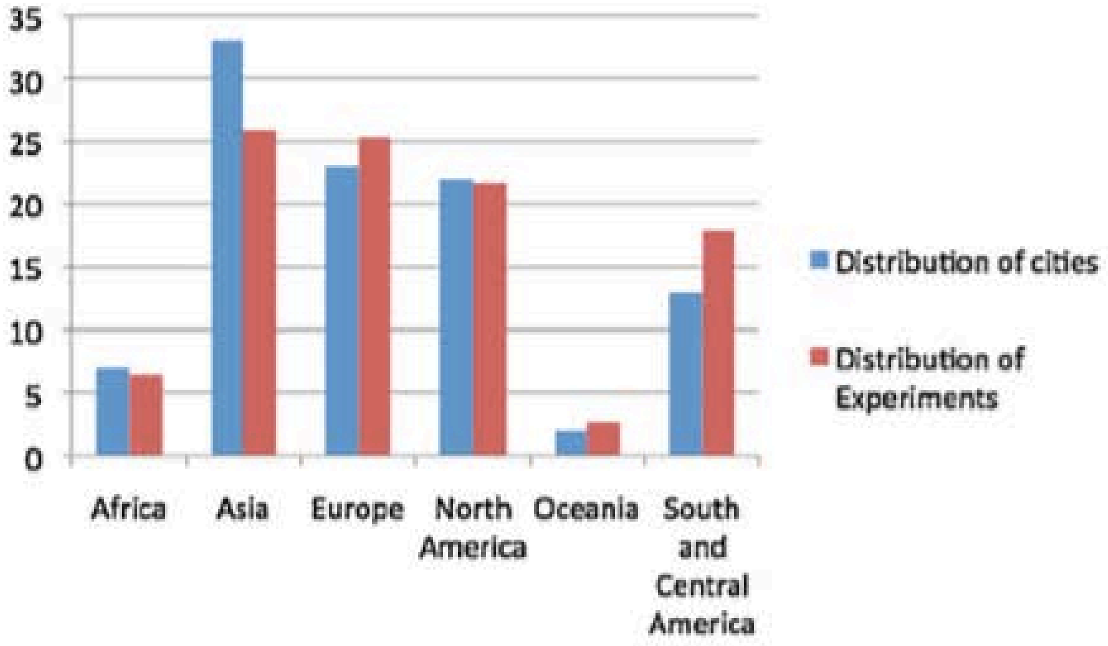


Fig. 1. Comparison of the frequency distribution of cities and experiments in different world regions.

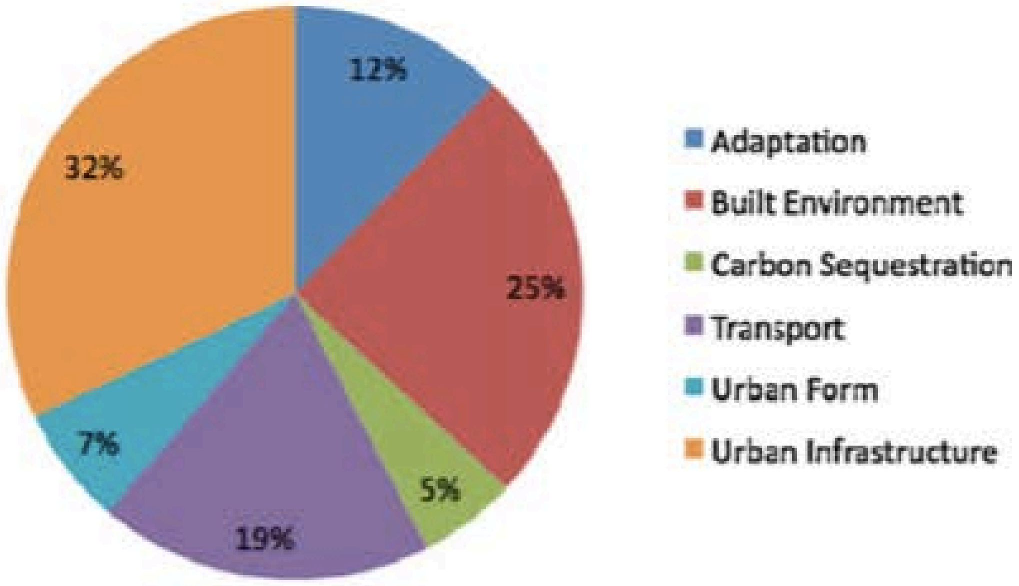


Fig. 2. Distribution of experiments in sectors.

