2.9 US Clean Energy Sector and the Opportunity for Modeling and Simulation

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Abstract. The following paper sets forth the current understanding of the US clean energy demand and opportunity. As clean energy systems come online and technology is developed, modeling and simulation of these complex energy programs provides an untapped business opportunity. The US Department of Defense provides a great venue for developing new technology in the energy sector because it is demanding lower fuel costs, more energy efficiencies in its buildings and bases, and overall improvements in its carbon footprint. These issues coupled with the security issues faced by foreign dependence on oil will soon bring more clean energy innovations to the forefront (lighter batteries for soldiers, alternative fuel for jets, energy storage systems for ships, etc).

1.0 INTRODUCTION

The National Institute for the Commercialization of Clean Energy (NICCE) is poised to ride a growing wave of global demand for clean and renewable energy technologies. Government, industry, and consumers represent three influences driving clean and renewable energy technology to meet growing demand while addressing environmental, political, and economic challenges. These challenges range from the national security risks associated with foreign dependence on oil, to global climate change, to the economic costs of outmoded energy production.

1.1 Market Environment

A recent report by the Organization for Economic Co-operation and Development (OECD) argued that, "Knowledge is the main driver of today's global economy… Countries need to harness innovation and entrepreneurship to boost growth and employment. This is the key to a sustainable rise in living standards." [1]. Clean energy technology in particular is driven by innovation and entrepreneurship. Moreover, according to the OECD, "young firms are key to job creation." In the United States companies less than five years old account for nearly all of the increase in employment in the private sector in the past 25 years. These are the companies that NICCE cultivates.

Venture capital investment in clean energy as a percentage of all venture capital has grown every year since 2001, from 0.9% to 12.5% despite a reduction in overall venture investment during the economic downturn (see Table 1).

Table 1. Clean Energy Venture Capital Investments in U.S.-based Companies as a Percentage of Total, 2001-2009 ([2],[3],[4]).

Year	Total venture investments (in U.S.S billions)	Energy technology investments (in U.S.S millions)	Energy technology percentage of venture total
2001	$40.6	$351	0.9
2002	$22.0	$271	1.2
2003	$19.7	$424	2.2
2004	$22.5	$650	2.9
2005	$23.0	$797	3.5
2006	$26.5	$1,308	4.9
2007	$29.4	$2,867	9.8
2008	$28.3	$3,213	11.4
2009	$17.7	$2,216	12.5

Moreover, growth in the overall global clean energy market is projected to grow from $144.5B in 2009 to $343.4B in 2019,

distributed fairly evenly among biofuels, wind power, and solar power [2].

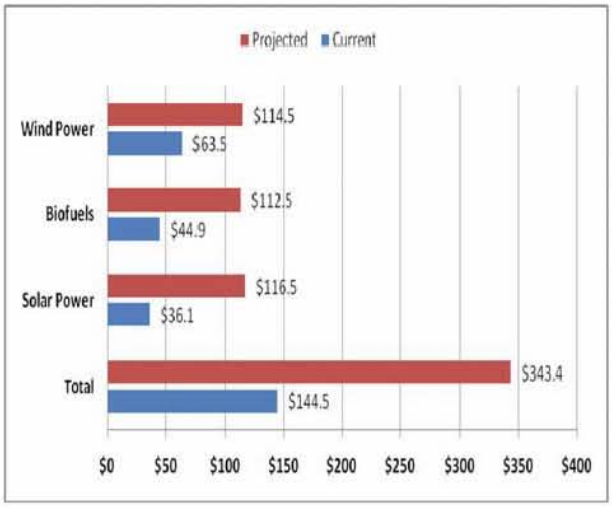

Figure 1. Global Clean-Energy Projected Growth 2009-2019 [2].

The clean energy market is forecast to expand by more than 200% in the next 10 years alone. This rapid growth will be driven by three categories of technology identified by the National Renewable Energy Laboratory (NREL), the leading national laboratory for alternative and renewable energy under the US Department of Energy:

- Accelerated evolutionary technologies driven by industry, approximately 3 years from market
- Disruptive technologies driven by major technological advances, approximately 3-10 years from market
- Revolutionary technologies driven by basic research, 10 years or more from market.

The projected market growth shown below will be almost entirely the result of accelerated evolutionary and disruptive technologies. NICCE is aimed precisely at companies positioned in these two stages.

