Sunny Side Up

Characterizing the US Military's Approach to Solar Energy Policy

Varun Sivaram

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Advised by Professor Michael May and Professor Martha Crenshaw

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List of Acronyms

AAF – Auxiliary Airfield

ACC/A7 – Air Combat Command A7, Mission Support Energy Office

AFB – Air Force Base

AFCESA – Air Force Civil Engineering Support Agency

DoD – Department of Defense

ECIP – Energy Conservation Investment Project

EO – Executive Order

EPA – 2005 Energy Policy Act

ESPC – Energy Savings Performance Contract

GAO – Government Accountability Office

IEEE – Institute of Electrical and Electronics Engineers

LCOE – Levelized Cost of Electricity

NDAA – National Defense Authorization Act

PPA – Power Purchasing Agreement

PPBS – Planning–Programming–Budgeting System

QDR – Quadrennial Defense Review

RDT&E – Research, Development, Test, and Evaluation

REC – Renewable Energy Certificate

RPS – Renewable Portfolio Standard

SPIDERS – Smart Power Infrastructure Demonstration for Energy Reliability and Security

TVA – Tennessee Valley Authority

VFT – Value Focused Thinking

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Abstract

Since 2007, the Department of Defense (DoD) has invested considerable resources and research into deploying solar panels to power its domestic military bases. This thesis seeks to apply theoretical models of policymaking to explain the enactment, implementation, and revision of the DoD's solar energy policy. In none of these stages can an idealized rational actor model account for the military's decision-making process; the panels purport to enhance energy security but do not do so, they are expensive, and they appear to strive for but fail to achieve federally mandated renewable electricity targets. Kingdon's multiple streams analysis best accounts for the timing of the DoD's decision to pursue solar, due to an open "policy window" in 2005. Furthermore, theories of ritualistic bureaucratic compliance in hierarchies explain the haphazard pattern of implementation. Finally, bounded rationality and incrementalism correctly predict the DoD's incomplete decision-making process when revising solar energy policy to include secure microgrid technology. These insights can and should inform DoD officials to critically analyze the motivations behind pursuing solar technology, consider nonrenewable microgrids to meet their stated goals of energy security, and lobby Congress to either allocate more funding for expensive renewable technology or relax its mandates in light of national security concerns.

Chapter 1: Introduction

"The Department [of Defense] 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 fluctuations."

~Quadrennial Defense Review (QDR), 2010

The Puzzle

Since 2007, each of the Services has completed, begun construction on, or is finishing negotiations to build solar energy arrays at military facilities at a rate far higher than the civilian solar adoption rate. Anyone reasonably familiar with solar technology and its current and projected applications at military bases can offer the following insights:

1. Solar arrays, as currently deployed and given current technology, do not advance the operational effectiveness of a military base; the array simply feeds power back into the power grid and will not function in its absence.
2. Solar arrays are not the only way to reduce greenhouse gas emissions. It is unclear why the change in Department of Defense (DoD) policy from supporting civilian installations to building military owned solar arrays better reduces emissions.
3. Solar arrays may provide stable power prices, but at a high cost, since the technology is significantly more expensive than conventional fossil fuel combustion. Again, it is not clear why solar is the optimal choice over other electricity sources that do not use commodity fuels, such as wind power, geothermal, fuel cells, etc., or do not provide intermittent power as solar does.

Therefore, the puzzle that confronts an outsider, curious about the sudden interest in solar, is why this interest has blossomed at all, why it is happening now, and why the military's deployment of solar panels does not support its stated objectives. The policy relevance of solving such a puzzle should be clear: as the military continues to expand its solar deployment, the specific goals it intends to meet should inform the installation strategy employed. For example, if the goal is to increase operational reliability in the face of grid failure, solar must be coupled with energy storage and the capacity to operate off-grid. Alternatively, if the goal is to stimulate private solar adoption by using military installations as a test bed for driving down costs and spurring publicity, the installations should experiment with a variety of technologies and eschew expensive add-ons (like energy storage). And if there is no discernible goal or coherent set of goals that the Department intends to pursue, serious policy reflection is warranted. Given solar's prominence in the public discourse as a promising renewable technology, solar power projects lend themselves to retroactive rationalization or justification through futuristic platitudes. However, precision in defining the goals of solar can actually achieve benefits for the military.

2009 and 2010 saw an incipient DoD interest in integrating solar panels into self-sufficient "microgrids" that have the potential to improve on base energy security. This development presents another set of questions. Is renewable energy, like solar power, really the optimal way to power these microgrids? And what explains the time lag between investing in solar and then investing in renewable microgrids?

The phenomenon of DoD solar power adoption offers a chance to analyze every aspect of the policy process, from the initial emergence of problems related to electricity grid reliance to the evaluation and incremental revision of implemented policies. This paper seeks to explain the observed data using theoretical frameworks that have already been developed. Therefore, the analysis will not simply be ad hoc, but rather seek to classify the specific case of DoD solar adoption as an element of a larger set of phenomena predicted by the policymaking literature.

This chapter will introduce the reader to the historical and technical background of solar power and federal and military renewable energy policies. Subsequent chapters will introduce the theoretical literature and then apply it to explain the enactment, implementation, and revision of DoD solar energy policy.

