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A path to a renewable energy system: A financing and regulatory model

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A Path to a Renewable Energy System A Financing and Regulatory Model

Edward (Ed) Kelly

A Graduate Thesis Submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

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Table of Contents

Acknowledgements	ii
Table of Contents	iii
List of Tables and Graphs	vi
List of Figures	vii
Abstract	viii
I Introduction	1
A Original Energy	8
II Current Energy System	9
III Hegemony and Resource Wars	11
IV Future Energy	13
A Kondratiev Long-wave Theory	14
B Schumpeter	16
C Energy Change	17
D Centralized & Decentralized Power Production	19
E Wind Energy	20
F Solar Energy	23
G Smart Grid	25
H Vehicle to Grid (V2G)	26
I Exchanging Power	27
J Community Based Energy Development and Microgrids	28
V Benefits of a Renewable Economy	33
A CO2 Reduction and Climate Change	33
B National Security	35
C Wealth Transfer	36

D Economic Revitalization	37
E Water usage and Conservation	39
VI Barriers to Adoption and Implementation of a Renewable Path	40
Problem Statement	40
A Cost	40
B Storage.....	41
C Public Acceptance and Awareness.....	42
D Vested Interests	43
VII Public Policy.....	44
A Choice Awareness Theory	44
B Induced Innovation.....	45
C Dynamic Efficiency.....	46
D History and Results	48
E Incentivizing Private Investment.....	48
1 Renewable Energy production Tax credits (PTC)	49
2 Feed-in Tariffs (FIT)	53
F National.....	58
1 Smart Grid.....	59
2 Incentives	60
3 Regulatory	60
4 Mortgage Based Financing	61
5 Netmetering.....	66
G States	67
1 Renewable Portfolio Standards	67

2	Feed-In-Tariffs	69
3	Incentives	71
4	Regulatory	72
5	Solar Leases	73
6	Solar Power Purchase Agreements	74
H	Local Policy	78
1	Local or Municipal Ownership	78
2	Property Assessed Clean Energy (PACE).....	79
3	Building, Zoning, Homeowner Associations and Utility Co Requirements	81
VIII	Conclusions and Observations	83
	Acronyms	87
	Appendix A.....	87
	Appendix B	87
	Bibliography	88

List of Tables and Graphs

Table 1: Companies with Solar Leases	71
Graph 1: Wind Power in the United States	20
Graph 2: Solar PV Existing Capacity in World	24
Graph 3: Comparison of gross revenues using export volumes for 2008 and \$75/ bbl.....	35
Graph 4: Production Tax Credit for Renewable Energy	49

List of Figures

Figure 1: <u>Reinventing Fire</u> figure shows timeline for reducing dependence on fossil fuels .9	
Figure 2: Timeline depiction of Long-waves.....14	14
Figure 3; Energy Now, TV show of wind mills in cornfields21	21
Figure 4: Map of Wind Speeds of the U.S.....22	22
Figure 5: Pictorial representation of solar array and connection to grid.....23	23
Figure 6: Exchanging Power with Smart Grid.....27	27
Figure 7: Microgrid at the Illinois Institute of Technology 29	29
Figure 8: Graphic of Microgrid, Horizon Energy30	30
Figure 9: Climate Change Graphic32	32
Figure 10: Gains from Technology Progress44	44
Figure 11: States Feed-In-Tariffs.....53	53
Figure 12: Casual Loop Diagram, Feeding the Grid Renewably.....55	55
Figure 13: Renewable Portfolio Standard Policies, States.....65	65
Figure 14: Tax Credits for Renewables, States.....68	68
Figure 15: States with Solar Leases71	71
Figure 16: Geothermal Production Salton Sea, California76	76
Figure 17: Property Assessed Clean Energy (PACE).....78	78

Abstract

As the effects of climate change become more and more evident, the necessity of transitioning to a carbon-free economy and powering our energy and transportation systems from renewables energy sources is quite evident. This transition to a renewable-based energy system will be a massive undertaking, similar to the efforts put into WWII, where the country was united with unity of purpose. Taking on the vested interests of the fossil fuel industry and all their subsidiaries will take a political will that does not exist in this country at this time. Hermann Scheer describes what he calls a social movement; he feels only this can overcome the “agency capture” of our political systems by the fossil fuel industry.

In my analysis of economic theory I concentrated on Nikolai Kondratiev’s “long-wave theory” of the capitalistic system of growth and recession, which take place over approximately a fifty year cycle. Further, I examined Joseph Schumpeter’s adaptation of Kondratiev’s theory; Schumpeter ties every wave to a new fuel source that overtakes and replaces the existing fuel source and creates a new prosperity. In the “technology wave” (which we are currently in) it is my theory that the new fuel source will be renewables: solar, wind, geothermal, tidal, etc. The American spirit of entrepreneurship, invention and innovation will move renewables along the normal diffusion curve creating this new wealth and prosperity. Using these natural forces to provide the energy to run our society will keep us in harmony with the planet. The processes used to extract our energy from the planet are destructive and must end because they cause environmental and health problems. There has been a very well-funded and effective campaign to deny the effects

of fossil fuels on our climate and it is having a very profound effect. Society's indolence on this matter is a poor choice.

The real question that needs to be asked is, while there might be the fossil fuel reserves to last the world well into the 21st century, can the environment survive this? No. We see CO2 concentration in the atmosphere rising and climate change precipitously taking place as evidenced by flooding, severe storms and other extreme weather events. The recent super storm Sandy, which has devastated parts of the east coast, exhibits this. I believe Sandy was climate change related and the climate change models have predicted these extreme events.

I argue in this thesis that current conditions: reaching "peak oil," rising CO2 emissions, maintaining American military hegemony to secure fossil fuel supplies and the enduring severe weather events, will drive our capitalist system toward restructuring itself to create a new energy system fueled by innovation, invention and entrepreneurship with the government taking on a support role for the new renewable energy system. The laggards of the old fossil fuel energy system will desperately cling to their positions, but these will eventually give way to the new wave. This will create a future where energy is produced from the earth's natural forces and not torn from the earth to be burned.

Government's role should be to provide incentives for investments in renewables through favorable legislation and regulations. A level playing field needs to be created for renewables to put them on par with fossil fuels.

“Even if you’re on the right track, you’ll get run over if you just sit there.”

-Will Rogers

I Introduction

For the United States to achieve an economy based on a renewable energy system there needs to be an entire change in the structure of its existing system, in addition to regulatory policy overhaul and changes to financial incentives and lending. Currently, fossil fuel enterprises receive preferential treatment in all these areas. Since one of the primary goals of government is to ensure that sources of energy for its citizenry are guaranteed, this is often achieved at great cost to the economy and environment. Climate change and the increase in extreme weather foreshadow a greater severity to come if the United States continues to rely on fossil fuels. Hermann Scheer¹ describes how it will require a social movement for changes necessary to rid ourselves of this reliance on fossil fuels. In this thesis I argue that for the United States to maintain its standard of living it requires a major energy supply shift to renewables, as the destruction of the environment², creating world instability³, staging resources wars⁴ and bearing the exploding costs of maintaining our military hegemony cannot and should not be sustained. Progress lies in an economy based on renewables as the energy basis of the U.S. economy instead of a carbon-based economy. I also discuss the current energy system, a model for a future energy system and the financial and government support necessary to achieve such a future system. In addition, I discuss the obstacles to this new

¹Hermann Scheer was a member of the German Bunderstag(like our congress) and the champion and creator of the Feed-in-Tariff

² Scheer, 2002, Klare, 2001

³ Stokes & Raphael, 2010

⁴ Klare, 2001

energy model, the complete hegemony of the fossil fuel interests over our political system and how the military is used to keep energy supply lines flowing, with their cost being absorbed by the nation, as multinational corporations make huge profits.

There will be a brief discussion in Section IV of the long-wave theory of economics to outline how the petrochemical/fossil fuel wave is on the decline, it is in the stage of what Michael Klare calls “extreme energies,” with higher environmental and social costs, as well as other externalities. It is my thesis that the current wave, the technology wave, will grow to embrace innovation in renewables creating a new prosperity, using a hybrid of both Joseph Schumpeter’s and Nikolai Kondratieff’s theories on long-wave. My own theory is that each of these waves is based on an energy source that came into existence and eventually replaced the then-dominant energy source, which resulted in new prosperity.

Making the transition to renewables will not be easy, as the fossil fuel industry is arguably the most powerful vested interest in the world; it has enjoyed a very privileged position for decades with subsidies, amicable regulations and government favoritism. These energy companies have substantial investments in infrastructure and equipment, along with investments amortized over decades. Some of this infrastructure and equipment can be incorporated into the new energy system, but some will become “stranded assets,” in what Schumpeter calls “Creative Destruction”.

It is my opinion that our current conditions (“peak oil,” rising CO2 emissions, military cost to secure fuel, and the severe linked to climate change) will form the dynamics for the capitalist system to restructure and create a new energy system fueled by innovation, invention and entrepreneurship with the government taking a role to support this new

system. Supporters of the present fossil fuel energy system will cling to their positions, but these will eventually yield to the new wave. Our energy will be produced from the earth's natural forces and not torn from the earth to be burned; there is no future for nuclear and fossil fuel use for energy production. The United States needs to move toward sustainable and safe sources, abandoning its reliance on military hegemony, social, geopolitical, environmental and financial costs needed to provide fossil fuels.

Some of the financial incentives need to be maintained and expanded; regulatory policy and a lending restructure to give renewables favorable treatment should be implemented.

The following steps are necessary to create this new energy model.

- Set up Permanent Feed-in-Tariffs (FIT) that provide investors a guaranteed return on equity, similar to what power plants receive to create a level playing field.
(This is discussed later in this thesis)
- Increase additional funding for energy efficient mortgages (EEM) to help homeowners include renewables in their mortgage to amortize the cost over a longer period. (This is discussed later in this thesis)
- Expedite regulatory and interstate processes for large-scale wind and solar power plants and public-private cooperation to provide a smart grid to move energy from where it is created to where needed. Also, giving renewables priority access to the grid.
- Stabilize the production tax credit (PTC) for wind and stem its inconsistency.
(This is discussed later in this thesis)
- Provide a pricing structure that reveals the actual overall cost of fossil fuels, including the health and environmental costs.

These and more will be needed to create a new renewable energy model.

The 21st Century will be about how we produce and consume energy. “A country’s ability to access energy supplies and the ways in which it uses energy crucially determine the state of its economy, its national security, and the quality and sustainability of its environment.” ⁵ In Energy Politics, Brenda Shaffer refers to “hydrocarbon man,” as if placing him on the evolutionary chain. “Hydrocarbon man” is completely dependent on assured access to fossil fuels, a finite resource. Competition for these fossil fuels will increase as countries develop and seek the “American Lifestyle” and as the population of the planet increases. Fossil fuels are created by decomposition of buried, dead plants or animals, a form of stored solar energy via photosynthesis. When burned, these carbon-based fuels produce carbon dioxide, a main cause of global warming.

Wars have been fought and will continue to break out to ensure the supply of fossil fuels. Michael Klare, in Resources Wars, outlines this very clearly. Klare also postulates a confrontation between the United States and China as the ultimate resource war. Bruce Podobnik, in Global Energy Shifts, argues that the control of oil by the allied powers led to World War II; in particular, the United States’ oil embargo of Japan led to the Japanese attack on Pearl Harbor. Further, the expenditure of vast amounts of the U.S. military budget to secure fossil fuels, and to maintain fossil fuel supply lines, is bankrupting the country. It is no longer military might that defines a country’s power but its economic might. The United States debt to maintain its military power cannot continue, as the need to secure fossil fuels propels this borrowing.

⁵ Shaffer

Michael Klare originated the concept of "extreme energy": techniques for the production of energy which share characteristics of being environmentally damaging or risky. Such as exploitation of oil sands (which is what the "Keystone XL" pipeline is for)⁶, deepwater drilling, hydraulic fracturing, mountaintop removal mining, and uranium mining; as well as the United States' multi-billion dollar quest for thermonuclear fusion. The latter is present when the Sun transmits energy to earth as solar insolation on a daily basis; it is a matter of working out the conversion mechanism to utilize this energy. "Declining hegemonic powers have overextended themselves militarily {*Iraq War*} in an effort to retain dominance over energy supply."⁷

We experience the environmental devastation that these "extreme energies" have caused and will cause as "hydrocarbon man" pursues the need to obtain fossil fuels; we will need to wean him off fossil fuels. Examples are the Deepwater Horizon oil spill in the Gulf of Mexico, where a British Petroleum drilling rig exploded and leaked vast amounts of oil into the Gulf of Mexico, contaminating the Gulf and destroying important marine habitat of the coastlines and estuaries. The long-term environmental impact of the spill has yet to be fully realized. Another example is the 1989 Exxon-Valdez tanker spill in Alaska, when the tanker collided into the coastline and emptied its contents; it spilled 260,000 to 750,000 barrels into Prince William Sound utterly devastating this area. Another case is mountaintop removal, where entire sections of Appalachian mountaintops are blown off

⁶The Keystone XL pipeline is a proposed pipeline to bring tar sands oils from Canada to deepwater ports in the Gulf of Mexico, possibly for export. It is undetermined yet what will happen to the tailings from the refining process.

There is currently a Keystone pipeline that goes to refineries in Oklahoma.

⁷ Podobnik, 2006 pg 13

to access the coal deposits, this leads to the pollution of valuable waterways. Further, uranium mining leaves entire areas of the United States contaminated with radiation, where further entry is prohibited and cleanup too costly. Due to the need for these energies and the methods employed to secure them, the nation is forced to live with this war on the environment.

When America's natural resources are discussed wind or sun are never mentioned, it is always fossil fuel. In the discussion of the use of fossil fuels and their comparison to renewables, cost always is used as the key factor. What is not ever factored into this comparison is the cost of the externalities that are involved in the use, acquisition and extraction of these fossil fuels. For the purposes of this thesis we will concentrate on the barriers to implementation of renewables and, in particular, wind, solar and national policy needed for this to happen.

The question is how we can expedite the transition to renewables? That is the next step in the evolutionary chain and what I call "Renewable Man." Renewable man would use the natural forces of the planet: wind, solar, wave, tide, geothermal and biomass to power the planet by converting them to useable energy, technologies which are being improved upon all the time. Hermann Scheer describes "Hydrocarbon Man" as "pyromaniacs," burning anything to supply the energy that is needed. This would be laughable; however, it is an accurate moniker.

What is essential is a public-private partnership to support renewable energy, with the Federal Government providing the financial incentives as well as removing jurisdiction and regulation barriers. The private sector would provide the capital, innovation, and

expertise. The prosperity created by the centuries of fossil fuel usage does not necessarily need to cease. What is required is a transition to renewables as the new energy source.

The elimination of environmental costs from use of fossil fuels and an end to the wealth transfer from acquisition of overseas sources should also be stopped. This thesis will outline federal and state policies that can be pursued to accelerate the rate of diffusion or, as Professor Vernon Ruttan called it, “Induced Innovation.”⁸

In Section II, I will briefly describe the current energy system that exists within the United States. Section III discusses the United States’ position as the reigning hegemon, along with the huge expenditures of resources necessary to maintain the fossil fuel supply. Section IV describes a future energy system and its vital components involving existing electrical infrastructure and necessary upgrades. Section V describes the benefits of a renewable energy economy. Section VI discusses the existing barriers to full implementation of a renewable energy economy. Section VII examines policies of the national, state and local governments and public-private partnerships. Section VIII presents conclusions and recommendations.

⁸ Ruttan, 2001

*“Someday you will die and
somehow something's gonna steal your carbon.” Song Lyrics-Modest Mouse*

A) Original Energy

The source of all original energy is the sun, which, on a daily basis, supplies 174 petawatts (10^{15}) in energy. “Light and heat from the sun are the basis of (almost) all life on earth. Sunlight drives plant life via photosynthesis, and animals survive by eating plants. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.”⁹ Wind power is also created by the sun’s differential heating of the planet. Sun and wind are an infinite supply of energy that will never run out and requires no transport infrastructure.

Currently, solar photovoltaic (PV) panels have a high of 18% conversion rate for solar energy. Renewables do not require the huge amount of embedded energy that is part of the fossil fuel supply chain and it is not factored into their conversion rate, currently only 37% output from the primary energy input. A Pike Research report, which reported sale of 10 gigawatts (GW) (10^9) for 2010, forecasts an increase to 19 GW by 2013, possibly as high as 26 GW. As research continues to better convert the sun’s energy, efficiencies will increase as the size of units decrease, as will the cost per watt. The microchip serves as an example of these forecasts of size and cost reductions. The Pike report also forecasts grid parity by 2013; this is when the cost of the power from renewables will equal the cost of power from all electrical providers.

⁹ Wikipedia: Energy from the Sun http://en.wikipedia.org/wiki/Solar_energy

II Current Energy System

The modern day electrical energy system is a marvel of engineering created over 130 years starting with Thomas Edison's Pearl Street Station in lower Manhattan in 1882. The current energy system is a network of power plants, transmission lines and utility distribution companies, both public and private. The transportation sector rapidly exploded with Henry Ford's 1908 production system for automobiles and the internal combustion engine. These two factors created a long period of prosperity for the United States, interrupted by periodic recessions and a long depression during the period of the late 1920s and early 1930s.

Fossil fuels enabled this growth, with increases to the standard of living. However, we have reached a point in human history where the detrimental effects of the combustion of fossil fuels and the resulting CO₂ emissions have reached a near saturation point for the earth's atmosphere. A major shift to a new energy system, based on renewable energy, is critically important. Such an energy system will require a massive undertaking, requiring all segments of society to participate. It will involve upgrading the existing transmission grid to a "smart grid" and building new transmission lines to transmit the energy from renewables throughout the nation. It is integral that we begin phasing out fossil fuels and nuclear power plants and replacing them with renewables. The use of centralized and decentralized energy generation will be covered later in this thesis. Of the predictions of the time required to achieve this transition lies in Hermann Scheer's prognosis of a three decade aggressive transition to a solar economy. Others, such as Amory Lovins and his associates at the Rocky Mountain Institute, predict a medium range of 2050. In Reinventing Fire, they present a very compelling scenario for this transition, using

wedges as will be shown in Figure 1. Fossil fuel companies, on the other hand, predict 2100, which is tantamount to never.