V. Castán Broto, H. Bulkeley / Global Environmental Change 23 (2013) 92–102 97

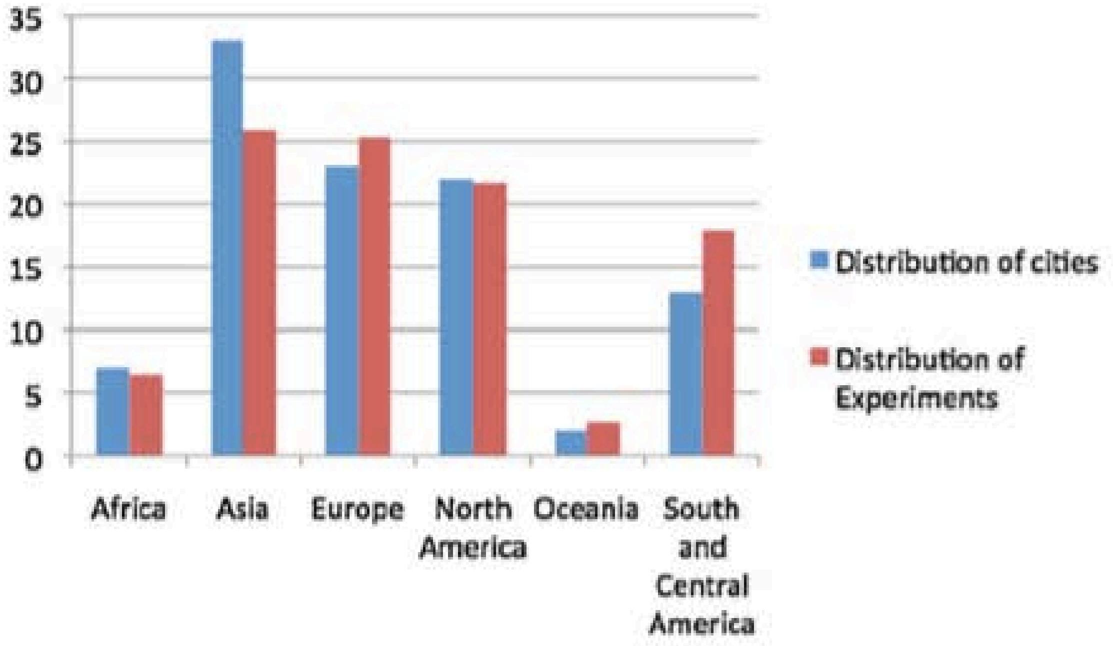


Fig. 1. Comparison of the frequency distribution of cities and experiments in different world regions.

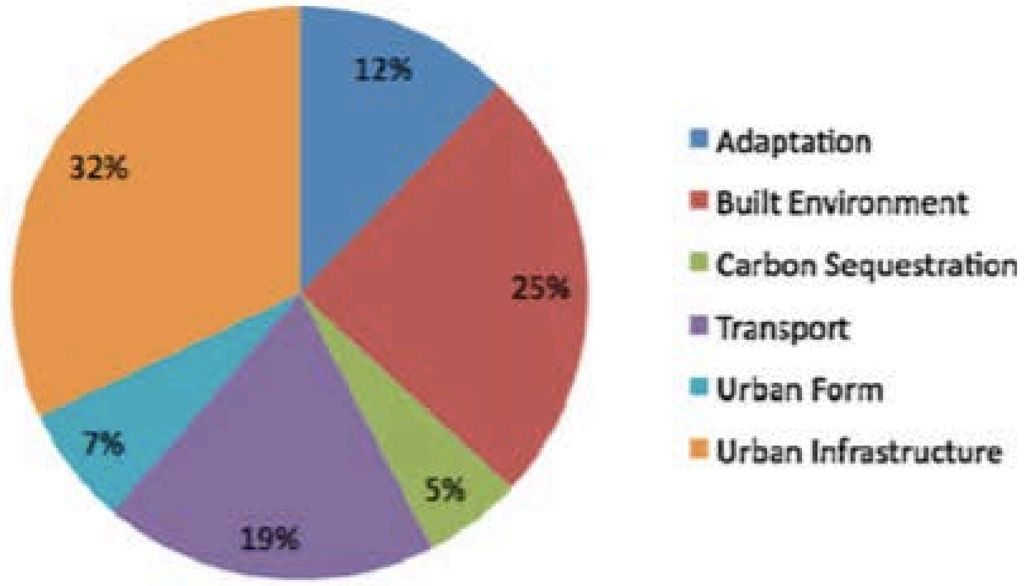


Fig. 2. Distribution of experiments in sectors.

“purposive and strategic but explicitly seek to capture new forms of **learning or experience**... they are interventions to try out new ideas and methods in the context of future uncertainties serving to understand how interventions **work in practice**, in new contexts where they are thought of as innovative” (Castán Broto & Bulkeley, 2013: 93). --- Castán Broto and Bulkeley (2013)

Main Argument: Mobile Experiments

- Urban experimentation, while contingent and limited, represents an important point for the production of knowledge by providing a “point of reference” to which other cities utilize in their work.
- This ”point of reference” gets mobilized and mutated, but reinforces a regime of governance that embeds particular governmental logics, rationalities, and imagined subjects in mobile policies, expertise, and associated knowledge.