Background

Solar Power

Solar power can refer to electricity generated using solar photovoltaic (PV) or solar thermal technologies. The former entails generating electricity from the interaction of solar radiation with a semiconducting material, commonly crystalline silicon, while the latter involves concentrating solar radiation to trap heat and subsequently powering a generator with that heat, for example by boiling water to drive a steam turbine.[1] Solar thermal installations benefit from economies of scale, while solar PV cost is generally constant or declining as the array size increases. Most solar power is connected directly to the transmission grid, which pools power from solar and other generating facilities for distribution.[2]

Although solar power installations are eligible for a 30% Federal Tax Credit, among other incentives, the cost of generating electricity from either PV or solar thermal technology, including incentives, is greater than that from conventional sources like natural gas or coal. A 2008 analysis computed the costs per kilowatt-hour of renewable sources, called the levelized

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[1] Technically, concentrated solar power (CSP) as described above is only one of many different ways to harness solar thermal energy – others include daylighting, solar walls, etc. For this paper we will use "solar thermal" to refer exclusively to CSP projects.
[2] Godfrey Boyle and Open University, Renewable energy (Oxford University Press in association with the Open University, 2004).

cost of electricity, and compared them to costs of coal and natural gas; given that the high-end estimate for coal refers to carbon capture, conventional, high emission fossil fuel combustion is clearly cheaper according to Table 1 below.[3] Note that peaking natural gas, referring to electricity dispatched to respond immediately to fluctuating demand, is by far the most expensive power compared to the other sources, called baseload power.[4]

Table 1-1 – Levelized Cost of Electricity by Source

Technology	Coal	Natural Gas (combined cycle)	Natural Gas (peaking)	Solar PV	Solar Thermal
Cost (cents/kWh)	7.8-14.4	7.4-10.2	22.5-34.2	16.0-19.6	12.9-20.6

Solar power is also less preferable to other electricity sources because of its cyclic and intermittent generation characteristics. Since it does not produce electricity by night and its output varies over the day, sometimes fluctuating rapidly as cloud cover changes, solar power introduces variability into the electricity grid that must be compensated for by expensive dispatchable power. However, an advantage of solar is its high power delivery during peak demand times (summer afternoons), which reduces peaking natural gas requirements. Therefore, the intermittency of solar power is roughly balanced by its peak power delivery, and a comparison of levelized cost of electricity with conventional sources is reasonably instructive.

Recently, the potential for distributed sources of generation, like solar power, to provide emergency backup power has been investigated. In order to act as an "islanded microgrid" in the event of a grid blackout, the solar array must be configured to operate without the grid, and some form of energy storage must exist to provide power at night and to smooth out intermittencies

[3] Levelized Cost of Energy Analysis (Lazard, Inc., February 2008).
[4] There is actually significant variability in this statistic, since the price of dispatchable power depends on many factors such as the level of peak demand, etc. For our purposes, this summary statistic is adequate to convey that peaking power is significantly more expensive than baseload power, even given its cost volatility.

from the solar array. The former requirement is best met if an active control system detects loss of grid power and dynamically transitions to islanded operation. Several papers have identified active grid detection schemes and mechanisms to accomplish a seamless transition, but no large scale systems have successfully implemented an "intentional islanding" scheme.[5] In fact, in most states, interconnection regulations require that any distributed generation source shut down in the event of a grid fault, in order to protect utility workers from electrical hazard. The second requirement for an islanded microgrid, energy storage, is prohibitively expensive at present. Various alternatives to expensive lead-acid batteries are under consideration, such as compressed air storage, but according to current estimates, a fully complementary storage system would more than double the cost of a solar power installation.[6] Therefore, public regulation, technological hurdles, and economic costs have prevented commercialization of solar power systems capable of serving a back-up function in the event of grid failure.

Federal Policy

Over the past decade, the executive and legislative branches have imposed increasingly stringent mandates upon cabinet level agencies to advance renewable energy. In 1999, President Clinton's Executive Order 13123, *Greening the Government Through Efficient Energy*,

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[5]References used:
H. Zeineldin, E.F. El-Saadany, and M.M.A. Salama, "Intentional islanding of distributed generation," in Power Engineering Society General Meeting, 2005. IEEE, 2005, 1496-1502 Vol. 2, 10.1109/PES.2005.1489218.

I.J. Balaguer et al., "Survey of photovoltaic power systems islanding detection methods," in Industrial Electronics, 2008. IECON 2008. 34th Annual Conference of IEEE, 2008, 2247-2252, 10.1109/IECON.2008.4758306.

David Watts, "Security & Vulnerability in the Electricity Grid," in (presented at the 25th North American Power Symposium, University of Missouri-Rolla, 2003), 559-566.

R. A. Walling et al., "Distributed generation islanding-implications on power system dynamic performance," in 2002 IEEE Power Engineering Society Summer Meeting, vol. 1, 2002.

Z. Ye and others, Facility Microgrids, 2005.

[6] K. Zweibel, J. Mason, and V. Fthenakis, "A solar grand plan," Scientific American Magazine 298, no. 1 (2008): 64–73.

mandated that the federal government install 20,000 solar energy systems by 2010.[7] This particular mandate was not very strong because individual agencies were not assigned goals to meet, and the renewable electricity requirement was not formulated in terms of output power.