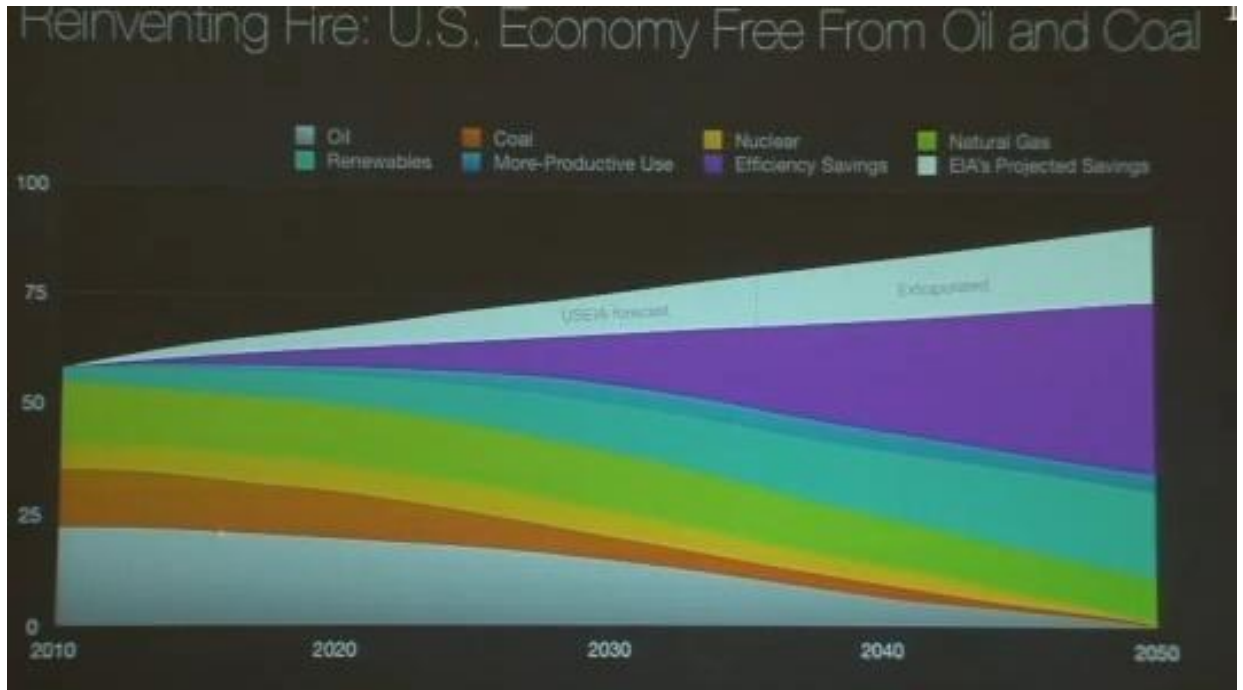


Figure 1 Source; Reinventing Fire, RMI 2012

The major factor in these predictions is, of course, the vested interest of the energy systems and the energy supply system. These would include: utility companies, multinational oil and gas companies, extraction and equipment companies, coal companies and all those involved in the transportation and processing of fossil fuels. This group also includes the military-industrial complex that secures global supply lines. These companies and organizations are possibly the strongest and best connected global vested interests, presenting a tremendous obstacle for renewables moving forward.

III Hegemony and Resource Wars

The United States became the dominant hegemon at the end of World War II, surpassing Britain. “The British and American periods of hegemony each rested upon the growth of each era’s key energy resources,”¹⁰ what resulted was a Pax Americana as the United States, with its global military and economic strength, created an era of stability.

Presently, the attempted hegemony of the United States over the necessary oil rich regions is sought through reliance on military and political power to ensure stable markets. It is essential for the United States to have a stable supply of oil to maintain its military and exert its strength worldwide.

Doug Stokes and Sam Raphael in Global Security and American Hegemony perceive the United States as a transnational state striving to maintain its hegemony over the world’s fossil fuel reserves. With increasing incidence the United States uses its military power to expand control, not only to secure fossil fuels for itself but also to maintain a stable and reliable oil and gas market for other nations. This hegemony has been readily surrendered by other nations to the United States. The United States often supports despotic regimes to keep these oil markets stable. The terms “energy security” and North America’s “vital interests” are used to justify North America’s use of force in vital regions of the world. “A school of thought becomes dominant when everyone involved regards it as so self-evident that they no longer perceive its contradictions.”¹¹

The United States’ energy appetite to maintain its industrial and military prowess requires an uninterrupted flow of fossil fuels. As such, the United States has endeavored to create

¹⁰ Podobnik pg 14

¹¹ Scheer 2012

a stable environment for transnational oil company investments. From a more Marxist viewpoint, “the US state is primarily a tool to be manipulated and utilized by the national based (i.e. American) capitalist class in order to maximize its specific economic interest at the expense of others.”¹² These resource wars have created an increased worldwide militarization with more countries seeking nuclear weapons. “A central characteristic of human history, however, is that no world order has ever been sustained in perpetuity. Instead hegemonic powers have consistently lost their technological and financial leads.”¹³ Declining hegemonic powers overextend themselves militarily to maintain their former positions; this is exhibited with the United States borrowing to maintain its military rather than investing in new energy technologies. Former U.S. Senator Alan Simpson (R-WY), of Simpson-Bowles, describes the following situation where the U.S. sends a carrier fleet into the China Sea. There is an ongoing conflict between China and Japan over ownership of some islands in this area and the U.S. has an obligation as an ally to support Japan. Simpson highlighted the absurdity of this situation, as we are likely borrowing money from China to do this. Interestingly, this scenario was also noted as a hypothetical in Michael Klare’s Resource Wars.

¹² Stokes & Raphael

¹³ Podobnik

IV Future Energy

Changing the way the nation produces and consumes energy in the future is essential. Renewable wind and solar energy is a necessary goal to pursue, both individually and nationally. There are a myriad of problems and externalities associated with the acquisition, extraction and use of fossil fuels, but they will be outside the scope of the thesis. The thesis will discuss several national public policy initiatives to facilitate the accelerated change to an energy system run by renewables. The guidelines will be specific for site electrical generation with the use of the existing electrical grid to balance excess production and/or a shortfall of electricity by a particular system. It is my thesis that working toward individual site generation is necessary due to the following.

“The housing sector consumes about one-fifth (21 percent) of all energy consumed annually in the United States. Of the 21.1 quadrillion BTUs (quads) used in the residential sector, less than one-third (6.5 quads) is ‘primary’ energy that is consumed in the home. The remaining energy is used to produce electricity or is lost in transmission. As a result of these losses, while housing consumes only one-fifth of all energy used, it uses 37 percent of all electricity produced in the United States.”¹⁴

Thus, site generation is the most efficient system for delivering electrical energy to homeowners or businesses, without the inherent losses from conversion of one form of energy to another; for example, converting fossil fuel to electrical energy with losses due to transmission. Also discussed will be the utility scale generation from both wind and solar to replace fossil-fuel power plants, as well as the national policies necessary to achieve this.

¹⁴ http://www.eia.gov/totalenergy/data/annual/pdf/sec2_3.pdf

A) Kondratiev Long-Wave Theory

In the 1930's Russian economist, Nikolai Kondratiev described long-wave theory. The basis of this theory is that the capitalist economy moves in a series of long-waves from depression to recovery (see Fig 2). When Kondratiev examines the data, he theorizes there are long cycles averaging 50 years. In his article, "The Long-waves In Economic Life," translated from Russian appearing in *The Review of Economics and Statistics*, he states: "During the recession of the long-wave, an especially large number of important discoveries and inventions in the techniques of production and communication are made, which, however, are usually applied on a large scale only at the beginning of the next big upswing."¹⁵ Carlota Perez¹⁶ points out that Kondratiev does not conclude that innovation is the engine for the next long cycle. Kondratiev is more concerned with his theory of the long cycle and their role in a capitalist economy. Therefore, it was left for other researchers to connect his theory to innovation. Kondratiev postulates that even though inventions are made, the economic conditions for their use need to be present. These innovations and inventions will come into action when there is an upswing in the economy but Kondratiev does not credit the innovations as the impetus for the upswing.

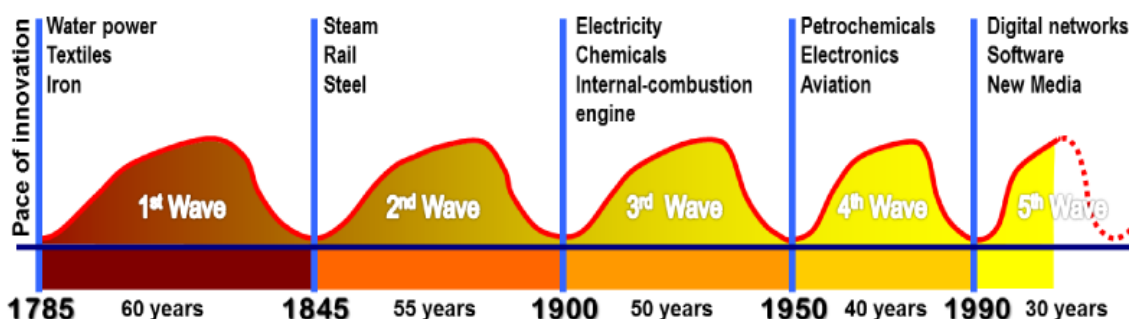


Figure 2 Source: Adapted from The Economist, February 20, 1999.

¹⁵ Kondratiev pg 111

¹⁶ Carlota Perez pg 2

Long-wave cycles of technological innovation and economic growth are closely connected and can be displayed within the concept of cycles or waves. Each wave represents a diffusion phase of technological innovations, creating entirely new economic sectors, thus creating opportunities for investment and growth. Since the beginning of the industrial revolution in the late 18th century, five waves have been identified:

- **1st wave (1785-1845).** Leaned on innovations such as water power, textiles and iron. The beginning of the industrial revolution in England was mainly focusing on simple commodities such as clothes and tools. The conventional maritime technology relying on sail ships was perfected, supporting the creation large colonial/trading empires, namely by Great Britain, France, the Netherlands, and Spain. Significant inland waterway systems were also constructed. The costs of production and transportation were significantly reduced.
- **2nd wave (1845-1900).** Involved the massive application of coal as a source of energy, mainly through the steam engine. This induced the development of rail transport systems, opening new markets and giving access to a wider array of resources. The steamship had a similar impact for maritime transportation and permitted expanded commercial opportunities in global trade.
- **3rd wave (1900-1950).** Electrification was a major economic change as it permitted the usage of a variety of machines and appliances. This permitted the development of urban transit systems (subways and tramways). Another significant improvement was the internal combustion engine, around which the whole automotive industry was created and permitted the motorization of mobility.

- **4th wave (1950-1990).** The post World War II period represented significant industrial changes such as plastics (petrochemicals) and electronics (television). The jet engine expanded the aviation industry towards the mass market and mobility could be realized globally.
- **5th wave (1990-2020?).** The current wave mainly relies on information systems, which have tremendously modified the transactional environment with new methods of communication and more efficient management of production and distribution systems (logistics). This spawned new industries, mainly computer manufacturing and software programming, but, more recently, e-commerce as information processing converged with telecommunications.

B) Schumpeter

Joseph Schumpeter, a Harvard economist, expanded on Kondratiev's long-wave theory. For Schumpeter, unlike Kondratiev, innovation was the impetus for the cyclical wave behavior, and these innovations caused the wave to increase. I subscribe to this theory. However, there was also a new energy source that enhanced this new wave with some of the innovation occurring as a result of this source. Further, these innovations were tied to new uses of the new energy source. Schumpeter also extols the importance of entrepreneurs who provide the leadership and, sometimes, the necessary funding for the innovation to prosper.

Schumpeter borrows from economist Karl Marx and his concept of *creative destruction*, using it to "describe a process in which the old ways of doing things are endogenously

destroyed and replaced by new ways.”¹⁷ Schumpeter believes that innovation is the critical element for economic change. The crucial role of the entrepreneur is “creative destruction,” with them acting as the agents of change within our capitalist system. Schumpeter sees capitalism as a form of economic and industrial change.

C) Energy Change

As shown, the United States is in the fifth wave, the technology wave. As with all previous waves, there was a dominant energy system replaced by a new energy system. Therefore, the current fossil-fuel energy system will be replaced by renewables in this process of creative destruction. What is being argued are these two main issues: 1) can renewables supply all the energy needs of the world? 2) Over what time period will this take place? John Clark quotes Alastair Buchan: “developments in the use of energy....have shaped the course of modern history more than other forms of technological change.”¹⁸ As we see in Figure 2 (pg 15), each wave has a dominant form of energy, but in the technology wave, this is not shown. As the petrochemical wave moves towards its decline, it descends into a trough, where, according to Kondratiev, the new innovation occurs.

In this wave NASA invented the photovoltaic (PV) panel to supply electricity in space travel. Also, the personal computer was invented and innovation began on the computer, and then the cell phone was refined to increased power with smaller batteries. The efficiency of PV cells was improved, but early in this wave, the cost of both wind and solar remains high.

¹⁷ http://en.wikipedia.org/wiki/Joseph_Schumpeter

¹⁸ John Clark, 1991

As Schumpeter had predicted, the entrepreneurs (Apple and Microsoft) quickly created nearly monopolistic markets with huge profits, but, according to Schumpeter's theory, this will not be maintained for long as other entrepreneurs enter this very profitable market.

Due to their high initial cost, wind and solar are still behind. They are, however, becoming more competitive. Energy disasters are occurring more frequently; Deepwater Horizon, Fukushima Daiichi, gas line explosions, etc, and the solution is renewables. Schumpeter's creative destruction will occur in this technology wave as the present economic order of fossil-fuel capitalism is replaced by a new form of energy production, with great prosperity as a result of this change. Resource wars will no longer be necessary; great wealth transfers to nations opposed to U.S. interests will not be required, and neither will the environmental destruction and death to secure these fossil fuels. "Capitalism then, is by nature a form or method of economic change and not only ever is but never can be stationary."¹⁹ U.S. energy can be home-based by using the natural forces of the planet. These energy sources are infinite and with minimal cost, and could be considered a "public good" because their use by anyone cannot be restricted. The only costs involved are the initial costs of conversion equipment: such as wind turbines and PV panels, as well as periodic maintenance.

¹⁹ Schumpeter 1942

D) Centralized & Decentralized Power Production

Centralized power production is what exists in the United States at present. Power is produced at large central power plants using some form of fossil fuel or nuclear to create electrical power. This power is then distributed through a series of transmission lines that comprise the electrical system infrastructure. Unfortunately, most of these large power plants burn fossil fuels which contributes large amounts of CO₂ emission, not to mention problems associated with nuclear waste and storage. Decentralized power production or site generation is a method favored by both Amory Lovins of the Rocky Mountain Institute (RMI) and the late Hermann Scheer of the German Bundestag and champion of the German “Renewable Resource Energy Act (EEG).”²⁰ Both argued that locally produced power by renewables is necessary for several reasons.

- CO₂ reduction
- Eliminates losses due to energy conversion and transmission which amount to 2/3 of the original energy input
- Ends large scale blackouts when certain components are damaged or fail.

Both authors present a case for complete transition to a renewable energy system. Scheer in Energy Autonomy projects a transition by 2040 and Lovins, in Reinventing Fire, by 2050.

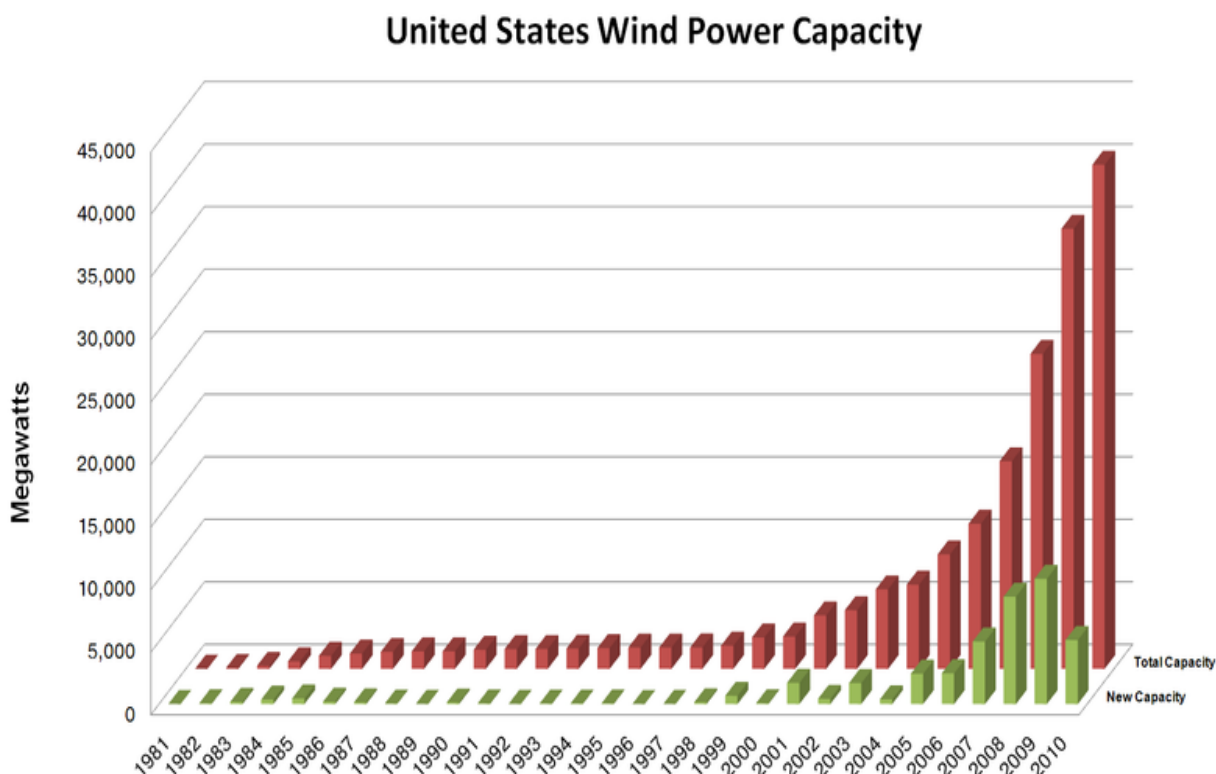
I propose both centralized and decentralized production. While I agree with Scheer and Lovins on the need for decentralized power production, there is also the need for large-scale renewable generation as will be discussed later in this thesis. Large scale solar in

²⁰ The EEG led to the introduction of Feed-in-Tariffs(FIT) discussed later in this paper

the Mojave Desert and wind in the Dakotas and Midwest are needed to produce power generation to replace our current fossil fuel and nuclear power sources. These would be coupled with a national smart grid to balance the power production necessary to create the energy system of the future. The smart grid will be discussed later in this thesis.