1.2 Government Incentives

The United States Department of Energy (DoE), Department of Defense (DoD), and Department of Agriculture (USDA)—the three most notable governmental departments in terms of funding and innovation—all have funding and mandates to develop clean energy technologies. The NREL summarized the 2010 market environment from the government perspective:

1. Invest $150B in alternative energy over 10 years.

2. Create green jobs with clean, efficient American energy.

3. Double production of alternative energy in three years– enough to power 6 million homes.

4. Upgrade the efficiency of more than 75% of federal buildings and two million private homes.

5. Put one million PHEVs (Plug-in Hybrid Electric Vehicles) on U.S. roads by 2015.

6. Reduce CO2 emissions by 80% below 1990 levels by 2050.

7. Transform the economy with science and technology.

For NICCE, this commitment is an opportunity, as federal, state, and local governments are looking for viable clean and renewable technologies ready for commercialization in the short term—3 to 10 years at most.

2.0 MAJOR DRIVERS

The following sections detail major drivers behind governmental and industry demand for accelerated evolutionary and disruptive clean and renewable energy technology in the next 10 years, including government regulations and mandates, industry investment in clean energy research and

development, and consumer interest and advocacy.

2.1 US Department of Energy

The Department of Energy has detailed Energy Management Requirements that capture various legislative initiatives including Executive Order (E.O.) 13514, the Energy Independence and Security Act of 2007 (EISA 2007), E.O. 13423, the Energy Policy Act of 2005 (EPAct 2005), the National Energy Conservation Policy Act (NECPA), and other policies.

Federal agencies must meet the energy management requirements outlined by federal statutory laws and regulations. The following clean energy technologies drawn from the Department of Energy summary of Energy Management requirements, which apply across multiple departments, represent areas of opportunity for NICCE:

2.2 Renewable Energy-Use Increase

The EPAct 2005 defines "renewable energy" as electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project.

It requires that the total electricity consumed by the federal government coming from renewable energy is:

- Not less than 3% in fiscal years 2007-2009
- Not less than 5% in fiscal years 2010-2012
- Not less than 7.5% in fiscal year 2013 and thereafter

Similarly, E.O. 13423 mandates that at least half of renewable energy used by the federal government must come from new renewable sources (in service after January 1, 1999). Again, this suggests an opportunity for NICCE since federal agencies will be searching for new clean and renewable sources.

2.3 Petroleum Use Reduction/Alternative Fuel-Use Increase

The EISA 2007 requires federal agencies to achieve a 20% reduction in petroleum consumption by 2015 compared to a fiscal year 2005 baseline. Moreover, it requires federal agencies to increase alternative fuel use 10% each year compared to a fiscal year 2005 baseline. E.O. 13423 requires federal agencies with 20 vehicles or more located in the U.S. to decrease petroleum consumption by 2% per year through fiscal year 2015 compared to a fiscal year 2005 baseline and requires federal agencies to increase alternative fuel use by 10% each year compared to the previous year. Both of these measures provide an opportunity for biofuels production, a key element of the NICCE market.

2.4 US Department of Defense

A more specific example comes from the Department of Defense, the single largest consumer of energy in the United States. For the DoD, clean energy technology falls at the intersection of national security, economic security, and environmental security.

Existing DoD consumption is heavily skewed towards jet fuel and electricity, providing a distinctive opportunity for biofuels and renewable electricity generation, including "smart grid" technology, both areas of opportunity for NICCE as identified by our commissioned Research Triangle International (RTI) report on clean energy incubators (see Figure 2).

According to the DoD 2010 Quadrennial Defense Review Report, "The Department is increasing its use of renewable energy supplies and reducing energy demand to improve operational effectiveness, reduce greenhouse gas emissions in support of U.S. climate change initiatives, and protect the Department from energy price

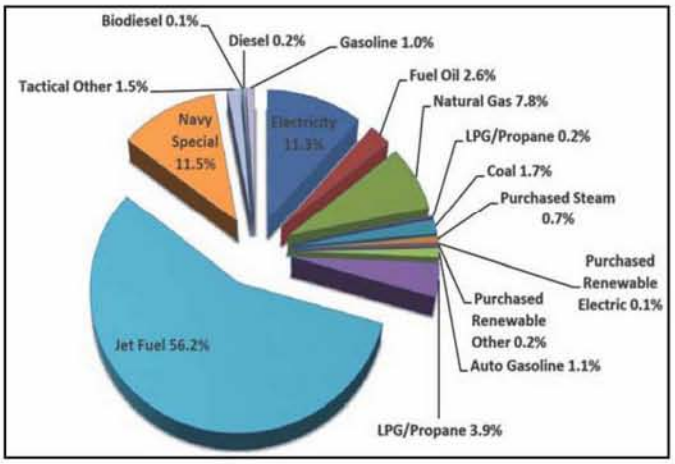

Figure 2. Existing DOE Energy Consumption [5].