In 2005, Congress passed the landmark Energy Policy Act (EPA), which established the tax credit incentive for solar power and also imposed tougher requirements on federal agencies. Under the EPA, each agency had to generate 3% of its power from renewables between 2005-2007, 5% between 2007-2013, and 7.5% thereafter. Subsequently in 2007, President Bush's Executive Order 13423 stated that at least half of statutorily mandated renewable power must be generated using sources that went into operation after 1999. Finally, the 2007 National Defense Authorization Act (NDAA) for FY 2007 required that the Department of Defense generate 25% of its electricity from renewables by 2025.[8]

To meet its statutory renewable portfolio requirement, the Department of Defense must acquire Renewable Energy Certificates (REC's), each of which is allocated to the producer of 1 MWh of renewable electricity. An REC can be sold with or without its associated energy, a transaction of the former variety constituting bundled energy and the latter, unbundled energy. Therefore, the DoD can pursue one of the following options to increase its proportion of renewable electricity as counted under the EPA and 2007 NDAA:

1. Purchase electricity and the REC's (bundled power) from a privately owned renewable source.
2. Purchase only the REC's from a privately owned source (and acquire electricity to power a base from elsewhere).

[7] Executive Order 13123—Greening the Government Through Efficient Energy Management, June 8, 1999.
[8] DOD Needs to Take Actions to Address Challenges in Meeting Federal Renewable Energy Goals (Government Accountability Office, December 2009).

3. Consume electricity from a renewable facility on federal land, and retain the REC's.
4. Consume electricity from a renewable facility on federal land, sell the REC's, and buy "replacement" REC's from a private source.

For renewable electricity generated and consumed on site, a "bonus" equal to the amount of the consumed power is awarded to the DoD for retaining the REC's; however, no renewable generation can be claimed if the REC is sold and a replacement certificate is not bought. Therefore, any on-site installation counts for either twice as much energy as it generates, or none at all. One final note: generation sources that are owned by a private party, but operated on federal land, qualify for scenarios (3) or (4). The upshot of this convoluted system is that the renewable contribution from an on-site generation facility is double-counted, compared to purchase of unbundled REC's, presumably to compensate for the capital cost of the on-site installation. However, the rule that the installation merely has to lie on federal land without necessarily being owned by the federal government allows power purchase financing agreements that enable the DoD to avoid capital costs and still achieve double counting. Selling on-site REC's and buying replacement REC's offers a further opportunity for the DoD to arbitrage price differences in REC's across state boundaries.[9]

DoD Renewables Initiatives

Until 2005, the DoD's renewable energy strategy largely consisted of buying REC's from private renewable power producers. Between 2000 and 2004, the percentage of power consumption from renewable sources (counting REC's) increased from 0.5% to 1.6%. In 2005, the proportion rose to 4.8%, and the DoD began investing more in on-site renewable projects. As

[9] GAO, 2009.

of 2010, the DoD reports that out of 452 total on-site renewable projects, 69% are solar power installations, most of them using PV technology.[10]

In 2007, Nellis Air Force Base was equipped with a 14.2 MW solar PV array, then the largest in the country, and the first large-scale DoD solar power project.[11] The Air Force has subsequently expressed interest in the potential for solar PV at other bases with high insolation. The Air Force agreed earlier this year to construct a 17 MW installation at Luke AFB in Arizona, and negotiations are under way to deploy 20 MW at Davis-Monthan AFB in Arizona and over 500 MW in Fort Irwin, in the Mojave Desert. In May, the Navy followed suit, announcing $200 million for solar installations at bases in the Southwest. [12]

The DoD also recently announced a program, "Smart Power Infrastructure Demonstration for Energy Reliability and Security"(SPIDERS), which aims to construct a fully islanded PV microgrid at Camp Smith, Hawaii, as a model for intentional islanding PV systems at other military bases. While the budgeted $40 million in funding has not yet been released for the project, it aims to complete the Hawaiian installation by 2013 and then "transition [the technology] to DoD and industry."[13]

However, in 2009 the Government Accountability Office (GAO) reported that the DoD was not making sufficient progress toward its mandated goal of 25% renewable proportion by 2025; the DoD itself testified that it was "not even close to meeting [its] interim target."[14] Additionally, the DoD does not have a unified, comprehensive plan for achieving its target

[10] Anthony Andrews, Department of Defense Facilities Energy Conservation Policies and Spending (Congressional Research Service, 2009).
[11] "Nation's Largest Solar PV System Takes Flight at Nellis Air Force Base," Air Force Press Release, December 17, 2007.
[12] Scott Streater, "Renewable energy: Pentagon's 25M acres could ease renewables siting debate," E&E News, December 3, 2009, http://www.eenews.net/public/Landletter/2009/12/03/1.
[13] George Ka'iliwai, SPIDERS: Energy Security JCTD Proposal, Brief (Department of Defense, n.d.).
[14] GAO, 2009.

portfolio, instead relying on the initiative of the individual services to pursue renewable projects. Furthermore, individual bases are afforded great latitude in deciding whether and how to implement a renewable project, without clear guidance on which DoD energy security or climate change goals they should be upholding. Therefore the picture of DoD renewable initiatives, according to the GAO, is a decentralized, haphazard one as the various services and individual bases strive to follow ambiguous high-level guidelines.[15]

Looking Forward

This chapter introduced the basic facts behind the DoD's solar energy policies. Recall that this thesis aims to explain the enactment, implementation, and revision of these policies. Therefore, we pose the following questions that subsequent chapters will aim to answer.

1. What explains the DoD's decision to begin to widely pursue on-site solar power installations?
2. What explains the Air Force's implementation of the solar power directive?
3. What explains the DoD's recent interest and investment in renewable microgrids?