E) Wind Energy

The biggest problem facing wind energy is its intermittency. It generally blows strongest at night when demand is lowest. The problem of intermittency can be overcome with storage of its power in various forms, which will be discussed later in this thesis. The benefits of switching to wind energy to supply the nation's power are many. For example, it can revive the economy by increasing jobs in manufacturing and construction, as most wind turbines cannot be imported due to size and construction. These jobs can be allocated to our returning military members, as this group has the skills and ability to install these turbines and a smart grid, such as work team cohesion and the ability to overcome any obstacle such as difficult terrain, etc.



Graph 1 United States Wind Capacity, Source: American Wind Energy Association, 2011

Driven by state renewable energy targets, fourteen states have installed over 1,000 MW of wind capacity, and a total of 37 states now have installed at least some utility-scale wind power. Much of the new wind power capacity is being built in the Great Plains and Midwest regions of the United States, which have a favorable combination of characteristics: ample wind resources, an extensive rail and highway network for shipping outsized turbine components, flat topography which both improves the wind and makes turbine components easier to ship, and broad acceptance from local farmers and ranchers. New development in some locations, however, is being limited by lack of additional capacity to transmit power to locations where it can be used.²¹

²¹ Texas Will Spend Billions On Transmission of Wind Power

http://www.washingtonpost.com/wp-dyn/content/article/2008/07/17/AR2008071702549_pf.html
<http://new.rmi.org/rfelectricityexecutivesummary>

Featured on an *Energy Now* TV show on November 12, 2011, was a story on a Chandler, Minnesota wind farm. This wind farm was located on a windswept farm in cornfields on leased land. The turbines were very compatible with this environment. This wind farm provided power to the local community as well as taxes totaling \$800,000 per year; it also provided \$500,000 per year for leases.²²



Figure 3:Source Energy Now: Blowing in the Wind

As we can see from this video on “Powering the Grid,” these wind turbines can be adequately spaced in these cornfields, occupying minimal area but getting the distance required. It is almost like we are growing energy, which can actually take advantage of the compatible locations where there are the wind resources.

²² <http://www.energynow.com/video/2011/11/11/energy-answers-blowing-wind-11122011>

Utility-Scale Land-Based 80-Meter Wind Maps

The U.S. Department of Energy provides an 80-meter (m) height, high-resolution wind resource map for the United States with links to state wind maps. States, utilities, and wind energy developers use utility-scale wind resource maps to locate and quantify the wind resource, identifying potentially windy sites within a fairly large region and determining a potential site's economic and technical viability.

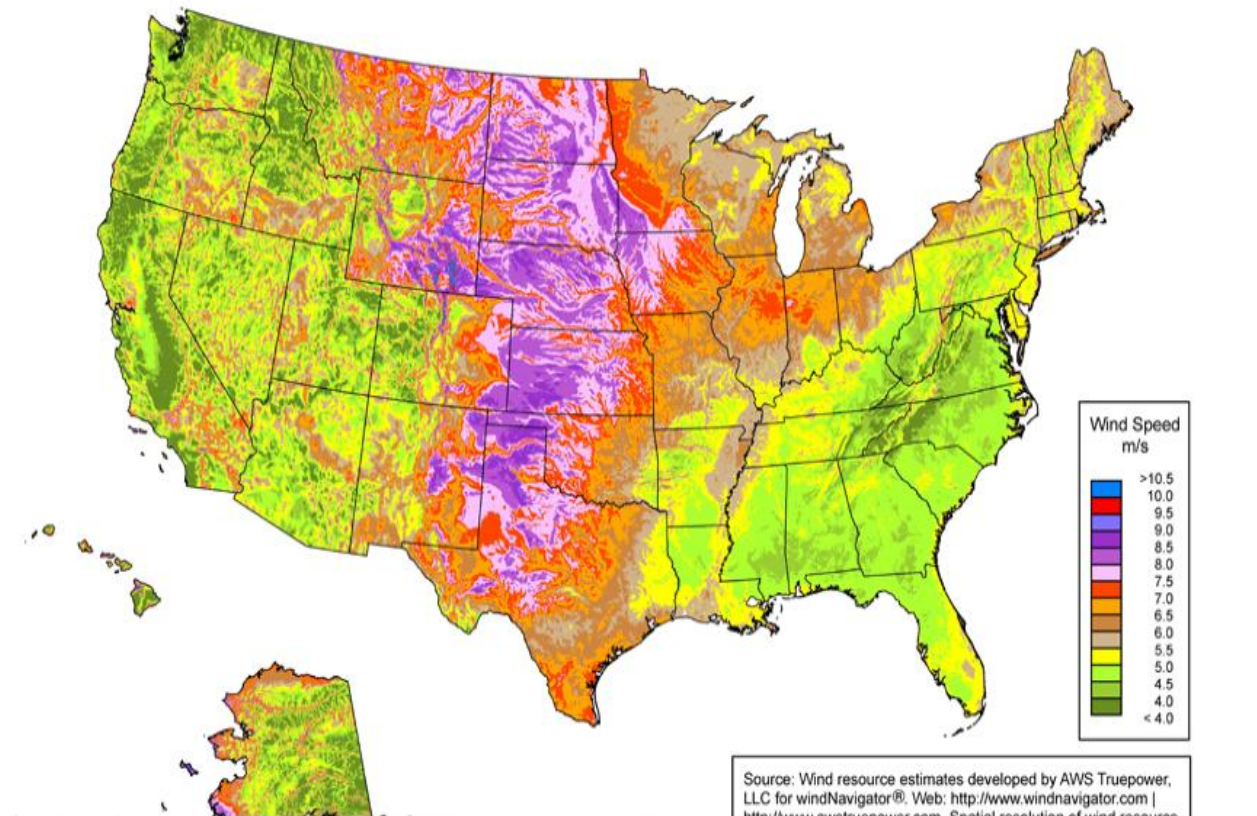


Figure 4: Wind Map Source: U.S. Department of Energy

F) Solar Energy

The sun is the original source of most energy and supplies ample solar energy on a daily basis. There is an unlimited amount of solar energy that the planet receives, much more than is needed for the planet to meet all its energy needs. The sun, by a process of thermonuclear fusion, creates energy that is transmitted to the earth in the form of sunlight. This solar energy cannot be depleted; it simply requires converting this solar insolation to usable energy. Photovoltaic cells are assembled into panels and are used in a direct conversion process to change the solar energy to electrical energy. Currently the

panels have a high conversion rate of 18%. This is expected to improve steadily as we move along our diffusion curve.

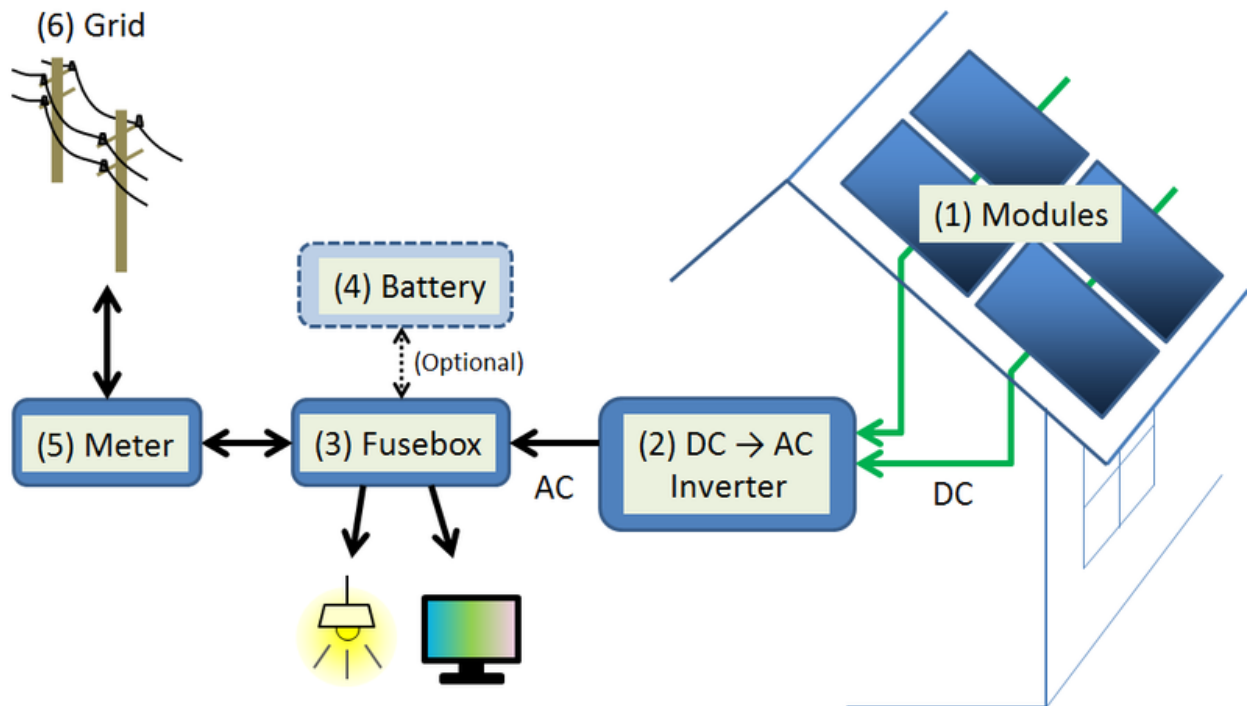
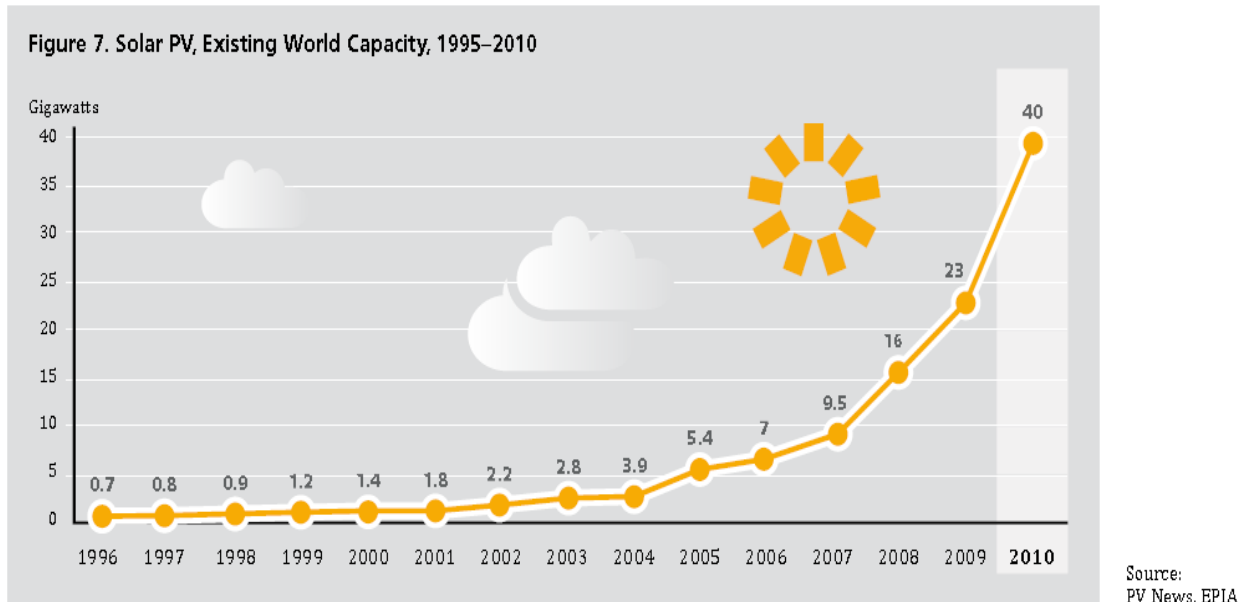


Figure 5: Source: ECO Homes

The exponential growth shown in graph 2 below is a good indicator. However, public policy changes are needed to expedite this increase in capacity.



Graph 2 Installed Solar Source : PV News

G) Smart Grid

“A Smart Grid is a form of highly-efficient intelligent electricity network that allows interactivity (two-way communications) between suppliers and consumers by utilizing information technology in electricity production, transmission, distribution and consumption.”²³ In the long term, the Smart Grid is anticipated to bring the degree of change that the Internet has brought to our way of life.

If we are to reduce our carbon footprint and stake a claim to global environmental leadership then clean, renewable sources of energy must be integrated into the nation’s grid. However, without appropriate enabling technologies linking these to the grid, their potential will not be fully realized. The electric industry is poised to make the transformation from a centralized, producer-controlled network to one that is less

²³ A Study Using a Monte Carlo Method of the Optimal Configuration of a Distribution Network in Terms of Power Loss Sensing

Hyun Ho Moon ¹, Jong Joo Lee ², Sang Yule Choi ³, Jae Sang Cha ⁴, Jang Mook Kang ⁵,

centralized and more consumer-interactive. “Our century-old power grid is the largest interconnected machine on Earth, so massively complex and inextricably linked to human involvement and endeavor that it has alternately (and appropriately) been called an ecosystem. It consists of more than 9,200 electric generating units with more than 1,000,000 megawatts of generating capacity connected to more than 300,000 miles of transmission lines.”²⁴

H) Vehicle to Grid (V2G)

The vehicle to grid concept has existed for decades but only recently has it been the subject of more extensive research on its actual operation. Electric vehicle battery storage can be used in several ways:

- To take the excess energy that is produced at night when the demand is low.
- To supply power back to the grid when the demand is high, as all these vehicles can be used as back-up storage.
- To run a household or business for a period of time when the grid is down, as hybrids can actually be run as a generator using whatever fuel they have.

The use of these electric vehicles will grow due to the development of batteries that are smaller, more powerful and more cost-efficient. This progression has been seen in microchips, mobile phones, and computers. This demand-side generation can be used to replace power from older fossil-fuel power plants that are being phased out. This would

²⁴ U.S Department of Energy: Smart Grid An Introduction http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf

require a national smart grid to digitally control the supply and demand. IBM is currently working on a 500-mile battery that can eliminate “range anxiety,” which is currently a major detriment to the adoption of electric vehicles. In addition, there has been an introduction of stations at many locations to recharge these vehicles.

I) Exchanging Power

Below is a possible illustration of the generation and distribution of a future national electrical system that is interconnected on a macro and micro scale. The homeowner has an individual generation system, whether wind or solar, which can power their home and charge their electric vehicle (EV). Any excess power is fed back into the smart grid for distribution. If the homeowner has a power shortfall, it can pull power from the grid. If the grid is down, it can pull power from their electric vehicle to supply their home for a period of time. Or if the grid has a shortfall, it can pull power off the stored electrical that all the connected EVs supply. Smart systems must be in place so the EV does not get completely discharged.

With the introduction of electric cars on a large scale, for the first time the power grid would also have significant battery storage capacity attached to it. If the wind is blowing and the sun is shining, the power generated by these alternate fuel sources could for the first time be stored in hundreds of thousands of batteries.²⁵

²⁵ http://www.ibm.com/smarterplanet/us/en/smart_grid/article/electric_cars.html

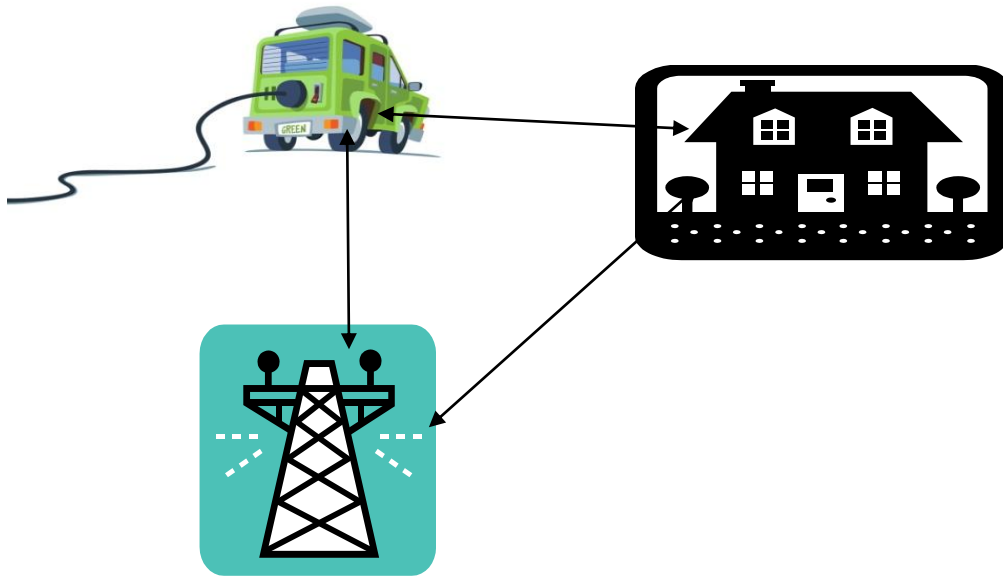


Figure 6: Exchanging Power with Smart Grid, Source: Ed Kelly

J) Community Based Energy Development and Microgrids

Community based energy development (C-bed) is a term describing small- scale community development projects to service the needs of the community while utilizing the connection to existing power grids. Local ownership of renewable energy projects is an effort to keep the resources within the community. The earlier example of Chandler, Minnesota outlined the benefits that accrued to the local governments and the farmers leasing the land for wind turbines. Also significant as an incentive is the pride of the local citizens in helping reduce CO₂ emissions. However, there are still many financial and regulatory barriers to these types of installation. Government programs need to be established to provide loans to finance these systems or to guarantee investors' security. Feed-in-Tariffs (FIT) are a good way to deal with the regulatory hurdles that make these projects difficult. FIT give the C-bed connections to the grid and set a rate for power sent back to the grid.

Another example is a multifamily project in Ithaca, New York called Ecovillage, which is a community of 30 energy efficient townhouses.²⁶ These are examples of decentralized power production. Microgrids store excess power on site for later use, but are also connected to the grid. Rogers, Simmons, et al; 2008, shows that community involvement in decentralized community-based energy development projects increases public acceptances of the project.²⁷ Also, c-beds reduce the chances of large-scale blackouts for prolonged period that are common with large centralized power plants. The one ingredient that was necessary in these types of projects was experts helping with planning and implementation.