fluctuations." This is not empty rhetoric. Significant directives mandating specific energy performance targets as shown in Table 2 back the report.

Table 2. DoD Energy Performance Targets [5].

Area	Goal	Legislation
Installations energy use	Reduce by 30% by 2015 from 2003 baseline.	EO 13423 / EISA 2007
Non-tactical vehicle (NTV) fuel consumption	Reduce 2% per year through 2015, 20% by 2015.	EO 13423
Electricity from renewable sources	A "Sense of Congress" goal: Reduce 25% by 2025.	EISA 2007 / NDAA 2007
Fossil fuel use in new/renovated buildings	Reduce 55% by 2010; 100% by 2030	EISA 2007
Hot water in new/renovated buildings from solar power	30% by 2015 if life-cycle is cost-effective	EISA 2007
Non-petroleum fueled vehicles use (ethanol, natural gas)	Increase by 10% annually.	EO 13423
Energy metering for improved energy management	Meter electricity by Oct 2012	EPAct200
	Meter natural gas and steam by October of 2016.	EISA 2007

2.5 US Department of Agriculture

The USDA's annual budget of $95B, includes major support programs for rural renewable energy projects and direct support for biofuels such as ethanol and biodiesel. The 2008 USDA Energy Council, report "Advancing Renewable Energy" highlights the Renewable Fuels Mandate, which requires a 500% increase in the use of renewable fuels to 36 billion gallons annually by year 2022. Similarly, the Federal Government Operations Mandate calls for a 30% reduction in energy consumption by federal government facilities by 2015.

Through its Rural Development grant and loan programs, the USDA implements commercialization strategies and supports agriculture producers and forest landowners, rural small businesses, electric cooperatives, and other rural investors in deploying renewable technologies such as ethanol, biodiesel, methane gas recovery, and wind, solar, and geothermal power. Moreover, USDA has demonstrated a commitment to the market adoption of renewable energy technologies as part of the mainstream energy grid. From 2001 through 2007, more than $674 million in USDA funds were distributed to 1,763 renewable energy research, economic development, and energy efficiency initiatives. These investments translated to an 80.3 million metric ton reduction of CO2 emissions and a savings/production of approximately 2.4 billion kilowatt hours of energy. In 2007, USDA committed nearly $75 million toward renewable energy programs, including research and development of cellulosic ethanol—a form of ethanol fuel created from switch grass, wood chips, and other woody biomass.

In recent years, NICCE and the USDA have partnered for the creation of green growth in rural areas creating jobs in local communities such as Southern Virginia.

2.6 State & Local Government Programs

While federal demand for clean and renewable energy is the main market driver in the clean energy economy, State and Local governments often control federal funds as well as local facilities, tax incentives, and other supports. Understanding those local structures is vital in gaining access to federal and state stimulus funding and tapping into the desire to attract "green collar" jobs to communities. These state and local communities represent distributed drivers of the clean energy economy. NREL has identified the "renewable portfolio standards" (RPS), regulations that require increased production of energy from renewable energy sources such as wind, solar, biomass, and geothermal for states around the country, as well as highlighting state renewable energy goals and solar-specific goals. The map below shows RPS goals.

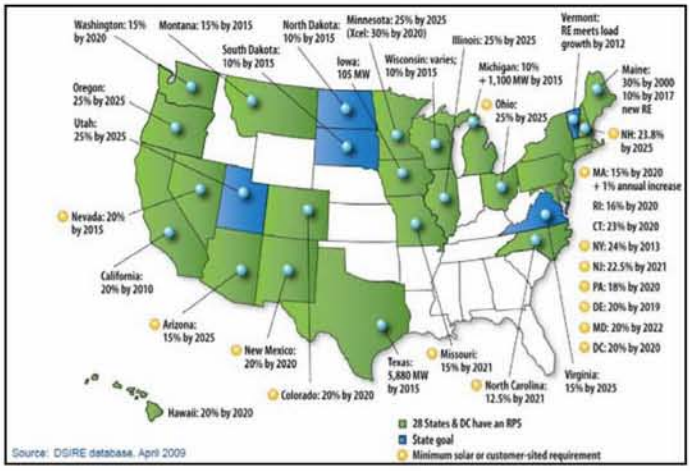

Figure 3. NREL Renewable Portfolio Standards [6]

In summary, by combining federal, state, and local demand, NICCE leverages all levels of government support, providing a wider network and reaching communities around the country while maintaining its national presence.