The background above offers some hunches about the answer to question 1. Surely federal renewable mandates played some role in motivating DoD solar adoption. However, it is still unclear how federal mandates fit together with the DoD's desire to improve on-base energy security and why solar was favored over other renewable and nonrenewable options. We restrict question 2 to a particular military service in order to deal with a tractable data set and make observations at the base level. This question challenges us to explain why the Air Force's deployed solar arrays do very little to enhance energy security, and also why it failed to report many eligible renewable kilowatt-hours of energy toward federal mandates. Finally, the third question asks why the military decided to combine renewable energy and base microgrids, given

[15] GAO, 2009.

that nonrenewable microgrids are arguably cheaper and easier to widely deploy. The next chapter will introduce the theoretical literature necessary to answer these questions.

Chapter 2: Theoretical Frameworks for Real Policymaking

The clearest way to explicate the policy process literature is to begin with a simple but widely discredited theory, the *Stages model* of policymaking (which roughly corresponds to Allison's first model of governmental decision, the Rational Policy model). The Stages model partitions the policy process into six distinct and sequential steps:

1. Issue Emergence
2. Agenda Setting
3. Alternative Selection
4. Enactment
5. Implementation
6. Evaluation

Moreover, the Stages model assumes that policymakers examine all possible data and policy alternatives when moving through the above stages; the goal is to achieve "maximum social gain" through the eventual policy outcome.[16]

Birkland notes that while the Stages model may have educational value, "the model is often set up as a straw man against which other models of decision making are compared."[17] To see why, consider that under this idealized model, an event like an earthquake should not precipitate sudden policy change because the actual disaster probably did not improve the scientifically determined latent earthquake risk. The Stages policymaker is already aware of all relevant seismologic data and would not require a natural disaster to alert him to the threat of future disasters. Similarly, under the Stages model, the policymaker will exhaustively investigate and rank order every possible alternative policy. Finally, the Stages model predicts that policy

[16] T. R Dye, Understanding public policy (Prentice Hall, 1992). 33.
[17] T. Birkland, An introduction to the policy process: Theories, concepts, and models of public policy making (ME Sharpe, 2010). 210.

brainstorming does not even start until the appropriate issue has emerged and officials have decided to tackle it.

The literature rejects all three of these predictions. Before introducing more sophisticated alternative models, we review some definitions. Cobb and Elder classify the various types of agenda—a set of issues or topics—that are increasingly narrow subsets of issues as one moves through the Stages model.[18] The *agenda universe* is the complete set of all conceivable topics of discussion. Next we consider the *systemic agenda*—a subset of the agenda universe that eliminates unreasonable topics (for example, the advancement of genocide)— as the pool of issues for the "issue emergence" stage. From the systemic agenda, Stages model policymakers select the *institutional agenda*—"that list of items explicitly up for the active and serious consideration of authoritative decision makers"—during the "agenda setting" stage. Next in the Stages model, policymakers formulate alternative policies to form the *decision agenda*, the set of policy options about to be acted on by a governmental body (e.g. legislation on the House floor).

A central theme in the literature is the winnowing of the systemic agenda to the institutional agenda and then to the decision agenda.[19] The Stages model postulated an exhaustive search and evaluation algorithm to do the job, but Schattschneider disagrees, arguing that "the definition of the alternatives is the supreme instrument of power."[20] He posits that a group, either a formal political actor or informal pressure group, can shape the institutional and decision agendas through conflict with proponents of the status quo. By dissenting, and *expanding the scope of that dissent or conflict* by appealing to other audiences, like the media or

[18] R. W Cobb and C. D Elder, Participation in American politics: the dynamics of agenda-building (Johns Hopkins Univ Press, 1983). 85.
[19] The literature calls this whole process "agenda setting," which is confusing because it corresponds to the "issue emergence" and "agenda setting" phases of the Stages model.
[20] E. E Schattschneider, The semisovereign people: A realist's view of democracy in America (Holt, Rinehart and Winston, 1960), 66.

the general public, a group can force the relevant decision maker to consider an alternative he would not otherwise include on the agenda. Baumgartner and Jones concur, applying the term *venue shopping* to the process whereby a dissenting party tries to broaden the scope of conflict by appealing to an audience most likely to be favorable.[21] Finally, Gaventa remarks that

> If alternative selection is key to the projection of political power, an important corollary is that powerful groups retain power by working to keep the public and out-groups unaware of underlying problems, alternative constructions of problems, or alternatives to their resolution.[22]

This statement presents a neat segue to Baumgartner and Jones' general model of policymaking, known as *Punctuated Equilibrium*, the first complete alternative model to the Stages model that we will consider.