Microgrids

A microgrid is a form of distributed power or decentralized energy generation. A microgrid can supply power to a small complex or community. The benefits of a microgrid are reliability and lower generation and transmission losses. For institutions such as hospitals and servers these can be a good solution to the need for continuous power. “Microgrids have been identified as a key component of the smart grid in order to improve system energy efficiency and reliability and to provide the possibility of grid-independence to individual end-user sites.”²⁸ Figures 7 and 8 show some arrangements. A renewable energy power source storage system and the microgrid need to be grid-tied to handle fluctuations in energy production. The reliability of a microgrid is exhibited when

²⁶ For further information see Home Power magazine issue 149 June & July 2012

²⁷ Rogers, J.C., Simmons E.A., Convery I., Weatherall A.: Public Perceptions of Opportunities for Community-based Renewable Energy Projects; *Energy Policy*, Nov. 2008

²⁸ Office of Electricity Delivery and Energy Reliability Smart Grid R&D Program: DOE Microgrid Workshop Report August 30-31, 2011 San Diego,

the main grid goes down, and the microgrid automatically disconnects and keeps generating power, and, if needed, pulls energy from the energy-storage systems. If the power outage is lengthy, a backup generator can be used. Smart systems will need to be built into the microgrid to perform these integral functions. Microgrids will be a key component of decentralized power and the Smart Grid. Microgrids differ from C-Beds; C-Beds do not have energy storage and are mostly for residential communities.



Figure 7 Microgrid: Source Milwaukee Journal Sentinel 2012-07-30

A ZBB Energy Corp. energy storage system has been installed and commissioned in Chicago as part of a microgrid demonstration project. The Illinois Institute of Technology and the U.S. Department of Energy are collaborating on a \$12 million project that aims to provide a template for micro grids at universities, military bases and business parks. The

microgrid is designed to keep electricity flowing during periods of power outages that affect the regional grid. In future phases the project aims to help manage power flow from intermittent sources of generation like solar power.

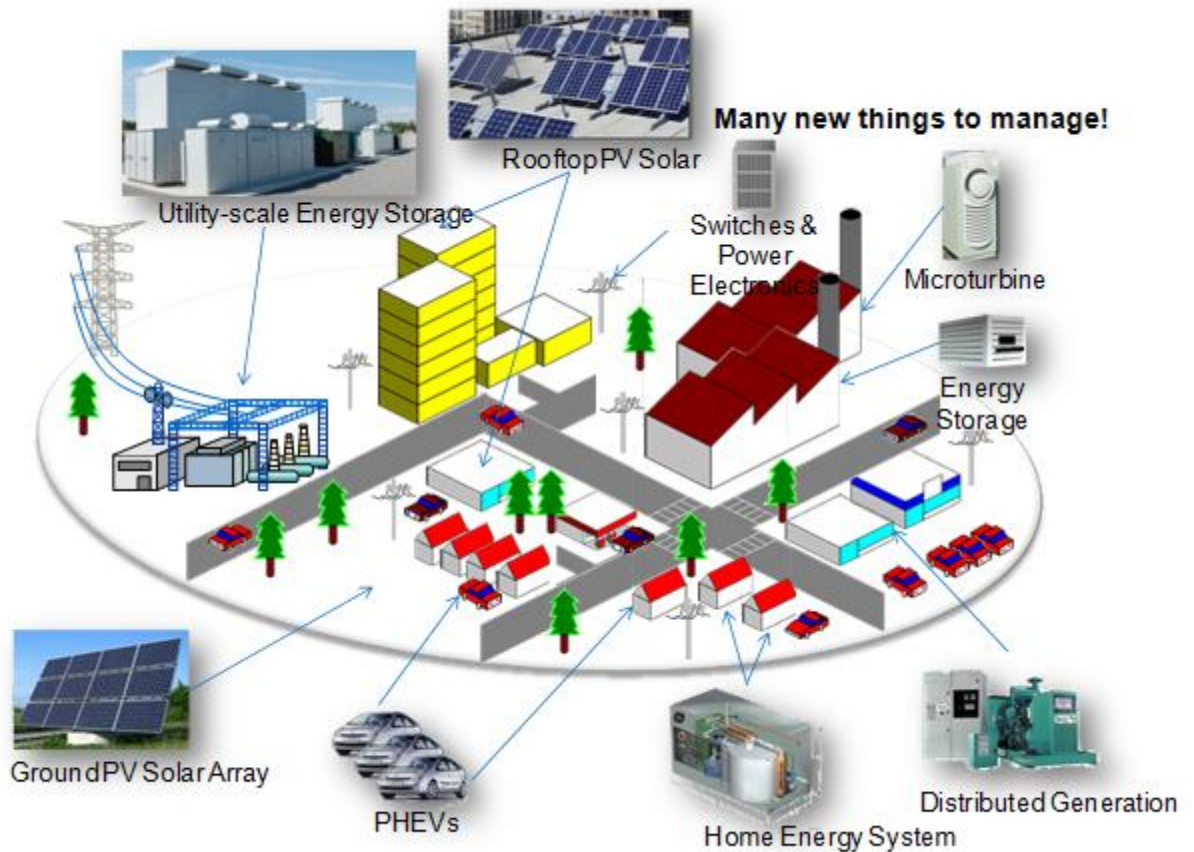


Figure 8: Microgrid Source, Horizon Energy

Horizon Microgrid Solutions

Horizon is working with a Southern California utility to build the first community microgrid in the nation. This \$18M project is co-funded by the utility, the U.S. Department of Energy, the California Energy Commission, and Horizon Energy Group. It is a 4.5MW peak demand community of 500 customers (residential, commercial, and agricultural) with much solar photovoltaic, heavy irrigation, and 120°F summer heat. Results will be:

- 15-20% reduction in the annual electric bill
- Smaller total emissions footprint (including CO₂)
- Improved reliability (less outages and shorter durations of outages)
- Deep penetration of renewable resources enabling commercial businesses to achieve LEED certification
- Solid return on investment (payback in less than 5 years)

V Benefits of a Renewable Economy

A) CO2 Reduction and Climate Change

As we see the early stages of climate change evidenced by increased extreme weather events, transitioning to a renewable energy system and eliminating the CO2 from fossil fuel are imperative. “An overwhelming body of scientific evidence now clearly indicates that climate change is a serious and urgent issue. The earth’s climate is rapidly changing, mainly as a result of increases in greenhouse gases caused by human activities.”²⁹

Renewable energies can reduce and eventually eliminate these greenhouse gases, but it will take time for the environment to recover. Thus, a renewable transition is urgent.

There is a very well-funded campaign of disinformation about climate change. This campaign decreased public opinion from a belief of climate change from 64% to 50%, shown on the PBS Frontline documentary, Climate of Doubt: “Today, the scientists studying climate change, the most unbiased of all parties involved, are being attacked on all sides by right-wing organization.”³⁰ Climate change deniers are well placed politically and financially. Take Senator James Inhofe (R) Oklahoma for example who is the ranking member of the U.S. Senate Committee on Environment and Public Works. Before 2008 he was the Chairman of this committee. In a 2003 Senate speech, Inhofe stated, “I have offered compelling evidence that catastrophic global warming is a hoax. That conclusion is supported by the painstaking work of the nation's top climate scientists.”³¹ Dr. Kenneth Shockley, an Associate Professor at the University of Buffalo, takes a strong stance against people such as Inhofe. ” Those who support or propagate the

²⁹ Stern pg 3

³⁰ Climate of Doubt, PBS Frontline

³¹ Wikipedia: Jim Inhofe; http://en.wikipedia.org/wiki/Jim_Inhofe

disinformation campaign about climate change are guilty of more than deception. They are guilty of exacerbating risks to our collective well-being and of undermining society.”³²

As the federal government has been unable to make even minor efforts to reduce climate change, hope shifts to the states to introduce measures to assist in the transition to renewables. A thorough discussion of these measures is included in Section VII: State Public Policy.

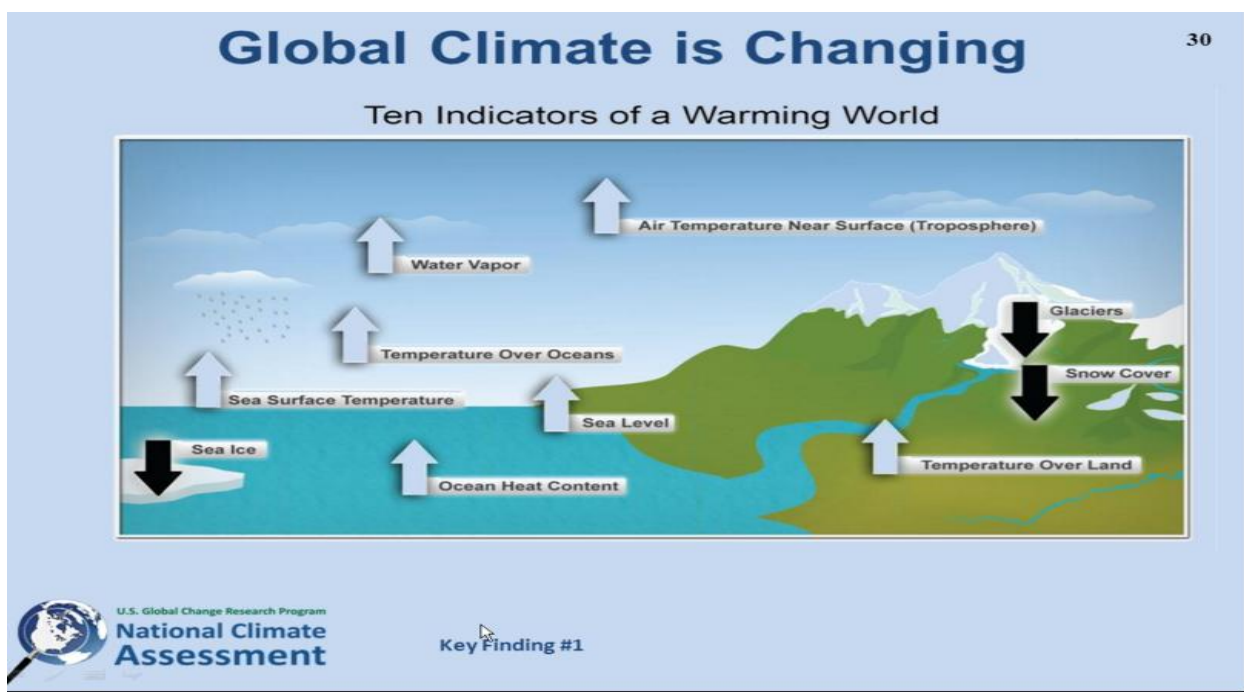


Figure 9 Global Climate, Source National Climate Assessment

³² Blog: Disinformation, Social Stability and Moral Outrage; <http://rockblogs.psu.edu/climate/>

B) National Security

The dependence on fossil fuel is a major threat to our national security. “The United States is spending approximately \$1 billion a day overseas on oil instead of investing the funds at home, where our economy sorely needs it. Burning oil that exacerbates global warming also poses serious threats to our national security and the world’s security.”³³ Lefton and Weiss note that the United States spends \$1 billion a day on overseas oil and in 2008 imported \$150 billion from “dangerous and unstable” countries. These vast expenditures could be used to ensure a more secure and stable energy future if invested in renewables, this conclusion is crystal clear. This funding of our enemies is definitely a cause for concern. The fragility of the economy to the flow of oil is a dangerous situation as evidenced by the oil shocks of 1973 & 79. The recent threat by Iran to block the Strait of Hormuz and stop the flow of oil from the Persian Gulf is another example. Could the United States survive for even three days without this overseas oil?

Has America lost its spirit to do big things? Surely a change to a new energy system would be a big thing. Have special interests so entrapped our political system that the government lacks motivation to transition to a different energy system? We saw massive industrial mobilization during World War II that was the key to our victory. The current danger is not as absolute as WWII but is still extremely threatening.

At a Defense Department conference Joint Chief of Staff Admiral Mike Mullen states;

When we find reliable and renewable sources of energy, we will see benefit to our infrastructure, our environment, our bottom line ... and I believe most of all ... our people. And the benefits from “sustainability” won’t just apply to the military. Rising sea levels could lead to mass migration and displacement similar to what we have seen in Pakistan’s flood ... and climate shifts could drastically reduce the

³³ Lefton & Weiss

arable land needed to feed a burgeoning population as we have seen in Africa. This scarcity of – and potential competition for – resources like water, food, and space – compounded by an influx of refugees if coastal lands are lost ... could not only create a humanitarian crisis, but create conditions of hopelessness that could lead to failed states³⁴

The obstructionism and the agency capture of the fossil fuel interests will take much to overcome, as Hermann Scheer describes, a social movement, but this movement has been somewhat disarmed by a very effective disinformation campaign on climate change. This ethos cannot last; as people witness the effects of climate change the impacts can no longer be ignored.

C) Wealth Transfer

As outlined in the previous section, there are large sums of money being transferred from the United States to other countries with no economic upside to America. The loss of this wealth weakens our economic position, as dependence on oil only grows and makes us vulnerable to oil shocks. At \$70/bbl., this amounts to approximately \$1,000,000,000/year.³⁵

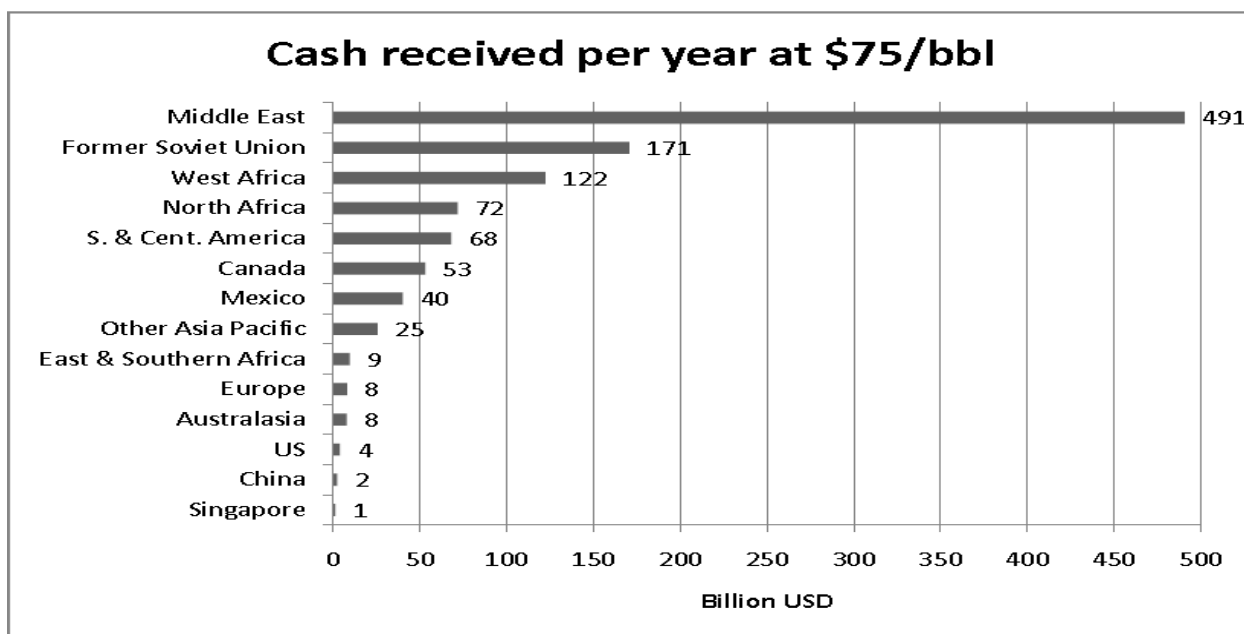
In common with many other environmental problems, human-induced climate change is at its most basic level an externality. Those who produce the greenhouse-gas emission and bring about climate change, thereby imposing costs on the world and on future generations, but they do face directly neither via markets nor in other ways, the full consequences of the costs of their actions³⁶

While fossil fuel companies are enjoying huge profits, environmental and health costs are transferred to our nation as the hidden costs of these externalities.

³⁴ Geoff Dabelko

³⁵ RSK[UK]LIMITED 3

³⁶ Stern 27



Graph 3 Comparison of gross revenues using export volumes for 2008 and \$75/ bbl.
Source BP,2009³⁷

Renewables would correct this huge wealth transfer and help reduce trade imbalances.

D) Economic Revitalization

America has used its world hegemony to maintain a supply of fossil fuels, specifically low-cost oil, which has provided the basis of economic growth for centuries. With the use of military or political power over countries, the United States has maintained its prosperity by striving for stability in the fossil fuel markets. However the nation has reached a point, because of climate change and wealth transfer, where a shift to an economy based on renewables is vital.

It is quite apparent that retaining wealth within the country and relying on its talent for innovation and engineering can ensure a transition to a revitalized economic model. The

³⁷ British Petroleum, 2009

nation's energy agenda should be creating new wealth and providing for new jobs that will accompany this revitalization. Joseph Schumpeter's expansion of Nikolai Kondratiev's *long-wave theory*³⁸ indicates that the latest wave, "The Technology Wave," follows all previous waves and is based on an energy source that came into existence and eventually replaced the then dominant energy source, creating a new prosperity within society.

The process of technological change and innovation involves the interaction of a few key variables: inventions, innovations, diffusion and investments. Merely the introduction of new technologies is not enough; the technologies must be accompanied by all of these variables. The adoption of renewables is dependent on a supporting infrastructure, power companies, government investment and incentives and private investment. Internet giants such as Google are using their economic clout of \$5 billion to back an East Coast transmission line between Virginia and New Jersey to connect offshore wind farms; this would eliminate the need for each separate wind farms to connect to land.³⁹ Google's investment should encourage additional investment by other entities to interconnect with this transmission, spreading the cost of creating infrastructure. These types of investments create what Schumpeter termed the "bandwagon effect" of firms joining a technological shift once certain elements are in place.

³⁸ Nikolai Kondratiev, a Russian economist, came up with long-wave theory back in the 1930s. The basics of it are that the capitalist economy moves in a series of long-waves from depression to recovery.

³⁹ http://www.masslive.com/business-news/index.ssf/2012/05/underwater_transmission_line_planned_for.html

E) Water Usage and Conservation

Excessive water usage and contamination or degradation by processes to secure “extreme energies” must cease. Hydrologic fracturing, which require vast volumes of water in the process, has been connected with groundwater contamination, mountaintop removal mining which contaminate streams and runoff, nuclear power requires that huge volumes of water for cooling and discharges these waters at high temperatures into the surrounding water systems are all examples of this. The Deepwater Horizon disaster has contaminated a vital estuary area in the Gulf of Mexico, with little indication of how intense these long-term effects on the US food supply will be. Transitioning to renewables will eliminate such environmental damage to this essential resource. Water is essential to life and the demands of population growth and diminishing safe resources make water more valuable than oil.

VI Barriers to Adoption and Implementation of a Renewable Path

Problem Statement

There are four (4) major obstacles that will need to be overcome or tempered in order to create the market-pull to create greater adoption of the renewable technologies and create the economy of scale to reduce price and increase affordability. As adoption of these renewable technologies increases, so will standardization and acceptance, coupled with the price increases for fossil fuel electrical production. The challenge is in creating the market-pull through financing incentives and other measures. It is important to note that it is not the innovation that is keeping renewables from progressing into the market place.