2.7 Industry

For industry, clean and renewable energy technology is becoming both economically and politically necessary as energy prices rise, governments implement more rigorous environmental standards, and consumers exert greater demand for clean, sustainable, and responsible business. While total investment in new clean energy generation capacity has outpaced conventional fossil fuels for the past two years in a row, the recent economic downturn has resulted in major reductions in venture capital investments, including in clean energy technology. Yet at the same time, investment in late-stage companies increased by 19%. Investment companies are making a clear move towards companies on the cusp of "crossing the chasm," exactly the point at which NICCE offers a distinctive commercialization process.

2.8 Consumer

Consumer demand for affordable clean energy technology is unequivocal. Energy companies are scrambling to clean up their brands. The recent BP oil spill only serves to reinforce public perceptions. However, the current economic climate-- from unemployment to foreclosures-- has consumers wary of rising energy costs. Clean energy will only be appealing to consumers if it is affordable, reliable, and convenient. The NICCE commercialization process captures this demand, focusing on economic and technological realities in order to evaluate potential clean energy technologies and identify markets.

3.0 DISCUSSION – NICCE BUSINESS MODEL

NICCE is building the Modeling and Simulation Center for Excellence near Washington, DC, in the Dulles Corridor and plans to have satellite facilities throughout the world that bring together inventors, investors, and local communities to enable the commercialization of clean energy technologies and the creation of "green collar" jobs around the United States.

NICCE identifies and cultivates entrepreneurial clean energy companies, taking them through a proven commercialization process based on strategic alliances with professional engineering and business service providers, modeling and simulation centers such as VMASC, advanced research laboratories, and potential investors. Companies progress through the NICCE commercialization framework with support from local NICCE-approved community-based clean energy business incubators. As these businesses mature, NICCE connects them with governmental, institutional, and private investors as well as manufacturing parties to bring secure, affordable, and clean energy technologies to market.

3.1 Next Generation Clean Tech Incubators

Historically, community-based business incubators target multiple industries and offer an array of generalized services to the companies within them to produce successful firms that will graduate from the program financially viable and freestanding. These incubator graduates have the potential to create jobs, revitalize neighborhoods, commercialize new technologies, and strengthen local and national economies." [7].

To reach this goal, incubators typically provide a set of services to help these companies reach self-sustainability and realize their market potential. With the help of NICCE, increasing numbers of organizations are going beyond this traditional set of incubation services to provide highly specialized technology business services, linking incubated companies with key R&D assets (national energy labs, universities, etc), and even providing capital investment. These organizations frequently have an economic development mission, and focus on a single industry or relatively narrow set of technology areas.

NICCE advances its model of enhanced incubator services further by remaining dynamic and flexible, tailoring its services and its own development trajectory to the rapidly evolving nature of the clean energy industry. With a better understanding of clean energy development, NICCE recognizes the need for sophisticated services to include modeling and simulation, third party energy validation, remote sensing services, a World Data Center on Energy, strategic finance alliances, product optimization, energy policy and government affairs, sales, marketing and business development augmentation. According to Research Triangle International, a group commissioned by NICCE, this new next generation incubator model is revolutionary and on target with the growing needs of the clean energy industry. Therefore, NICCE is developing a mega incubator called the National Capital Clean Energy Incubator to provide other incubators and their respective companies these services.

NICCE's national and international brand is sleek, accessible, and affordable with high ROI for its investors. NICCE's current customers believe that this model creates a value-added supply chain that is missing in the clean industry commercialization process today. These customers include semiconductor companies in smart grid, biofuels customers and grid watt level energy storage customers, to name a few.