Punctuated Equilibrium

In *Agendas and Instability in American Politics*, Baumgartner and Jones borrow the term punctuated equilibrium from evolutionary biology to describe the rapid bursts of activity and long intervening periods of stability that characterize policy. The periods of stability, they argue, are due to the existence of *policy monopolies*, "which attempt to keep problems and underlying policy issues low on the agenda." Birkland continues:

> Policy communities use agreed-upon symbols to construct their visions of problem, causation, and solution. As long as these images and symbols are maintained throughout society, or remain largely invisible and unquestioned, agenda access for groups that do not share these images is likely to be difficult; change is less likely until the less powerful group's construction of the problem becomes more prevalent.[23]

Policy change, therefore, only occurs when the policy monopoly is broken down. Through venue shopping and conflict scope expansion, opposition groups infrequently succeed in reframing the

[21] F. R Baumgartner and B. D Jones, Agendas and instability in American politics (University of Chicago Press, 2009), 36.
[22] J. Gaventa, Power and powerlessness: Quiescence and rebellion in an Appalachian valley (Univ of Illinois Press, 1982)
[23] Birkland, 177.

institutional and decision agendas, resulting in dramatic policy reversals. Crucially, "increased attention is normally negative attention to a problem, leading to calls for policy change to address the problem highlighted."[24] Baumgartner and Jones also briefly discuss an alternative mechanism for rapid policy change: positive attention given to an issue which propels constructive policy. They are less specific about the actual dynamics of the policy change in these cases, where policy monopoly breakdown is not the driver behind policy change.

Baumgartner and Jones famously apply punctuated equilibrium to explain the abrupt reversal of policies conducive to nuclear energy expansion in the US. Initially, the nuclear policy monopoly consisted of utilities, construction companies, civil and military nuclear interests, the Atomic Energy Commission (AEC), and the Joint Committee on Atomic Energy (JCAE). However in the 1970's, as the public and credible, influential groups like the Union of Concerned Scientists voiced safety concerns, the JCAE was disbanded, the AEC broken up and the Nuclear Regulatory Commission set up. As the monopoly broke up, the pace of nuclear construction halted, a stable equilibrium that has persisted since.[25]

Punctuated equilibrium therefore generates the following observable implications. A significant shift in policy should be associated with the breakup of some policy monopoly, precipitated by an opposition group broadening the scope of conflict or otherwise venue shopping. Negative attention on some problem should be the key instigator for shocks to the equilibrium. Finally, as a corollary to the above implications, the failure of a policy reversal to occur can be attributed to the inability of opponents to set the agenda by breaking up the policy monopoly.

Bounded Rationality and Incrementalism

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[24] Baumgartner and Jones, 23.
[25] Baumgartner and Jones, 59.

March and Simon coined the term *bounded rationality* to refer to policymakers' finite information processing capacity.[26] Baumgartner and Jones incorporated their insights into their own theories, characterizing policymaker decisions as "incomplete and driven by severe limits on their attention spans."[27] This presents another response to the Stages model conception of agenda setting (where policymakers rationally narrow the systemic agenda through exhaustive analysis); recall that Schattschneider noted that power struggles can drive agenda setting. Bounded rationality predicts simply that incomplete analytic capacity distances actual agenda setting from the predictions of rational theories.

Lindblom argues that incrementalism describes policymaking better than the Stages model's exhaustive search for institutional and decision agenda items. Incrementalism "takes existing reality as one alternative compares the probable gains and losses of closely related alternatives by making relatively small adjustments in existing reality."[28]

Birkland, expanding on Lindblom's incrementalism, explains that

> It uses and builds on what is already known, without relying on reanalyzing everything about what is currently being done. In this way, the incremental method allows the decision maker to take a fair number of short cuts: it eliminates the need to explicitly separate means from ends, to pick the analytically "best" policy, and to rely heavily on theories that the decision maker may have neither the time nor the inclination to use.[29]

Together, bounded rationality and incrementalism present a *path dependent* model of agenda setting and policymaking. Since later policy revisions are dependent on initial agenda choices, officials acting early on an issue can have a disproportionate impact on later decisions related to that issue. The key implication of these concepts is that policymakers do not 'start from scratch'

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[26] 1. J. G March and H. A Simon, Organizations (John Wiley & Sons Inc, 1958).
[27] Baumgartner and Jones, xxiii
[28] Robert Alan Dahl and Charles Edward Lindblom, Politics, economics, and welfare (Transaction Publishers, 1953). 82.
[29] Birkland, 212.

at each iteration of some policy—they rely on previous decisions to set future agendas. Bounded rationality and incrementalism are a significant improvement over the Stages model because they offer alternatives to unrealistic and highly idealized predictions.

Graham Allison, in his 1969 article *Conceptual Models of the Cuban Missile Crisis*, offered two contrary models to the Stages model.[30] The first (Model II), Organizational Processes, relies heavily (albeit not explicitly) on bounded rationality and incrementalism. Allison asserts that organizations act according to Standard Operating Procedures, heuristic routines that are context-independent. This allows an organization to respond to emerging issues, perhaps with limited effectiveness but within information processing constraints, and make decisions in a timely manner. Allison's other model (Model III), Government Politics, has more to do with Schattschneider's or Baumgartner and Jones' theories, attributing slow decision making to "a high degree of fragmentation and competition" in American politics. We neither expand on this model nor on Sabatier's related Advocacy Coalition Framework model[31] because the phenomenon we are concerned with, military solar energy policy, does not exhibit much competition or fragmentation within an agency (e.g., the Department of Defense).

Allison's introduction of Models II and III helped spur research into deviations from the rationality of the Stages model, including insights specifically developed for the military. Sabrosky (et al) refers to the military as an "organized anarchy," asserting that any systematicity in the decisions of the military are *post factum* rationalizations of the actions (this prefigures this paper's account of military investment in solar power). Sabrosky applies Model II's Standard Operating Procedures to describe the military's budget as a ratchet, because officials rationalize

[30] G. Allison, "Conceptual Models and the Cuban Missile Crisis," American Political Science Review 63, no. 3 (1969): 689-718.
[31] See: Paul A. Sabatier, "An advocacy coalition framework of policy change and the role of policy-oriented learning therein," Policy Sciences 21, no. 2 (1988): 129-168.

existing programs as a rule, irrespective of their merit.[32] He subsequently appeals to Model III to account for military parochialism between the Services; together, Sabrosky asserts, Allison's models predict and explain suboptimal military policy outcomes.