A) Cost

Arguments based upon cost comparison are not valid due to two factors: 1) the environmental and social costs are never factored into the comparison between renewables and fossil fuel and nuclear energies. 2) As we continue down the road of conventional energy these sources will be more costly and storage of nuclear waste and the fears of proliferation will only magnify.

Fossil fuel and nuclear power production have both environmental and social costs. For example, the use of our air and water to process or dispose of their waste products or the acceptance by the government for the disposal and storage of nuclear wastes and their accepting the liability of a nuclear accident. "In the first 25 years, the direct economic damage to Belarus, Ukraine and Russia has exceeded \$500 billion."⁴⁰

⁴⁰ *DemocracyNow.org*, 26 April 2011

Cost is a substantial barrier to the diffusion and adoption of renewables. The initial cost of a wind turbine or solar array for an individual homeowner is in the area of \$35,000 and this money needs to be paid up front, even with the federal tax incentive of 30%, this is still a substantial investment. It amount to paying 30 years of utility bills at once. It is the structuring of the costs of implementation, not the costs of the resources themselves.

Lenders have insufficient knowledge of renewables and do not understand their nature and intrinsic value. In my discussions with lenders about mortgaged based financing, they were unaware of any of the financial incentives available or how to equate appraisal values on these systems. I will explore various financial vehicles available later in this paper and some future possibilities. Solar leases are currently available from four companies; all of these will be discussed in length as well.

B) Storage

Storage is a significant problem for renewables and this barrier will need to be overcome to make renewables viable. Power from renewables is only produced when the wind blows or the sun shines. I will go through various strategies that are in process to deal with this issue and give the response that is needed to power our electrical system.

- 1) Batteries: as these become more developed and are able to retain more power, they can be used to balance power when demand increases. Presently, they only have a short duration and it takes large banks of them to have a significant impact.
 - 2) Pumped Hydro is a method that has been used in Nuclear power plants when there is excess energy. Water is pumped back to an uphill storage by this excess power
-

at wind or solar power plants. The water is then released when the demand increases or at times when the renewable is not generating sufficient power.

- 3) Compressed Air: this condition involves the use of underground caverns or old mineshafts. When there is excess energy production it is used to compress air or turn a flywheel as a means of energy storage. This stored energy is then released when demand increases.
- 4) Hydrogen: this method uses the excess energy from renewables to perform electrolysis on water to separate the hydrogen. Then this would be stored on site to be used later in either a fuel cell or generator to produce electrical power when demand increases. The combustion of the hydrogen releases no CO₂.
- 5) Electric Car Batteries: as the growth of electric vehicles (EV) increase, their batteries storage capabilities increase. These EVs can be used to store the excess renewable energy production and tap into it during production shortfalls (see the discussion earlier in this paper).

C) Public Acceptance & Awareness

Since the information flow on renewables is controlled by the energy industry, Hermann Scheer calls an “intellectual monopoly,” the public has very limited access to accurate information on renewables. What is meant by the term “intellectual monopoly” is that the energy companies become the experts that control the assessment of renewables and their feasibility. Putting energy companies in this position is the equivalent to the old adage of the fox guarding the chicken coop. It is against energy companies self interests to move for renewables that would replace their existing infrastructure as they have substantial investments in fossil fuel and nuclear power plants. So the public gets misinformation

such as the claims like renewables are great for the future (2100) and that renewables are too expensive at this time; all of these untrue. This situation perfectly highlights Henrik Lund's *Choice Awareness Theory*, which will be covered further on in this paper. So the public awareness and its acceptance of renewables is slanted and biased by the energy companies' undue influence on the information flow.

D) Vested Interests

The energy companies, which include all multinationals of oil, extraction, transportation and energy producers and suppliers, could possibly be the strongest group of vested interests in our nation. Governments are set up to give preferential treatment to these companies and provide them with tax incentives and regulatory barriers protecting their supply chains, etc. In trying to change the current energy system to one based upon renewables is a massive undertaking considering the resources and power that these vested interests wield. Hermann Scheer believes that a social movement to overcome the "agency capture" of our political system will be a Herculean task. Does the United States really have the political will for such an undertaking? I sure hope so.

VII Public Policy

A) Choice Awareness Theory

Henrik Lund submits in Renewable Energy Systems: the Choice and Modeling of 100% Renewable Solutions the concept of *Choice Awareness Theory*. *Choice Awareness Theory* represent two theses: “The first states that when society defines and wishes to implement objectives implying radical technological change, existing organizations will often seek to create the perception that the radical change is not an option and that society has *no choice* but to implement a solution involving the technologies that will save and constitute existing positions. (2) The second thesis argues that in such situations, society will benefit from focusing on Choice Awareness-that is, raising that alternatives *do* exist and that it is possible to make a choice.”⁴¹

A perfect example of this would be the current discussions over the Keystone XL pipeline. The arguments for this are that it will create much needed jobs and provide the energy independence from foreign oil. There is currently an existing Keystone pipeline that goes to the middle of the country. The new keystone would go to the deep water ports on the gulf coast, with the ability to export oil throughout the world. The jobs created would be temporary with no provision that the oil produced remains in the United States. The resources that are expended for this could be applied to harnessing the renewables from North Dakota, while creating more jobs and revenues to benefit to the

⁴¹ Henrik Lund: Renewable Energy Systems: The Choice and Modeling of 100% Renewable Solutions

United States. As opposed to the pipeline, harnessing these renewables could create true energy independence.

Hermann Scheer's "intellectual monopoly" is omnipresent in these decisions. Where the energy companies base appropriate decisions upon whether renewables are viable, with their exclusive judgments and decrees treated as unimpeachable and sacrosanct. These companies say that a rapid transformation to renewables is impossible. Therefore, we must take our time to do this, preserving their control over our political systems as well as over our energy systems. The energy companies keep the process of change under their control; their huge investments in fossil fuel infrastructure are spread out over decades, displaying a perfect example of Lund's first thesis.

B) Induced Innovation

The tax incentives of the Production Tax Credit (PTC) are a good example of government incentives to promote development of renewable energy, similar to those provided for fossil fuel production. While PTC only offers a 2.2 cents per KWH, that coupled with the 30% tax credit coming from the federal government and other incentives from various states provide the incentive for investors. Such incentives are sufficient to spur investors support these endeavors. Vernon Ruttan writes in his paper "The Role of the Public Sector in Technology Development: Generalizations from General Purpose Technologies":

If renewable sources of primary energy are to become widely adopted over the next quarter century, it seems clear that sustained public support will be required (Grubb, 1993; World Energy Council, 1994:48-52) (Table 13.1). The limited commercial success that renewable sources such as biomass, wind, solar-thermal, and photovoltaic have achieved has largely been due to the limited public support for research and development of these technologies and to changes in regulatory

regimes. At present, photovoltaics appear to have the greatest potential for commercial viability.

Ruttan goes on further to cite other sources:

A number of potential benefits not captured by conventional project investment criteria have been advanced in favor of renewable energy sources. These include (1) reduced air pollution, (2) abatement of global warming, (3) diversity of fuel supply, (4) reduction in the risks of nuclear proliferation, (5) restoration of degraded lands, and (6) contribution to decentralized regional development (Johansson et al., 1993:4). If electricity based on renewable resources is preferred because of these environmental and related benefits, the policy interventions required will include (1) reduction or removal of subsidies to artificially lower the costs of fossil and nuclear fuels, (2) design of policy instruments that ensure that environmental and other external costs are more adequately reflected in energy prices, and (3) stronger public support for research and demonstration of renewable energy technologies.” As of the late 1990s support for such policy intervention in most major industrial countries had declined compared to a decade earlier” (Dooley, 1998).

C) Dynamic Efficiency

“Dynamic efficiency is a term in economics, which refers to an economy that appropriately balances short run concerns (static efficiency) with concerns in the long run (focusing on encouraging research and development). Through dynamic efficiency, such an economy is able to further improve efficiency over time.”⁴² Therefore, dynamic efficiency is concerned with an optimal rate of innovation and investment to improve production processes that help reduce the long-run average costs (see Figure 4). This chart shows the additional improvement as particular incentives are applied to technology, aiding the market to create competition to reduce prices. As pointed out in Vernon Ruttan’s *Induced Innovation*, it is appropriate for government to provide such

⁴² Joseph E Stiglitz and Carl E Walsh, *Economics*

incentives.

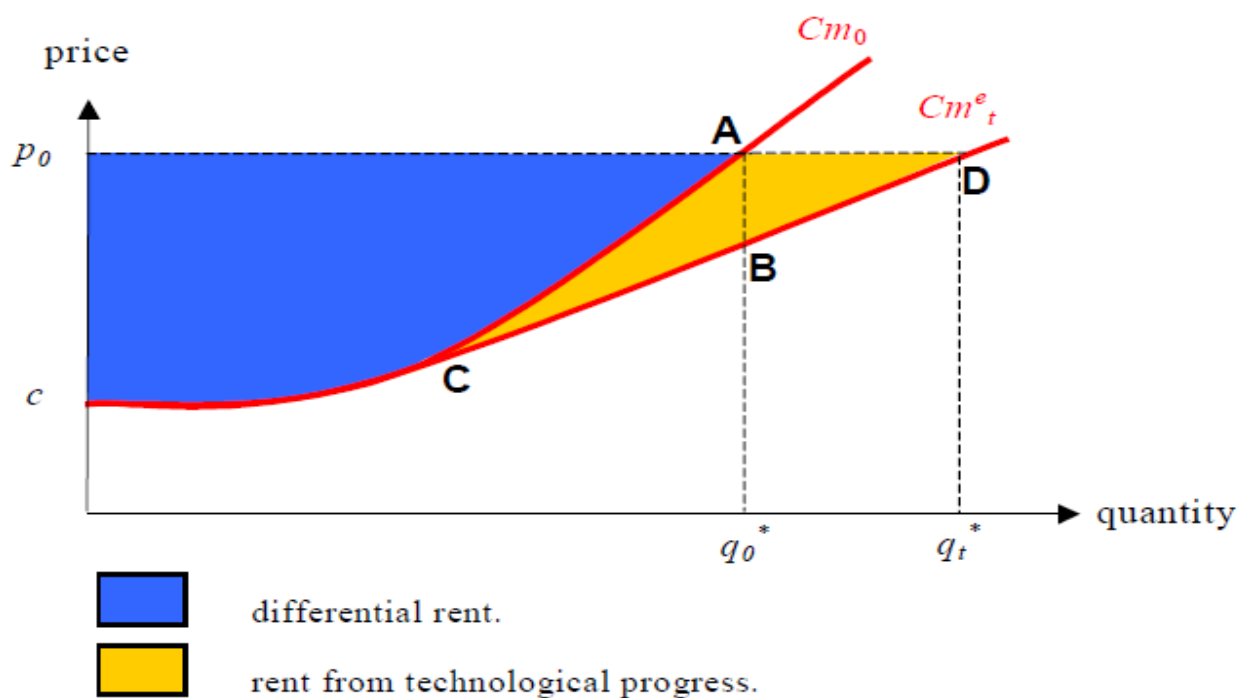


Figure 10 Gains from Technology Progress, Source Dr. Pablo Del Rio Gonzales

Dr. Pablo Del Rio Gonzales is Research Fellow at the Institute for Public Goods and Policies, and has written extensively on dynamic efficiency and Feed-In-Tariffs (FIT). Many financial institutions consider renewables to show a certain degree of risk, this trend was exacerbated by the *Solyndra* bankruptcy. The perceived risk can add to the financing costs of renewable projects, as they are highly dependent on the cost of capital. In addition, with the instability of public policy, these hurdles will undoubtedly slow the innovation and diffusion curve that dynamic efficiency seeks to create.

D) History and Results

Implementation of a national public policy that would combine public and private money to build a smart grid is needed. This smart grid would be used to move renewable energy from where it is produced to where it is needed. President Lincoln, in the midst of the Civil War, built the Transcontinental Railroad to bring goods throughout the country, creating the Industrial Age by the end of the war. President Eisenhower created the federal highway system and achieved the same results. The government's involvement in the internet led to a huge expansion and great improvements in technology. All these public-private partnerships lead to economic booms. It is this model that needs to be pursued for renewables to be paired with a smart grid.

E) Incentivizing Private Investment

Reliance on Renewable Energy Production Tax Credits (PTC) and Feed-in-Tariffs (FIT) can be used to accelerate the adoption of renewables for energy production, especially solar energy and wind power. These options have encouraged investment in utility-scale renewables. I will compare and contrast these two options and why both are a good means to reduce our dependence (and eventual elimination) on carbon-based fuels. These options could also create a job growth and expansion of the U.S. manufacturing base, following decades of contraction. "Substantial private investment is needed if public policy objectives to increase the share of renewable energy and prevent dangerous anthropogenic climate change are to be achieved."⁴³ When I examined the PTC, I viewed this as a federal tax expenditure policy, as well as the ups and downs that have occurred due to inconsistencies in this policy. The FIT, on the other hand, has to do with changes

⁴³ Wüstenhagen 2011

in federal regulation as it applies to energy production policy with regards to power plants. There are currently four states that have some form of FIT and ten where they are proposed.⁴⁴ There is no Federal level FIT at this time and in the present political climate none are expected. Former Rep. Jay Inslee (D-WA) attempted this while he was in congress but it never left committee. Jay is currently Governor of Washington state; we could see a FIT in that state.

1. Renewable Energy Production Tax Credit (PTC)

The Renewable Energy Production Tax Credit (PTC) is a tax incentive to aid in the production of energy from renewables source. The PTC is currently set to expire in December of 2012, but has been given a one year extension with the “Fiscal Cliff Bill.” PTC has been left to expire four times in the past. Due to the long range planning of wind and solar energy production facilities, this expiration has been chaotic for planning these facilities. For the United State to reduce its use of fossil fuel and its dependence on imported oil, it is necessary to have vigorous activity on the renewable front. Any long-range energy policy should completely discontinue the use of fossil fuels for producing of electrical energy.

It is a proper role of government to formulate policies to induce these innovations. In “Induced Innovation” the late Vernon Ruttan (Economics Professor, University of Minnesota) postulated this theory. “The perspective that emerges in my recent book, Technology, Growth and Development: An Induced Innovation

Perspective. . . . government has played an important role in technology development and transfer in almost every U.S. industry that has become competitive on a global scale.”

History of the Production Tax Credit (PTC)

The Energy Production Tax Credit (PTC) was originally enacted as part of the “Energy Policy Act of 1992.” There was not much activity at that time, as wind technology was beginning to develop, however, with the extensions of the “Energy Policy Act of 2005,” there has been significant increases in installed wind energy. The “American Recovery and Reinvestment Act 2009” extended the tax credit for producing electricity from wind, biomass, geothermal or solar, solid waste, and qualified hydropower facilities for three years.⁴⁵ A bill introduced into congress to extend the PTC, the “American Renewable Energy Production Tax Credit Extension Act of 2011”: H.R.3307⁴⁶ sits in committee with a very slim chance of passage with the current state of political affairs. This may change if the legislature would aid President Obama. Below are some of many articles relating to the PTC:

[Analyst: Global wind market would be affected by PTC expiration](#)

The global market for wind energy would be affected next year if the renewable-energy Production Tax Credit in the U.S. is not extended, writes columnist Gerard Wynn. Efforts to extend the PTC, which would expire on Dec. 31, have been slowed because its extension has been linked with a number of other expiring or expired tax incentives in legislation, Wynn writes. [Reuters](#)

[More utilities own wind power generation](#)

Xcel Energy's and MidAmerican Energy's business strategies on wind power shows two divergent approaches, analysts say. Xcel acquires much of its wind power from developers under multiyear contracts, while MidAmerican prefers to own almost all of its wind power capacity. About 23% of new wind capacity was utility-owned last year, up at least 5% from typical levels, said Jeff Anthony, business development director for the American Wind Energy Association. [Star Tribune \(Minneapolis-St. Paul, Minn.\)](#) (3/31

⁴⁵ Thomas.gov

⁴⁶ IBID

[Policy uncertainty could hurt Maine's wind sector, advocates say](#)

Maine's wind industry has grown to become a \$1 billion market and the biggest supplier of wind-generated power in New England, supporters said. However, the industry's growth could be undermined by the uncertainty regarding the federal renewable-energy Production Tax Credit and efforts by Gov. Paul LePage to rethink the state's wind power rules, including the so-called "expedited permitting" process. "It's not that we are going to change it. But after five years of experience, it is time to take another look at that," said Ken Fletcher, director of the governor's Office of Energy Independence and Security. [Bangor Daily News \(Maine\)](#) (free registration) (3/30)

[PTC uncertainty cited as Ind. wind project is canceled](#)

EnXco has canceled plans for a wind project in Boone County, Ind. The company cited the uncertainty over the renewable-energy Production Tax Credit as one of the reasons for the project's cancellation. EnXco also said that part of the project site intruded into a "federal beam path and Federal Aviation Administration zone" where wind turbines are not allowed. [The Indianapolis Star](#) (4/3)

[Mitsubishi will cancel planned Arkansas factory if PTC expires](#)

Mitsubishi Heavy Industries will cancel its plan to open a wind turbine factory in Arkansas if Congress doesn't renew the federal Production Tax Credit. "We need a market to operate our factory. Right now, the market is not so good. We have a site but cannot operate it," said Yoshinori Ueda, assistant general manager of MHI's wind turbine unit. "If we have the PTC, we will go ahead." [RechargeNews.com](#) (3/9)

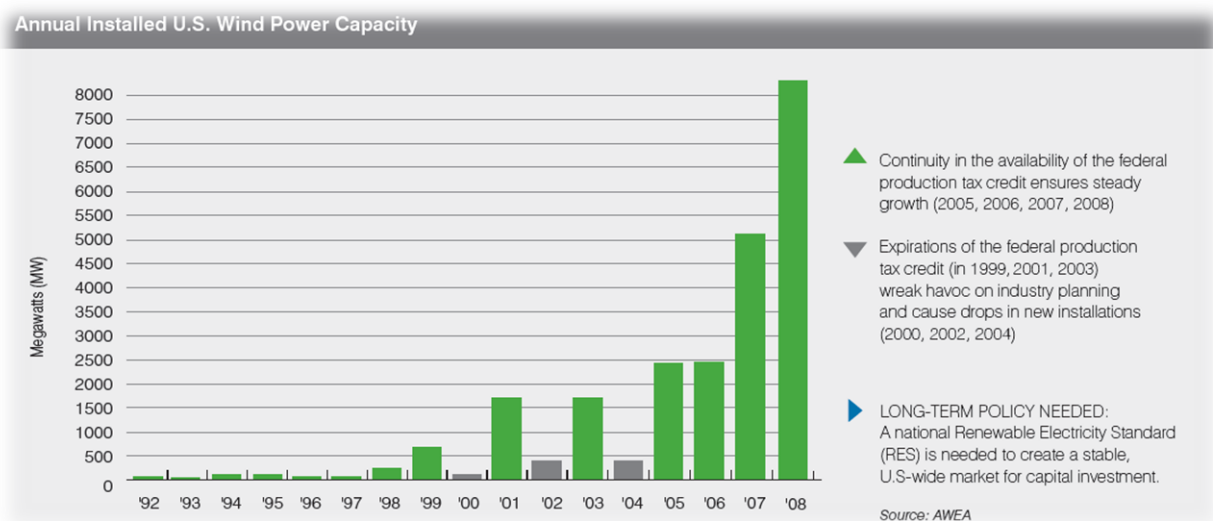
Nonetheless, the necessity for a stable future the need for this type of investment cannot be overstated. The "on-again/off-again" status of the PTC contributes to a boom-bust cycle of development that plagues the wind and solar industries. Generally, investors show risk aversion to systems that are prone to frequent and politically motivated changes. They also shy away from projects that involve long approval processes with uncertain outcomes. Due to the long planning and development cycle of renewable projects, there is a need for stability as these projects go through a myriad of

environmental reviews. The Cape Wind Project in Massachusetts took ten years for approval and still has not begun!