3.2 Clean Energy Commercialization

While technology commercialization in general is well understood, clean energy commercialization poses a number of unique challenges. Extensive experience has led the NICCE management team to develop the following process for commercialization. Companies entering NICCE go through an extensive evaluation process to determine their position in the market and the services they need. In working with local NICCE approved incubators and through the NICCE strategic partnerships businesses get professional services support, modeling and simulation,

and other programs to help the companies cross the "chasm" and ultimately get to market.

NICCE management believes that it is uniquely positioned to provide commercialization services along the business development continuum, with an emphasis on identifying mid-stage companies that still require development but present a considerable investment opportunity. This mid-stage approach is captured well by a concept proposed by Geoffrey Moore in his book, "Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers." [8].

A recurring problem with new technology companies occurs after early adopters have proven the concept but before there is large-scale adoption. This marketing, development and financing gap always looms large in any new technology company's future. NICCE gets companies to the chasm and helps them across through partnerships, large-scale government contracts, and its investor relationships. NICCE evaluates whether companies are likely to succeed in the jump across "the chasm" and then helps them make that jump through the NICCE clean energy commercialization process (see Figure 4).

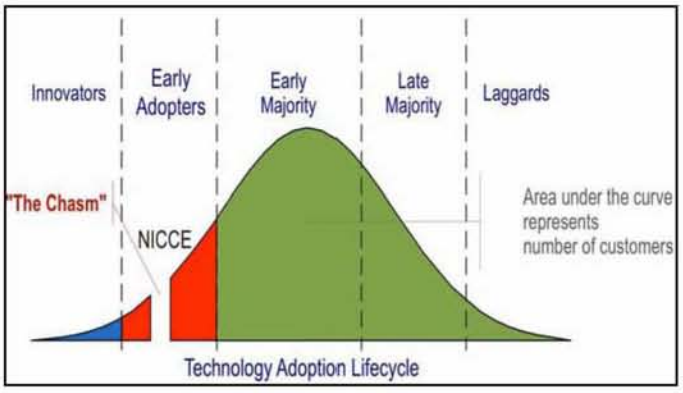

Figure 4. NICCE Commercialization Process.

NICCE's commercialization process begins with an evaluation—where does a given company sit on the commercialization spectrum? This allows NICCE to place the company at a given point along the process and identify the services and steps necessary to take that company to commercial success. The flow chart that follows illustrates that process.

The initial assessment is key in this process, as it establishes whether a company is ready to enter NICCE and whether it has any potential for commercialization. Three key questions NICCE asks during this phase are:

1. Is the technology best in class?

2. Can the company bring the technology to market within 36 months?

3. Is there a large-scale customer, like the DoD, a utility or NASA and can the company meet volume and profit targets?

By emphasizing this "entry test," NICCE can assure investors of validated opportunities while earning a reputation among start-ups for honest evaluation. This saves both inventors and investors time and money. Moreover, NICCE's sometimes takes an equity stake in member companies and it aligns the interests of all three parties—the success of a NICCE member translates into success for NICCE, its strategic partners, and its investors.

The commercialization process itself is the result of years of experience on behalf of the management team in starting, cultivating, and commercializing technologies and businesses. Each step is accompanied by a comprehensive package of services that experience has shown help a given company "cross the chasm" to commercialization and success.

4.0 CONCLUSION(S)

In conclusion, NICCE is leading the way toward a greener US economy. The models developed herein represent best practices

for clean energy commercialization and these practices ultimately will lead to job growth in local communities. Modeling and simulation, along with the World Data Center on Energy represent a value added service and much needed asset for all clean energy development. The private sector, along with national laboratories and universities must work hand in hand to grow this next generation industry. NICCE serves as a catalyst for these groups coming together to grow and develop a new wave of innovation in the US.

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6.0 ACKNOWLEDGMENT

Dr. Carole Cameron Inge, Chairwoman and CEO of NICCE developed the NICCE business framework and the models described in this paper, along with her colleagues at Virginia Tech University and Research Triangle International. Dr. Inge has been named one of the leading US women in energy and mot recently was the founder of the Virginia Tech Modeling and Simulation Center for Collaborative Technology, the first modeling and simulation center in the university's history. Dr. Inge serves on the US Under Secretary of Energy's Clean Energy Ministerial advisory taskforce called the Clean Energy Education and Empowerment and she is an international speaker and professor for the Practising Law Institute (PLI), a legal education organization chartered by the Regents of the University of the State of New York, founded in 1933.