Rhodes reforms Sabrosky's broad-brush painting of the military as parochial, arguing instead that Allison's Model III—"where you stand depends on where you sit"—should be replaced by an idea-based model where policymaker objectives depend on their personal ideals.[33,34] Rhodes analyzes budgetary allocations in the Navy and fails to find confirming evidence that the allegiance of the Chief Naval Officer results in a predictably parochial budget.

Bendor and Hammond have also criticized Allison's models, asserting that they are an oversimplification both of the policymaking process and of the logical space encompassing possible models of policymaking.[35] Their objections are too numerous to enumerate here, but some critiques apply particularly to the subject matter at hand. First, Bendor and Hammond challenge conventional (and Allison's) wisdom that the rational actor model is a simple, straightforward construction. For example, the Stages model implicitly assumes that the actor is motivated to achieve a single objective; however, there is nothing irrational about having several prioritized objectives, and the modeling gets considerably more complicated. Moreover, Bendor and Hammond accuse Allison of conflating decision theoretic and game theoretic aspects of the Model I (or Stages) Actor. Recall that our definition of the Stages Actor stipulated a policymaker who maximized some utility function, like social good. This is a decision-theoretic account, which Bendor and Hammond contrast with game theoretic dynamics. A rational policymaker

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[32] A. N Sabrosky, J. C Thompson, and K. A McPherson, "Organized anarchies: military bureaucracy in the 1980s," The Journal of Applied Behavioral Science 18, no. 2 (1982): 137.
[33] Edward Rhodes, "Do Bureaucratic Politics Matter?: Some Disconfirming Findings from the Case of the US Navy," World Politics 47, no. 1 (1994): 1–41.
[34] Allison, 711.
[35] J. Bendor and T. H Hammond, "Rethinking Allison's models," The American Political Science Review 86, no. 2 (1992): 301–322.

placed in a game theoretic setting, say a Prisoner's Dilemma, may choose the outcome that does not maximize social utility because that outcome is a Nash equilibrium. Extending this, there may be multiple Nash equilibria or none, so the social utility stipulation is basically meaningless.

Next, Bendor and Hammond critique Allison's Model II, especially Allison's assumption that Standard Operating Procedures generate simple, predictable results. On the contrary, consider the simplicity of the rules of chess and the enormous number of available moves; similarly, Allison's Model II assumption that an organization is constrained by some set of rules does not make it much easier to predict the organization's behavior. We will utilize this insight later to explain why military bases, constrained by the single rule to invest in solar power, still exhibit large variation in their implementation of the policy. In other words, procedural compliance is compatible with a wide range of outcomes.

Where does this leave us? With respect to applying Allison's models to the military, Model II seems to stand on stronger footing than Model III; Rhodes' rebuttal to Allison and Sabrosky is empirically strongest and at a minimum leaves one in doubt as to the explanatory relevance of parochialism to military policymaking. Finding no clear discrepancies in the various Services' attitude toward solar power, we conclude that it is safe to exclude parochialism and Model III from the present analysis. Model II, however, which deals with organizational routines, was reinforced by Sabrosky, ignored by Rhodes, and will be supplemented by Peters in following sections. Therefore, this paper will take Model II seriously, albeit with Bendor and Hammond's caveat. Finally, Bendor and Hammond's critique of Model I means that there is more to being a rational actor than one might expect. Notably, a rational actor can have multiple priorities. Therefore, whenever this thesis purports to demonstrate that a policy deviates from the

Stages model, we endeavor to prove that even if the policymaker had multiple rank-ordered priorities, the observed policy would still not make sense.

Multiple Streams

In *Agendas, Alternatives, and Public Policy*, Kingdon rejects the Stages model assumption that treats a government agency, Congress, or other policymaking body as a linearly thinking actor. [36] Instead of following a sequential progression of stipulating priorities and goals, identifying problems, formulating solutions, and finally appraising political feasibility, Kingdon's policymakers pursue the latter three steps simultaneously without ever forming consensus on overall goals. These three concurrent "streams"—problems, policies, and politics—may coincide to form a brief "policy window," by which Kingdon means appropriate problems and proposed solutions are matched under favorable political conditions and thus translated into public policy. This model builds upon the *garbage can* model introduced by Cohen, March, and Olsen, who liken policymaking to the mixing of problems, solutions, and participants streams in a garbage can—i.e., in some unpredictable and haphazard manner.[37] Kingdon's primeval soup of policies, explained below, resembles the garbage can imagery, but Kingdon's model is made more robust by explicitly adding a political dimension to the agenda setting process. Kingdon also comments specifically on cabinet-level agencies, such as the Department of Defense, asserting that:

> The president's priorities – once they are made clear – set the policy agendas for his appointees. … The appointee finds it prudent to bend with the presidential wind. …On occasion, cabinet secretaries and other presidential appointees attempt to curry favor with the White House by anticipating what the president would like to see and then moving decisively on a proposal that will win

[36]John Kingdon, *Agendas, Alternatives, and Public Policies (Longman Classics Edition) (2nd Edition)* (Longman, 2002).
[37] M. D Cohen, J. G March, and J. P Olsen, "A Garbage Can Model of Organizational Choice," Administrative Science Quarterly 17, no. 1 (1972): 1–25.