Short term extensions of the PTC are insufficient for sustaining the long-term growth of renewable energy. The planning and permitting process for new wind facilities can take up to two years or longer to complete. As a result, many renewable energy developers that depend on the PTC to improve a facility's cost effectiveness may hesitate to start a new project due to the uncertainty that the credit will still be available to them when the project is completed.”

Source: PTC for Renewable Energy.⁴⁷

Graph 4 reinforces this point indicated by the drop in wind power capacity when the PTC expires. Also indicated in Graph 4 is the exponential growth in installed wind power from 2005 to 2008. “Tax preferences for energy production were first established in 1916, and until 2005, they were primarily intended to stimulate domestic production of oil and natural gas.”⁴⁸ With the Energy Policy Act of 2005, tax incentives for renewable energy grew substantially.



Graph 4: Production Tax Credit for Renewable Energy,
Source: Union of Concerned Scientist

⁴⁷ Union of Concerned Scientists

⁴⁸ CBO

2. Feed-in Tariffs (FIT)

A Feed-in Tariff (FIT) is a form of financial incentive that pays the generator of renewable energy a guaranteed minimum tariff per kWh for a specified period. The payment is similar to what utility companies are paid when they build power plants. The formula is based on the cost to build the generation facility along with a reasonable profit that is set by Energy Regulators; this amount is guaranteed for a specified period of time. This is comparable to how electricity from conventional power plants has been regulated in North America for many decades, and utility regulators are familiar with the concept. These give investors the surety they need to remove the risk associated with such investments, which at times requires a large capital outlay. Policy makers need to reduce the risks associated with these types of investments. The cost of building facilities for renewable energy production lies largely in initial costs in providing the equipment. There are no future costs for the fuel to produce the energy. “The goal of feed-in tariffs is to offer cost-based compensation to renewable energy producers, providing the price certainty and long-term contracts that help finance renewable energy investments.”⁴⁹ Feed-in tariffs are simply payments per kilowatt-hour for electricity generated by a renewable resource. These are the most successful policy for the support of rapid development of significant amounts of renewable energy.

“Feed-in tariffs are used in Germany, France, and Spain and have driven these countries to world leadership in renewable energy development. In so doing, feed-in tariffs have created hundreds of thousands of new jobs in Europe

A feed-in tariff

- Allows renewable energy generators to interconnect with the grid, and
- Specifies the amount that they are paid for their electricity,

⁴⁹Wikipedia: Feed-In-Tariffs

- And specifies how long they will be paid.”⁵⁰

History of Feed-In-Tariffs

In 1990, Germany adopted "Stromeinspeisungsgesetz" (StrEG), translated as “Law on Feeding Electricity into the Grid.” Spain and Denmark soon followed with similar legislation. The German legislation passed by the *Bundestag* (equivalent to the U.S. *House of Representatives*) set the rates for renewables at 90% of retail electricity rates. However, the most important part of this legislation was that it guaranteed connection to the utility grid for producers of renewable power. The legislation did not have much effect on solar, as the price of this technology in the 90s was too high, but it did have a very positive effect on wind power, leading to one-third of the global deployment of wind power to reside in Germany.⁵¹

In 2000 Germany adopted an upgrade on the Feed-in Tariff law “German Renewable Energy Act.” The law “has proved to be the world's most effective policy framework at accelerating the deployment of renewable energy technologies.”⁵²

Germany's new feed-in tariff made a number of important changes to its previous policy:

1. First, the purchase prices were methodologically based on the cost of generation from renewable energy sources. This led to different prices for wind power, solar power, biomass and biogas sources, and geothermal energy, as well as different prices for projects of different sizes, to account for economies of scale;
2. purchase guarantees were extended for a period of 20 years;
3. utilities were now allowed to participate⁵³

⁵⁰ Primers on Feed-in Tariffs, Advanced Renewable Tariffs, & Renewable Energy Payments : retrieved from [http://www.wind-works.org/FeedLaws/PrimersonFeed inTariffsandAdvancedRenewableTariffs.html](http://www.wind-works.org/FeedLaws/PrimersonFeed%20inTariffsandAdvancedRenewableTariffs.html)

⁵¹ Wikipedia: Feed-In-Tariffs

⁵² IBID

The rates offered were designed to decline annually based on expected cost reductions, in a mechanism known as “tariff depression.” The changes in the legislation led to a slight increase in consumers’ utility bills and as the technologies become more cost effective the utility costs decreased.

United States Tariff History

In The United States the first form of Feed-in Tariff was implemented in 1978 by President Carter, in the “National Energy Act.” The purpose of the Act was to encourage energy conservation and the development of new renewable energy sources: wind, solar, geothermal, etc. While innovative, this form of incentive was hardly ever used and disappeared due to the high cost of these technologies at that time.

As mentioned, in 2009, Representative Jay Inslee (D-WA) introduced a bill to create Feed-in-Tariffs at the Federal level, to set guidelines for intergovernmental relations between the various state and federal regulatory agencies, as well as create long-term investment security for the rapid deployment of renewables. Hopefully this portends more legislation supporting FIT moving forward.

While the federal FIT currently has little chance of passage in the current congress, at the state level we see a strengthening of the RPSs. With Jay Inslee as Governor of Washington state, there is likely to be activity there. California Gov. Brown is pushing to raise their level of renewables; California is replete with wind from the Mojave Desert and sunshine.

⁵³ Wikipedia: Feed-In-Tariffs

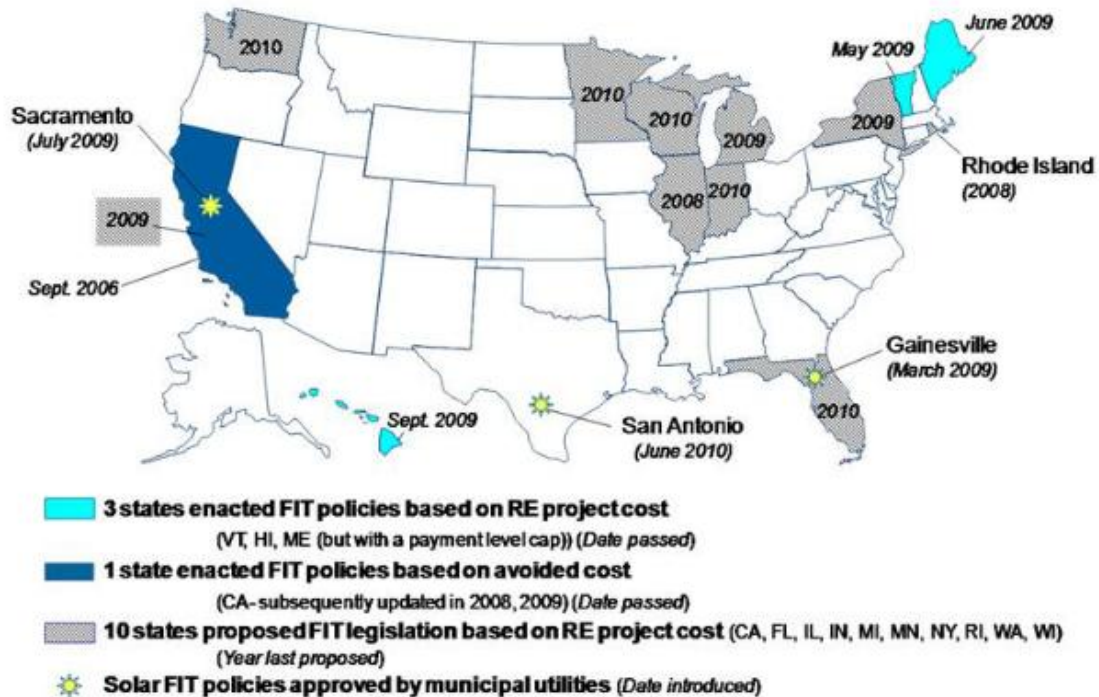


Figure 11 Feed- In-Tariff Policy in the United States Source: NREL June, 2010⁵⁴

Spain

Spain has made support for renewables a national priority for more than two decades in spite of different governments and political majorities. It is this concerted effort that has aided the growth of renewables, making Spain a world leader in renewable energy generation and equipment manufacturing.⁵⁵

⁵⁴ <http://www.nrel.gov/docs/fy10osti/44849.pdf>

⁵⁵ del Rio & Gual, 2007

In 1997 the Spanish parliament passed the “*Law of the Electricity Sector (law 54/97)*” with three provisions:

- 1) gives Renewable Energy Systems (RES) preferential treatment
- 2) Guaranteed grid access to RES producers
- 3) Created price support for RES producers⁵⁶

As a result of this legislation, the rate for a KWH was set at \$.36, very high for 1997, because of the high cost of PV panels at that time. This cost was to be passed on to the consumer. Contrary to the German FIT, with its degression provision, the Spanish rates stayed the same, even as the technology became more affordable. If we are to consider cost distribution and its effects on various participants in this system, we must consider all sides. “Predominantly captive consumers or other actors (taxpayers and distributors) should not be excessively burdened. If the burden increases significantly over time public acceptance diminishes and political pressure to change increase.”⁵⁷ To give the reader a comparison my KWH charge is \$.12. This runs contrary to idea of dynamic efficiency that purports the cost reduces over time. Pablo del Rio in his paper on “*Dynamic Efficiency*” offers the following caution: “However, while a coalition of forces is necessary in the takeoff stage, it may have negative implications in the long-term if it leads to regulatory capture and rent seeking by renewable energy firms, making support instruments difficult to change or remove when they are no longer justified.”

⁵⁶ del Rio & Gaul 2006

⁵⁷ Huber, 2004 in del Rio & Gaul

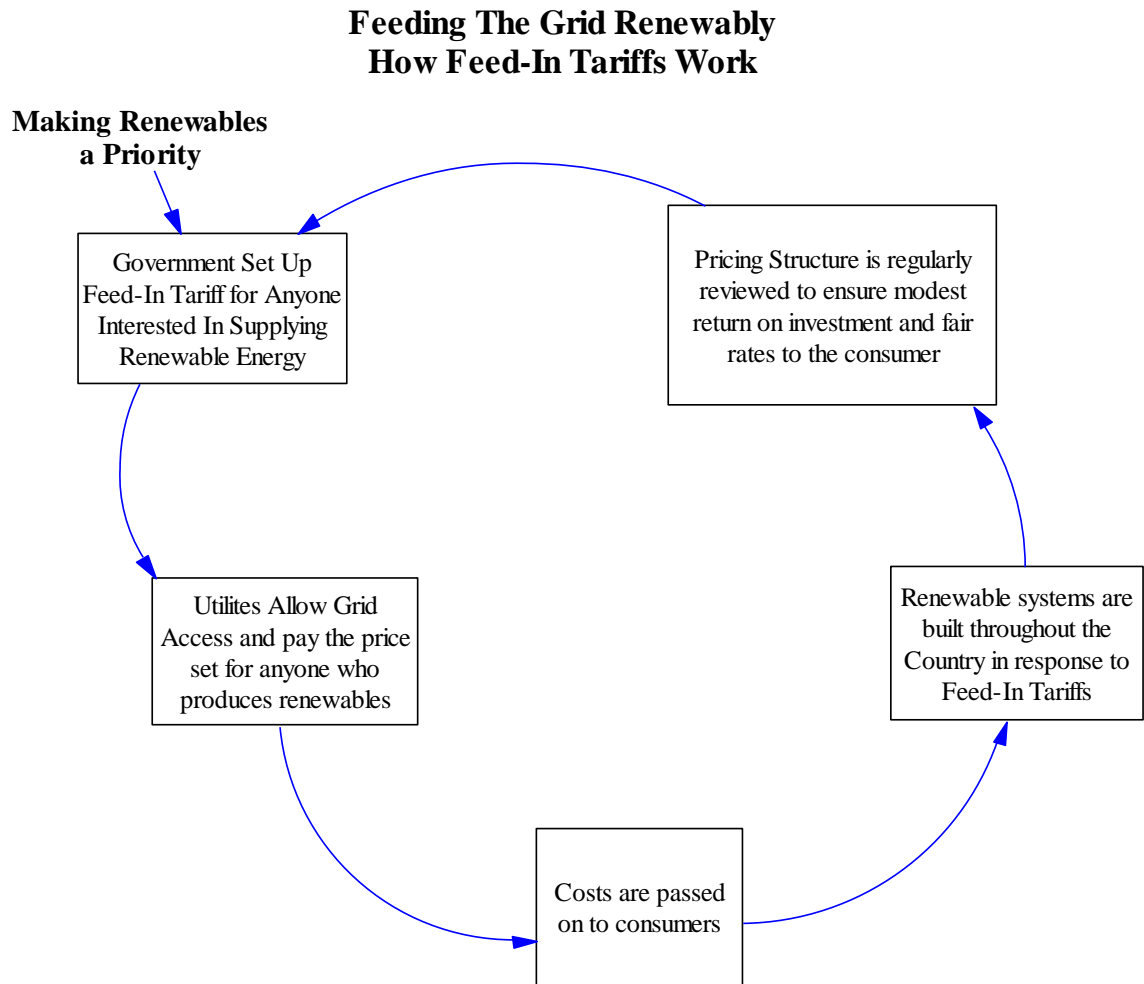


Figure 12 Feeding the Grid, Source: Ed Kelly

F) National

“In the twenty-first century, the American Dream requires progress we won’t achieve without effective government policies, including direct investment....public-private partnerships to create an environment where these things can happen.”⁵⁸

⁵⁸ Bill Clinton [Back to work](#)

Required are:

- 1) A national effort to create the smart grid to bring renewable energy from where it is created to where it is needed.
- 2) Federal legislation to create feed-in tariffs in states where renewables will be built that can be connected to the smart grid
- 3) Expand the Energy Efficient Mortgage (EEM) program to cover the initial cost of home based renewables, such as wind and solar.
- 4) Continue tax incentives currently in place.

Implementing the above recommendation can have many beneficial effects. If we see the past models of the transcontinental railroad, interstate highway and the internet, these were followed by periods of growth and prosperity. The undertaking of a national smart grid can put many people back to work. As Bill Clinton states in Back to Work, it is time for the United States into get back in “the future business.” As stated previously, wind power from North Dakota alone could supply 25% of U.S. electrical needs.

Using these available unlimited resources could secure real energy security; as well as retain the vast amount of money that leaves this country to acquire oil and protect our vulnerability to interruption of this flow.

1. Smart Grid

Smart grid describes a national grid system within the United States. It is “smart” as it provides for a two-way interaction between supplier and end user. The smart grid will enable the United States to use energy wisely, interconnecting locations of renewable production with urban areas in need of power. The Federal Government will play a vital

role in creating this smart grid. For example, the Federal Energy Regulatory Commission (FERC) has jurisdiction over interstate transmission of power. The Federal Government can supply either money or tax incentives to spur private investment. Building the smart grid will take substantial investment. However, compare this with the wealth transfer leaving this country yearly at \$70 a barrel, of 1 trillion dollars; this figure will also double in a short period of time. The benefits of modernizing our energy sectors and creating new jobs cannot be overstated.

2. Incentives

As discussed earlier in this thesis, the Federal Government has a vital role in encouraging private sector investment in renewables and transmission lines. Current incentives and loan guarantees should be used and sustained. Feed-in-Tariffs secure for the investor a reasonable return on their investments, while Production Tax Credits make renewable investments economical viable.

3. Regulatory

The power of the Federal Government comes into play for renewables to streamline the process the Federal Energy Regulatory Commission (FERC) uses in dealing with interstate transmission from large wind and solar farms, as the power generated may need to cross multistate borders. The Department of the Interior could be needed to leverage the placement of some of these wind and solar farms on public land. These are some examples of how the Federal Government can provide “amicable” regulations for this new energy source.

4. Mortgage Based Financing

Renewables should be considered in the initial planning stages of any new construction, with financing included. Financial sources, such as Energy Efficient Mortgages (EEM), increase the ceiling on the amounts a homeowner can borrow. EEM should be used to include renewables into the mortgage, just as wells, septic, etc. The current status of EEMs has a cap of \$8,000, which would need to be increased substantially. This would amortize the cost of renewables over a longer period, including tax deductibility of the payments. Homeowners are basically paying 30 years of utility bills upfront when choosing renewables. Units can be sold with the property and appraisals should accurately reflect their value.

As I discuss wind and solar power with others they seem quite receptive to their use, but are reluctant because of costs. The financial means need to be available to make these installations possible. An economic model exists with the increase in homeownership, as people are able to finance their home over a long period of time and receive the tax deductibility of this, homeownership has increased.

Americans share the belief that their housing should be affordable, comfortable, and energy efficient. But, research has shown that the level of investment in energy efficiency in housing is less than that which is economically justified. Two major barriers limit investment in home energy efficiency. First, energy efficiency represents increased front-end cost, either as a home is first built or as an existing home is later improved. It is a long-term investment that must be financed. Second, there are insufficient market data to fully understand the value of energy efficiency in housing.”⁵⁹

⁵⁹Implementing HUD's Energy Strategy U.S. Department of Housing and Urban Development ,Office of Policy Development and Research, Energy Task Force Submitted Pursuant to Section 154 Energy Policy Act of 2005

Home mortgages have been the traditional way for homebuyers to finance the cost of their residences. A mortgage divides the price of a property in monthly payments spaced over a 15 or 30 year terms. The Energy Policy Act of 1992 authorizes the creation of EEM. Here is the exact text from the act.