> presidential approval and gratitude, even though the president did not order such action.[38]

Kingdon thus provides a framework for evaluating the military's decision to pursue solar. By analyzing the three streams—problems relating to current energy policy, proposed solutions including on-site solar and alternatives, and political conditions conducive to certain policies—we may be able to identify a policy window at the confluence of the three streams that explains the decision to pursue solar and its timing. If the Stages model fails to explain DoD policy, this policy window analysis might fill the explanatory gap.

After Kingdon's work, the problem stream idea was further elaborated in an effort to identify why and when certain problems are identified over other potential issues. Schon and Rein argue that salient problems emerge as a result of issue framing. They state:

> From a problematic situation that is vague, ambiguous and indeterminate, each story selects and names different features and relations that become the "things" of the story -- what the story is about. Each story places the features it has selected within the frame of a particular context.[39]

Deborah Stone concurs, noting that:

> Problem definition is a matter of representation because there is no objective description of a situation; there can only be portrayals of people's experiences and interpretations. Problem definition is strategic because groups, individuals, and government agencies deliberately and consciously design portrayals so as to promote their favored course of action.[40]

Therefore a "frame" is a choice of how to view a problem, chosen either subconsciously or strategically. It involves an implicit prioritization of values and an emphasis on certain facts over others that drive alternative selection. For example, fossil fuel energy consumption can be framed as an environmental problem or a security problem, with correspondingly different sets

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[38] Kingdon, 32.
[39] Donald A. Schön and Martin Rein, Frame reflection: toward the resolution of intractable policy controversies (Basic Books, 1995), 26.
[40] Deborah A. Stone, Policy paradox and political reason (Scott, Foresman, 1988).

of possible solutions—energy generated from imported natural gas may ameliorate emissions from coal but not energy security. Rochefort contributes a taxonomy of problem characteristics, suggesting severity, incidence, novelty, proximity, and crisis as attributes that are each positively correlated with the recognition of a particular problem.[41] His final variable, crisis, relates to Kingdon's concept of a "focusing event," which is a high profile event that brings public and policymaker awareness to a problem.[42] To summarize, the problem stream consists of problems identified by policymakers on the basis of various attributes, among them focusing events, and framed such that particular goals are prioritized above others causing some solutions to appear normatively superior.

Concurrently, policies are being formulated, often without explicit problems to address and simply as a result of policymakers' desire for action, according to Kingdon.[43] Kingdon's conception of the policy stream resembles a "primeval soup" of policies that are suggested by thinktanks, politicians, and interest groups, each with its own agenda and none necessarily acting in reference to any commonly agreed upon problem. Indeed, Kingdon characterizes these motive-less policies as solutions in search of problems. Especially important to energy policy, Peter Haas identifies another important actor in the policy proposal process – a scientific epistemic community, consensus among whom can often be a powerful policy motivator (for example, in the case of the 1987 Montreal Convention that banned ozone-damaging chlorofluorocarbons).[44]

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[41] David A. Rochefort and Roger W. Cobb, "Problem Definition, Agenda Access, and Policy Choice," Policy Studies Journal 21, no. 1 (3, 1993): 56-71.
[42] Kingdon, 41.
[43] Kingdon, John. "The Reality of Public Policy Making." *In* Marion Danis et al., Ethical Dimensions of Health Policy (Oxford University Press US, 2005).
[44] Peter M. Haas, "Banning Chlorofluorocarbons: Epistemic Community Efforts to Protect Stratospheric Ozone," International Organization 46, no. 01 (1992): 187-224.

Finally, there is the political stream, which is an umbrella term describing the institutional dynamics that either obstruct or conduce to a particular policy's implementation. McCombs and Shaw suggest that a sympathetic mass media can raise awareness and support for a particular problem-policy pair and thus facilitate its passage.[45] Kingdon also identifies electoral landslides and interest group pressure as factors that drive the direction of the political stream. In the case of a cabinet-level agency enacting policies, an auspicious political stream can consist of Presidential and/or Congressional directives, as noted above by Kingdon.

Renewable Energy Policymaking

The literature concerning renewable energy agenda setting is relatively young and sparse, but two prominent analyses invoke many of Kingdon's concepts. The first, by Laird, concludes that problem framing and the policy stream are important analytical tools to understand fluctuating historical interest in renewable energy.[46] Moreover, since renewable energy policy necessarily entails futuristic predictions of technological innovation, consumer demand, and uncertain variables, rational decision procedures are difficult to formulate. Therefore, policies flowed from framing of the energy problem as an economic or security issue, and when the two frames coincided in their normative recommendations when oil prices spiked in the 1970's, a policy window opened for investment in renewables.