“(a) IN GENERAL- Not later than 18 months after the date of the enactment of the Energy Policy Act of 1992, the Secretary, in consultation with the Secretary of Housing and Urban Development, the Secretary of Veterans Affairs, representatives of existing home energy rating programs, and other appropriate persons, shall, by rule, issue voluntary guidelines that may be used by State and local governments, utilities, builders, real estate agents, lenders, agencies in mortgage markets, and others, to enable and encourage the assignment of energy efficiency ratings to residential buildings

“(3) encourage consistency with, and support for, the uniform plan for Federal energy efficient mortgages, including that developed under section 946 of the Cranston-Gonzalez National

Affordable Housing Act (42 U.S.C. 12712 note) and pursuant to sections 105 and 106 of the Energy Policy Act of 1992;

“(4) provide that rating systems take into account local climate conditions and construction practices, solar energy collected on-site, and the benefits of peak load shifting construction practices, and not discriminate among fuel types; and

“(5) establish procedures to ensure that residential buildings can receive an energy efficiency rating at the time of sale and that such rating is communicated to potential buyers.”⁶⁰

There are several options available to finance residential renewable energy systems. EEM, Energy Improvement Mortgages (EIM) or Solar Leases. Presently, there are no leases available for small scale wind turbines, but only large scale. EEMs are available from many of the federally insured mortgage programs: HUD (through the FHA), Fannie Mae, Freddie Mac and Veterans Affairs. An EEM is a mortgage that credits a home's energy improvements in the mortgage, based on the premise that the money saved from utility bills by energy improvements could be used for additional payments toward the mortgage: “EEMs give borrowers the opportunity to finance cost-effective, energy-saving measures as part of a single mortgage and stretch debt-to-income qualifying ratios on loans thereby allowing borrowers to qualify for a larger loan amount and a better, more energy-efficient home.”⁶¹

To qualify for an EEM, the borrower must have an Energy Rater do an analysis that provides the home energy rating. This process verifies that the home is energy efficient and the Rater will also give a dollar value to the improvements. This added dollar value gives the homeowner the ability to borrow more.

In addition to EEMs there is also the Energy Improvement Mortgages (EIMs), used to purchase existing homes that will have energy efficiency improvements made. “EIMs

⁶⁰ <http://www.ferc.gov/legal/maj-ord-reg/epa.pdf>

⁶¹ U.S Department of Energy
http://www.energystar.gov/index.cfm?c=mortgages.energy_efficient_mortgages

allow borrowers to include the cost of energy-efficiency improvements to an existing home in the mortgage without increasing the down payment. EIMs allow the borrower to use the money saved in utility bills to finance energy improvements. Both EEMs and EIMs typically require a home energy rating to provide the lender with the estimated monthly energy savings and the value of the energy efficiency measures - known as the Energy Savings Value. EEMs (and EIMs) are sponsored by federally insured mortgage programs (FHA and VA) and the conventional secondary mortgage market (Fannie Mae and Freddie Mac). Lenders can offer conventional EEMs, FHA EEMs, or VA EEMs.”⁶²

Conventional Energy Efficient Mortgages

Conventional lenders who sell their loans to Fannie Mae or Freddie Mac can expect these loans to be accepted by these organizations as would a conventional loan, but the borrower will get the benefit of the additional value for the energy improvements to be capitalized in their loan. This allows for it to be paid off over the life of the loan. The Fannie Mae loan also adjusts the value of the home to reflect the value of the energy efficiency measures.

⁶² Energy Policy Act 1992, section 105, pg 23
<http://www.ferc.gov/legal/maj-ord-reg/epa.pdf>

Below are some brief descriptions of the various EEMs:

1) FHA's Energy Efficient Mortgages FHA provides for conventional loans such as 15 or 30 year fixed rate or adjustable rate mortgages to be secured through approved lenders. For a searchable list of lenders, see Appendix B. The usual qualifying conditions are: a satisfactory credit history, a sufficient steady income, and a down payment. Remember, the FHA is only 3.5% of the property value. If the improvements on an existing property are to be made in the future, the money will be held in escrow and the work will need to be completed within 90 days. The FHA permits sufficiently qualified homeowners to do their own improvements.

2) Fannie Mae and Freddie Mac These programs are very similar to the FHA described above. Some lenders are more comfortable dealing with these two mortgage programs.

3) VA (Veterans Affairs) this program is specifically for U.S. military veterans, with different underwriting requirements for energy improvements over \$6,000:

- 1) If the new monthly payments increases by 20% or more, the underwriter must certify that the veteran can qualify for this payment.
- 2) The value of the improvement must be supported by an appraisal.

4) Benefits of a Green Mortgage

A study published in the *Appraisal Journal* in 1999, published by The Appraisal Institute, a national trade associations of real estate appraisers, documented that for every \$1

decrease to a home's annual energy costs, the home's value increases by \$20. For example if you saved \$100 per month in energy costs for an annual savings of \$1200, your home's value would increase \$24,000. With the increase over the past 10 years in energy costs, this amount is higher in all likelihood.

With an EEM, your estimated monthly savings are applied to your debt-to-income ratio. The loan officer is allowed to factor the savings into that equation that will do one of two things:

- Allow the applicant to qualify for a more expensive home
- If you have chosen a home at the top of your price range, the effect of the monthly savings on your debt-to-income ratio will make qualifying easier
 - Fannie Mae estimated an additional 6.5% of individuals would qualify for a EEM mortgage over traditional mortgages because of the added monthly savings⁶³

5. Netmetering

Part of the U. S. Energy Policy Act of 2005 (EPACT) required that all public utilities, when requested, make Netmetering available to all their customers that have installed renewable systems.

Section 1251 states: NET METERING.—each electric utility shall make available upon request net metering service to any electric consumer that the electric utility serves. For purposes of this paragraph, the term ‘net metering service’ means service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the

⁶³ Green mortgage: <http://www.greenmortgagecompany.com/>

local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period.

Usually, the excess power from the consumer's generation facility, if any, will be compensated at the "avoided cost", which is generally very low. Although some companies such as Georgia Power and the Tennessee Valley Authority (TVA) pay very competitive rates. In general, however, the avoided costs are quite low, 1 to 2 cents per KWH.

G) States

1. Renewable Portfolio Standards

Renewable Portfolio Standards (RPS) are a requirement that investor owned or public owned utilities produce a percentage of their electrical production from renewable sources. This type of state legislation attempts to reduce fossil-fuel consumption and create energy security and independence. This is generally coupled with federal or state tax incentives to stimulate economic activity.

Due to potential gridlock in Washington D.C., the states have become incubators for growth of renewable energy. The states, by providing for mandatory RPS, have stimulated the investments in wind and solar within their states as well as the economic development associated with this activity. California, having already exceeded its goal of 20% of its energy provided by renewables, is now set to achieve 33% by 2020, a very aggressive goal but certainly achievable. These are the kinds of "induced innovation" discussed earlier in this thesis. Colorado's RPS is set for 30% by 2020, and New York is set for 29% by 2015.

While all the above states RPS are mandatory, Virginia has chosen to make its RPS voluntary, and it is only at a meager 4% up to 2015. The 2007 Virginia Energy Utility

Regulation Act (S.B.1416) and (H.B. 3068) created these and added rate incentives for compliance with the goals of the RPS. Voluntary RPS rate incentives have not worked to produce more renewables, leading to rate increases for Virginia's electrical consumers (for further discussion see footnote 67).⁶⁴

A ready market is available for generators of renewable energy, by the use of state RPS, creating the market-pull in the energy sector that stimulates economic growth in this area.

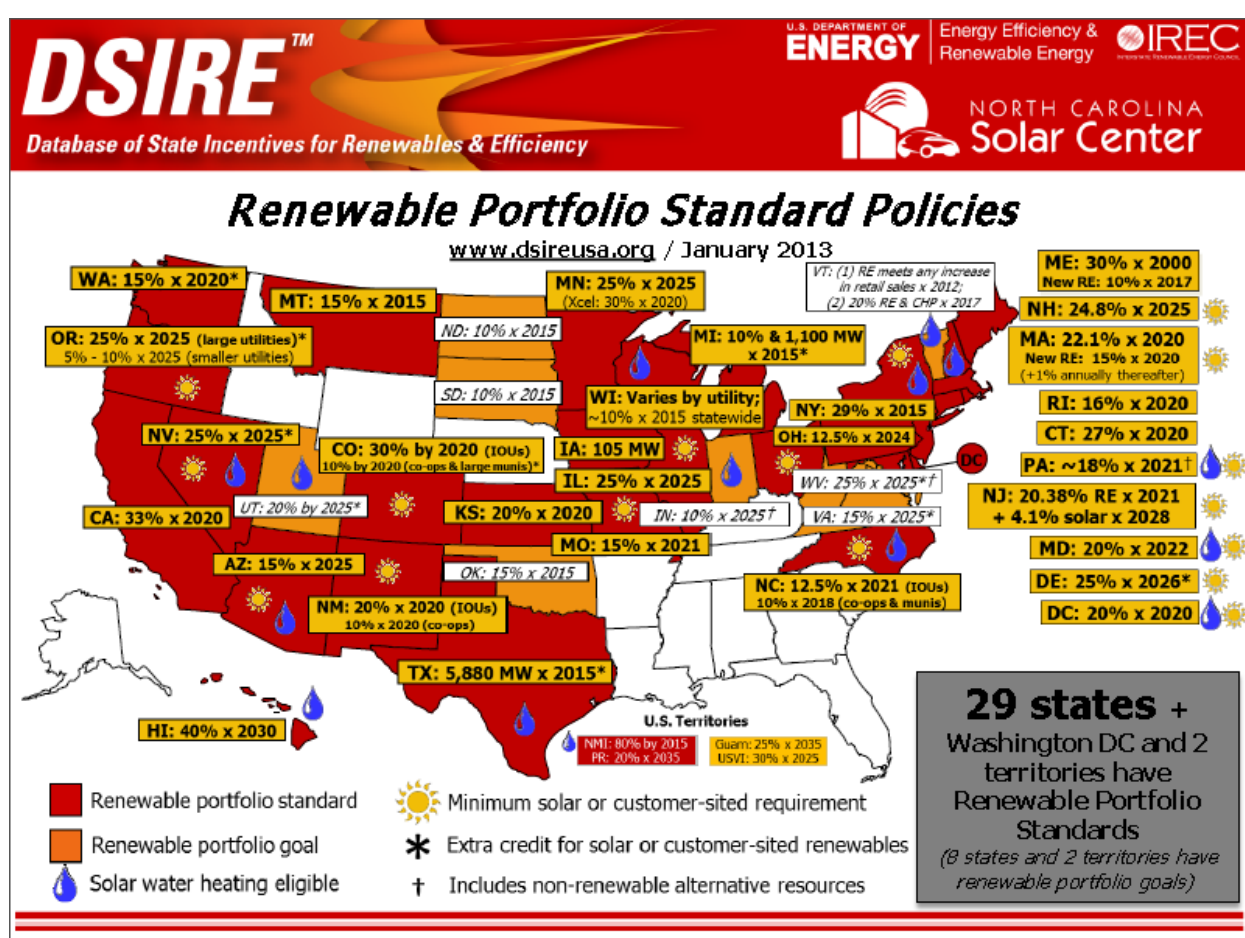


Figure 13: Renewable Portfolio Standard Policies Source DSIRE

⁶⁴ Ed Kelly, JMU; ISAT paper: Virginia Renewable Energy Policy and Politics, Spring 2013
If you would a copy, e-mail to kellyep@dukes.jmu.edu

2. Feed-in-Tariffs

As the map below shows, states have enacted Feed-in-Tariffs (FIT) based on different criteria, but all of them will be beneficial to the growth of renewables within each specific state. (See Section VII part II for a more extensive discussion on FITs)

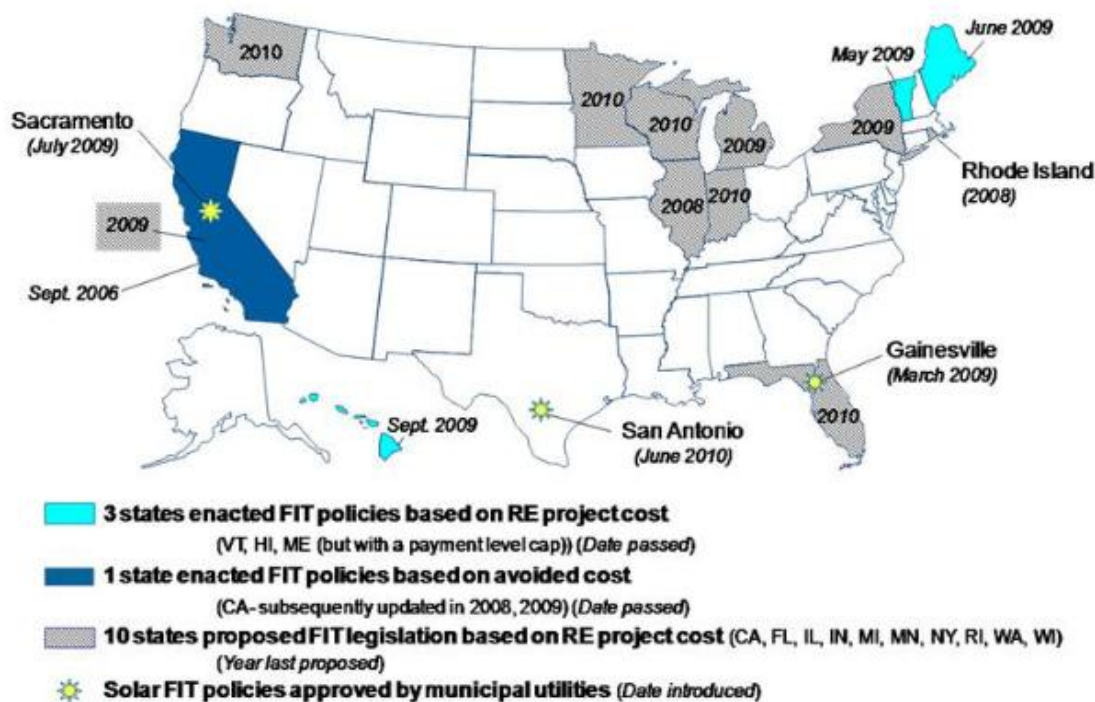


Figure 14 Feed-in-Tariffs in the United States Source NREL 2010

As the states work toward FITs, they appear to be merging with the RPS to meet the regulatory requirements. The two appear very complementary. Tying this with CBED statues we begin to see the presence of dynamic efficiency that was discussed earlier.

California has played a leading role in development of Feed-in-Tariff legislation, beginning with the introduction of Assembly Bill 1969 in 2006. This legislation capped the statewide maximum at 250 megawatts (MW), but a bill passed in 2007 increased this to 478 MW. An interesting facet of this legislation is the rate is tied to time of delivery. In Southern California Edison territory peak payment can be as high as \$0.31/KwH in the summer (Rickerson). Coincidentally, this is when solar arrays will be generating the most power and when the demand is at its peak.

In Minnesota, their Feed-in-Tariff legislation has spurred a Community Based Energy Development Program (CBED). This is an effort to maintain local economic development. For example, *Fenton Wind Farm* in Chandler, Minnesota, spans 3 counties and consists of 137 GE 1.5 MW wind turbines (the turbines were also produced in the U.S.). The wind farm pays \$800,000 per year in taxes and fees to the local municipalities, as well as \$500,000 to local property owners for the leases.

There has been an interesting development in the Feed-in-Tariff development in that these are not mutually exclusive from Renewable Portfolio Standards (RPS). This requirement involves the PTC and FIT guaranteeing independent generators a security in their investment, as energy suppliers are looking for this generation to meet the RPS state requirement.

3. Incentives

Here is an example of a program in New Jersey:

In September 2007 the New Jersey Board of Public Utilities (BPU) began an investigation into ways to develop and support the solar financing mechanisms based on Solar Renewable Energy Certificates (SRECs). An SREC is a tradable commodity equivalent to one megawatt-hour (MWh) of electricity generation from a solar energy resource. Electricity suppliers in New Jersey use SRECs to meet their obligations under the solar carve-out portion of the state's renewable portfolio standard (RPS). Because of this demand, SRECs are potentially valuable to qualifying solar system owners and their sale can result in significant revenue over the life of a solar project. The BPU SREC financing initiative, which ultimately resulted in the utility programs described below, is an attempt to introduce greater price certainty into the SREC system.

After extensive stakeholder consultations, in August 2008 the BPU issued an order requiring Atlantic City Electric (ACE), Jersey Central Power and Light (JCP&L), and Rockland Electric Company (RECO), three of New Jersey's four investor-owned electric distribution companies (EDCs) to offer long-term (10 - 15 year) SREC purchase contracts to solar system owners.

The following is a particularly excellent program:

The fourth investor-owned EDC in New Jersey, PSE&G, has not thus far been required to develop such a program because its Solar Loan program adopted in April 2008 provides similar benefits. The PSE&G Solar Loan program allows solar system owners within its service territory to finance a portion of the system cost through the utility, and repay the loan with SRECs at a guaranteed minimum SREC price.⁶⁵

⁶⁵ http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=NJ41F&re=0&ee=0

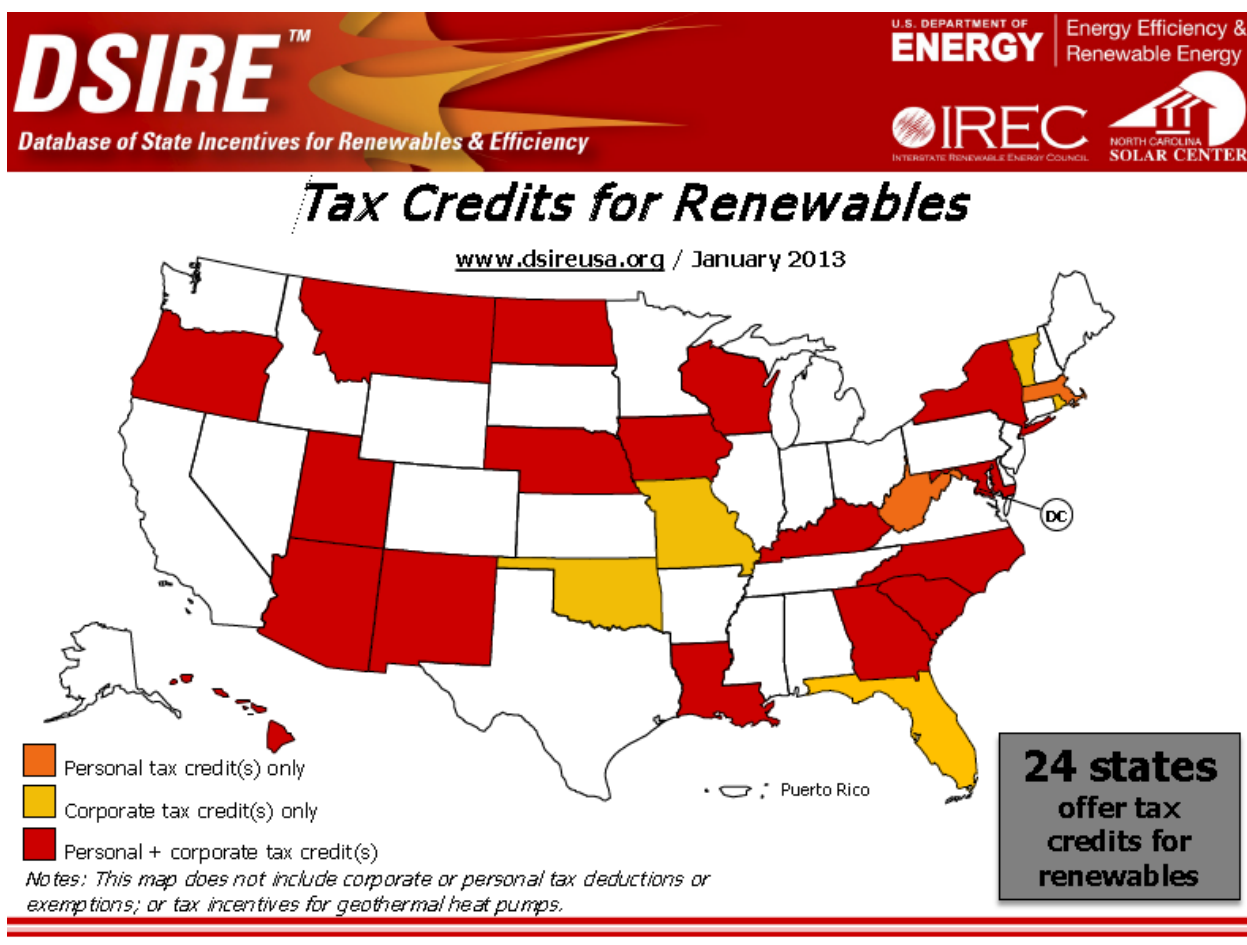


Figure 15: Tax Credits for Renewables Source DSIRE

4. Regulatory

States can also assist in the regulatory process by removing burdens or dismissing unwarranted challenges as renewables attempt to expand within their respective states. Each state has its own energy regulatory commission with different state regulations.

5. Solar Leases

A Solar Lease is a legal contract made between the homeowner and the leasing company for the leases of the solar panels. The homeowner pays no upfront cost but instead pays a flat monthly fee for the lease of the panels. A typical solar lease lasts anywhere between 15-25 years. The monthly cost is fixed with a small increase on an annual base (see Table 1). Maintenance and upkeep are included in the monthly fee. At the close of the contract period, homeowners may have the choice of renewing the contract, purchasing the system, or having the equipment removed. A slight variation on this is the Power Purchase Agreement (PPA), which includes a set rate and a meter and only charges for the electricity used. The downside of this type of lease is that the homeowner will not receive any of the tax credits from federal or state, nor any of the utility company incentives should they be available.

Solar leases are another option for solar panels on a residence. There are presently four companies providing this option to residential homeowners. Although limited to certain states, they are rapidly expanding (See Appendix C). These four lease companies are 1) Sungevity, which is available through Lowe's Home Improvement Center in the states that it covers {see Fig 9}, 2) Solar City: Google has invested \$240 million in this company, 3) SunRun: the nation's largest residential lease company, and 4) groSolar, which has sold its residential division to Solar City so it can concentrate on the commercial side, which has been rapidly expanding. There are many commercial ventures that are in place, for example, the Washington Redskins home stadium (*FedEx*

Field) has entered into a lease agreement with NRG Energy (a very large diverse energy company) for a ten-year lease with an option for ten more years.

6. Solar PPAs

In the United States, the Solar Power Purchase Agreement (SPPA) depends heavily on the existence of the solar investment tax credit, which was extended for eight years under the Emergency Economic Stabilization Act of 2008. Due to the profits being subject to taxation, the SPPA relies on financing partners with a "tax appetite" who can benefit from the federal tax credit. Typically, the investor and the solar services provider create a special purpose entity that owns the solar equipment. The solar services provider finances, designs, installs, monitors, and maintains the project. With the passage of the American Recovery and Reinvestment Act of 2009, the investment tax credit can be combined with tax exempt financing, significantly reducing the capital required to develop a solar project.



Figure 16 States in Which Solar Leasing Companies Operate

The following table gives a good comparison of the four leasing companies

Lease Terms	Sungevity	SolarCity	SunRun	groSolar
Length of Lease	10 to 20 years (with 5 year extension option)	20 years (with 5 year extension option)	18-20 years	15 years
Credit Score Requirements	FICO score of 680 or greater	FICO score of 700 or greater	FICO score of 700 or greater	Not stated
\$0 down option	√	√	√	√
Free Maintenance and Cleaning	√	√	√	Not stated
Free Monitoring	√	√	√	Not stated
Insurance	√	√	√	Not stated
Performance Guarantee	√	√	√	Not stated
Annual Lease Payment Increase	2.5%	3.9%	3%	Not stated

What happens if I sell my house before the end of the lease	<ul style="list-style-type: none"> • Transfer to new homeowner • Prepay remaining lease payments and add it to the asking price (after year 6) • Prepay the remaining lease payments and have it removed for free (after Year 6) 	<ul style="list-style-type: none"> • Transfer to new homeowner • Prepay remaining lease payments and add it to the asking price • Prepay the remaining lease payments and having it removed for free 	<ul style="list-style-type: none"> • Transfer to new homeowner • Prepay remaining lease payments and add it to the asking price • Prepay the remaining lease payments and have it removed for free 	Not stated
End of lease options	<ul style="list-style-type: none"> • Renew lease • Sign a new lease with new equipment • Have it removed for free • Buy outright 	<ul style="list-style-type: none"> • Renew lease • Sign a new lease with new equipment • Have it removed for free 	<ul style="list-style-type: none"> • Renew lease • Sign a new lease with new equipment • Have it removed for free • Buy outright 	<ul style="list-style-type: none"> • Renew lease • Sign a new lease with new equipment • Have it removed for free • Buy outright

Table 1 Companies with Solar Leases

Shortcomings of Solar Leases

There are some interesting dynamics involved for public policy. Since the inception of the Energy Efficient Mortgage in the 1992 EPACT, the limit on the amount of additional money to be added to the mortgage value has remained capped at either 5% of the loan or \$8,000 dollars. As mentioned earlier, the cost of a net-zero solar arrays for a moderate size home is around \$30,000; a wind turbine would be \$45,000. The gap in available capital appears to be the reason for the low use of these mortgages. As shown above, the

“Housing and Economic Recovery Act of 2008” has not changed these limits. On the contrary, the “American Recovery and Reinvestment Act of 2009” has increased future incentives for investors to provide funding to the various solar leasing companies. Thirteen billion was included in this bill to extend tax credits for renewable energy production (until 2014). This appears to be a good aspect, but as we delve further some unintended consequences appear to unfold.

- 1) Because of the easy availability of solar leases and the lack of additional capital in EEMs, homeowners will choose leases over purchase; therefore, the tax incentives are not reaching the public.
- 2) These leases are centered in states where the incentives are higher.
- 3) Investors are not limited to U.S. citizens; thus if I am a Chinese solar panel manufacturer, I can invest in a leasing company that uses my panels, in essence, being subsidized by the U.S. Government.

I have a model for a solar array in adjoining Fort Valley, Virginia, to make use of their data, as we are at the same latitude. The site has good solar access with very little shading. The owner, after extensive research, decided on *Canadian Solar* panels, as it has the best price and rating on the market. When researching this company, *Canadian Solar* is a Chinese company set up in Canada that takes advantage of the lack of tariffs due to NAFTA. There is definitely a need to revisit the loan amounts of the EEMs and make these more attractive to homeowners. As these laws and incentives currently stand, there are loopholes where government money can subsidize non-domestic panels.

H) Local Policy

1. Local, Municipal Ownership

Some localities are moving toward municipal ownership of renewable generation facilities. California's original RPS, passed in 2002, required investor-owned utilities (IOU) to produce 20% of their power from renewables by 2010, while publicly-owned utilities (POU) were encouraged to do the same. POUs are owned either by a municipal or similar government or by a cooperative of customers. With the passage of California's S.B. 2 and the California Public Utilities Commission rulemaking, the new RPS was increased to 33% by 2020. Also, the new legislation now mandates compliance by POUs.



Figure 17 Geothermal Plant at the Salton Sea, California

2. Property Assessed Clean Energy (PACE)

PACE is an innovative way to finance solar panels or other energy improvements.

Municipal governments can issue bonds that are sold to investors. This money is then loaned to homeowners or commercial properties to finance energy improvements. The loan then becomes an assessment on the property tax to be paid over the life of the loan, e.g. 15 or 20 years. This type financing is familiar to municipalities, known as land-secured financing districts, are commonly used for improvements such as sewers, etc. This assessment can be transferred to a future owner when the property is sold.

PACE loans permit the property owner to obtain the energy savings immediately and use these savings to pay the loan. This property tax payment is deductible. There are some concerns with the PACE loans, in particular from lending industry giants Freddie Mac and Fannie Mae, as property taxes are in a superior position to any other indebtedness.

Since PACE loans are usually taken out after the first mortgage, it creates an involuntary subordination as the underwriters have an obligation to these additional PACE loans.

Currently eight states have PACE financing and 20 are on hold pending the resolution of legal objections from these mortgage underwriters.



Figure 18 Source: U.S. Department of Energy

Congress should enact legislation that supports residential property assessed clean energy (PACE) programs in the nation's states and metropolitan areas. Such legislation should require the Federal Housing Finance Agency (FHFA) to allow Fannie Mae and Freddie Mac to purchase residential mortgages with PACE assessments while at the same time providing responsible underwriting standards and a set of benchmarks for residential PACE assessments in order to minimize financial risks to mortgage holders.⁶⁶

Virginia passed its PACE legislation in 2009 with SB 1212, the "Clean Energy Financing Bill," providing Virginia localities with the authority to create their own clean energy financing programs. An excellent example of the success of the PACE program is Riverside County, California, where 6000 homeowners have borrowed \$100 million

⁶⁶ Brookings Institution: Strengthen Federalism: Enact Legislation Supporting Residential Property Assessed Clean Energy Financing; <http://www.brookings.edu/research/papers/2012/11/13-housing-energy-efficiency>

dollars to install solar on their residences. The boom to the local economy can be realized by the contractors doing the installations.

3. Building, Zoning, Homeowner Associations and Utility Company Requirements

State and local building codes need to be receptive to renewable energy installations and have clear guidelines for their installation. Zoning regulations should be adjusted to have reasonable guidelines for renewable energy installations. Here in Shenandoah County, VA the zoning on wind turbines requires the structure to be in an agricultural district on 15 acres of. When I inquired about these guidelines, the County Zoning Administrator simply told me to bring a challenge to these restrictions.

Homeowner Associations (HOA) have presented problems throughout the country as the HOA's Covenant, Conditions and Restrictions (CCRs) can prohibit the installation of renewables. Legislation is pending, or has been passed in various states; for example, "The California Solar Rights Act" was passed in 1978 to protect the homeowner's right to install solar panels on their property, but it also permits a HOA to impose reasonable restrictions on the installation.

The utility companies of several states have taken a more welcoming approach. Virginia, unfortunately, is not one of those states. Dominion Power has taken an adversarial approach to protect their monopoly. At one point, Washington and Lee University in Lexington, Virginia was installing a 444KW solar installation on its campus, which was the largest in Virginia at this time. The University was partnering with a third-party investor (Secure Futures) to finance the installation, due to the fact that the university as a

non-profit it cannot take advantage of the tax incentives offered by the Federal Government. This would have been a common power purchase agreement (PPA) between Secure Futures and the University. The 2007 “Virginia Energy Utility Regulation Act” was passed as regulation on the utility companies, but the Act was unclear about PPAs in relation to retail sales. Dominion Power tendered a *cease and desist letter*, claiming that Secure Futures needed to produce 100% of the University’s power from renewables. This was clearly a misinterpretation of the details of the Act; eventually a settlement was reached between the two parties.⁶⁷

Taking from this example, there can be many obstacles to renewable energy.

*“Once there is clear proof that an idea can be realized, it becomes increasingly difficult for opponents to stop it they can only put obstacles in its way.”*⁶⁸

⁶⁷ For further discussion on this see; Ed Kelly: Virginia Renewable Energy Policy and Politics ISAT 580, sp 2013

This paper is available by e-mail kellyep@dukes.jmu.edu

⁶⁸ Scheer 100% pg. 110

VIII Conclusions and Observations

The financial incentives that have been outlined in this thesis are worthwhile for federal, state and local governments to undertake. Germany is a stellar example of how a Feed-In Tariff can be used with substantial results, as per the theory of dynamic efficiency. The emergences of FIT proposals are a significant development for the renewable energy sector, potentially transforming the renewable energy market. While there is political gridlock at the Federal level over the PTC, there are bright spots throughout the nation with regards to FITs and RPS. Below an excerpt from the Hermann Scheer's The Solar Economy; Scheer who was known as the "Green Hero," having replaced the legendary *Finn McColl* of Irish folklore but a green hero in a different context.

Only a solar resource base offers any escape. The apologists of the fossil global economy justify their failure to make even half-hearted progress along this road with an equally tired fossil of an argument: in a world of global competition, the 'luxury' of concern for the environment must be earned through further conventional economic growth. This economic philosophy is in reality a necrosophy- the wisdom of the dead. Its' absurd consequence is that the price for safeguarding the environment is the freedom to continue- for how long?- damaging it. This 'wisdom' has dominated our culture for far too long and we can no longer afford to heed it⁶⁹

On the economic side, if we do not take the lead in renewables, we are missing a golden opportunity to revive both the U.S. economy and optimism; we will be unable to counter our dependence on foreign oil or avoid detrimental climate change. The death and destruction from the acquisition and use of fossil-fuels must be curtailed. As we look at events such as Fukushima, Japan, Maconda, and the resource wars necessary to secure our energy supply, surely most would agree this cannot continue. The economic means discussed in this thesis provide a way to do this, as the United can encourage investment

⁶⁹ Scheer Energy Autonomy

in a cleaner future. Scheer states that a social movement is necessary to achieve accelerated deployment of renewables, but we are only at the early adoption stage.

The opposition to a renewable energy infrastructure and its impact cannot be overstated. There are huge profits being made and will continue to be made off of fossil-fuels if this country does not take action. The only outcomes from their continued use are intense climate disturbances, severe weather events, and conflicts as these resources become scarce. Conventional fossil-fuel companies' structures are not set up for renewables. These companies are structured around a different business model. The closest they can come would be biofuels. As stated by Scheer: "realized that social change must come from people on the local level."⁷⁰ He understood how social participation can be a driving force for change, while the structures built for supplying conventional energy represent barriers and detours on the road to renewables. There needs to be a paradigm shift in thinking in the United States that is coupled with thinking and acting differently. Can this be accomplished in the time period that is necessary? Yes. There is a lot of discussion about rekindling the American spirit and what has made this country great in the past. This dialogue is being led by former President Bill Clinton and echoed by many others. The challenges that face us now are no greater than those we have faced in the past, and these were overcome by a united country, not a divided one. "Renewable man" uses the natural energies of the planet to supply our energy needs. The use of imported oil leads to a great wealth transfer from the United States to the petro countries. The use of renewables can serve to end this process.

⁷⁰ Hermann Scheer: The Solar economy

The most glaring question is this: while there might be fossil-fuel reserves to last the world well into the 21st century, can the environment survive? No. We have been given a many illustrations of the reality that this cannot continue, the devastating superstorm Sandy serving as merely one example of many.

Current conditions: reaching “peak oil,” rising CO2 emissions, the cost of maintaining American military hegemony to secure fossil fuel supplies and the severe weather events caused by climate change will be the dynamics that should cause the capitalist system to restructure itself to create a new energy system.

Due to the United States’ current financial and political situation, it is doubtful whether the necessary investments will be made to create the dynamic efficiency to move renewables down the diffusion path more quickly. The fossil-fuel vested interests are very well represented in Congress, and this avenue for change may be blocked at the national level. What is needed is a social movement (Scheer) that will force Congress to move in the direction needed for this dynamic efficiency. There is a historical precedent for this however: banning CFCs. We have seen fossil fuel companies exercise opposition by staging a very successful misinformation campaign on climate change. Public opinion has moved from 64% believing in climate change to a 50-50 split; quite the successful campaign. Other countries do not have the huge expenditures that the United States undertakes to maintain its military might, but instead can invest in progressive research and development (R & D).

Our goal should be to use the planet's natural forces to provide for our energy needs, while ending the war with each other and against the environment. This change must occur before we destroy both.

There may be conditions, under which various sites are not conducive to these renewables, but there are many other methods to reduce the demand on these sites and these can be taken. Reducing demand is always less expensive than producing supply. Conservation and efficiency should always be the initial goals. Where consumers need to rely on utilities to produce electricity, a national energy policy to shift toward renewable power should be vigorously pursued. For example, in a National Renewable Energy Laboratory (NREL) report showed that a single state, North Dakota, has the theoretical potential, after subtracting land that is unsuitable for energy development (natural areas and parks), to have more capacity (770,000 megawatts) than all the fossil-fueled power plants in the United States combined.⁷¹

Never doubt that a small group of thoughtful people could change the world. Indeed, it's the only thing that ever has.

Margaret Mead

⁷¹ U.S. Department of Energy - Energy Efficiency and Renewable Energy
http://www.windpoweringamerica.gov/wind_resource_maps.asp

Acronyms

BTU: British thermal unit

FIT: Feed-In-Tariff

KWH: Kilowatt/Hours

KW: Kilowatt

MW: Megawatt

PTC: Production Tax Credits

REC: Renewable Energy Certificates

Appendix A

FHA http://www.energystar.gov/ia/partners/bldrs_lenders_raters/EEM_Fact_Sheet.pdf

Freddie Mac

http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Fmac_Energy_Efficient_Mortgage-without_contact.ppt

Fannie Mae

<http://www.fanniemae.com/flApplication/fanniemae/findLender.jsp?p=Find+a+Lender+Search>

Veterans Affairs

<http://www.benefits.va.gov/homeloans/rlcweb.asp>

Appendix B

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