Rowlands examines contemporary renewable policy, applying Kingdon's multiple streams approach to Ontario's renewable electricity policy.[47] According to Rowlands, consideration of the problems related to fossil fuel generation cannot explain the timing of the government's Renewable Portfolio Standard (RPS), whereby it imposed a requirement on

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[45] Maxwell E. Mccombs And Donald L. Shaw, "The Agenda-Setting Function Of Mass Media," Public Opinion Quarterly 36, no. 2 (June 20, 1972): 176 -187.
[46] Frank N. Laird, Solar energy, technology policy, and institutional values (Cambridge University Press, 2001).
[47] I. H Rowlands, "The development of renewable electricity policy in the Province of Ontario: The influence of ideas and timing," Review of Policy Research 24, no. 3 (2007): 185–207.

utilities to generate a proportion of their electricity from renewables. Using multiple streams analysis, identifying the confluence of environmental and public safety concerns, a policy stream that had previously floated the idea of an RPS, and the Liberal Government's election in 2003, Rowlands concludes that a policy window opened in 2004 to facilitate implementation of the RPS policy. Taken together, these two studies of renewable energy in historical and contemporary contexts suggest that multiple streams is a powerful analytical tool that fills the explanatory gap when rational actor theory cannot explain an energy policy.

Interaction of Politics and Bureaucracy

Sabatier criticizes Kingdon's streams model for failing to give a complete account of the policymaking process.[48] Multiple streams may well explain when the time is ripe for policy change (when a policy window opens), but it does not explain what happens after the window opens nor does it delve into the mechanics of policy making. To make an analogy, multiple streams analysis is a thermodynamic account, explaining the favorability of circumstances to a particular policy development; it requires a kinetic explanation of the process that an organization undergoes in making a decision, implementing it, and revising it.

This thesis deals with decision-making by a bureaucratic organization, the Department of Defense. This bureaucracy is largely staffed in an apolitical manner, except for some officials at the top of the organizational hierarchy. Furthermore, the DoD derives its funding from a political body, the Congress. The decision-making dynamics of this scenario—a bureaucracy funded by a political body— have been well studied in the literature and we can make use of several theoretical predictions. The literature classifies those predictions pertaining to the internal

[48] Sabatier, Paul A. (1991). "Toward Better Theories of the Policy Process," *PS: Political Science and Politics* 24 (June): 147-156.

organizational behavior as *Bureaucratic Politics,* and those related to interaction between Congress and an executive agency as *Executive-Legislative Relations*.

First we consider the internal dynamics of the organization. Recall that Allison discussed SOP's as a driver of bureaucratic decision-making; Peters furthermore asserts that the hierarchical structure of bureaucracies and absence of self-evaluation mechanisms affect the quality of information available to policymakers. Information, he argues, is distorted in both directions of travel within the hierarchy. Subordinates tweak information to please superiors as information travels upwards. [49] And, crucial to understanding why policies are implemented the way they are, "there is a tendency to comply ritualistically with rules and directives while possibly subverting the real purposes of the organization."[50] Recall Bendor and Hammond's insight that ritualistic compliance with a set of rules still leaves considerable variety of possible policy outcomes. This will be crucial to understanding how military bases complied with existing guidance and innovatively dealt with the other, unconstrained, variables to collectively defeat any overriding purpose to DoD solar policy.

Finally, the dearth of accurate self-evaluation metrics for bureaucracies, in contrast to the corporate balance sheet, means that:

> Public organizations lack any ready mechanism by which to judge their effectiveness and consequently have nothing that can trigger "search activity" to find a better organizational framework.

Internal bureaucratic structure therefore does not benefit from any feedback improvement mechanism, according to Peters.

In constructing a model for a particular bureaucracy, it seems logical to incorporate other bureaucracies as relevant variables in the model; however, this threatens to make the models

[49] B. G Peters, The politics of bureaucracy (Psychology Press, 2001). 127.
[50] Peters, 126.

very complex, because the number of inter-bureaucratic interactions increases rapidly as we consider more agencies.[51] Luckily, Goodin rejects the intuitive prediction that multiple agencies, all vying for funds out of the same common budget, will engage in all-out competition. Rather,

> A model of bureaucratic politics [approaches] a satisficing model. The agencies are in competition, but this competition is limited by the costs of that competition to the preservation of the relative position of the agency and its control over central policy concerns.[52]

Therefore, he argues, bureaucracies will only fight for funds if they relate to central organizational interests, and otherwise they will generally accept political budget decisions so long as the allocations reasonably protect the status quo. In building a model of bureaucratic politics, it suffices to consider only one bureaucracy at a time.

Finally, we come to the actual interaction between the political body and the bureaucracy, a dynamic that is commonly characterized as a competition. The bureaucracy's goal is to secure as much funding as possible for core programs, and the political body's objective is to ensure accountability for its funds and limits on unnecessary expansion of the bureaucracy. Each side exploits its inherent advantages by using the following strategies. Bureaucracies often have more technical expertise and are therefore able to present complex data justifying their financial requests that the politicians must accept.[53] Building on this technical superiority, bureaucracies often engage in a PPBS (Planning-Programming-Budgeting System), which basically requests budgets for programs instead of specific line items. This allows bureaucracies more latitude in their allocation of spending between line items; additionally, staff limitations of the political

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[51] The number of interactions goes as $(n^2-n)/2$, where n is the number of agencies

[52] Peters, 175. Also see R. E Goodin, "The logic of bureaucratic back scratching," Public choice 21, no. 1 (1975): 53–67.

[53] J. Higley, K. E Brofoss, and K. Groholt, "Top Civil Servants and the National Budget in Norway," The Mandarins of Western Europe (1975): 253–274.

bodies result in delegation of program reviews to the bureaucracy itself. Therefore, the bureaucracy can leverage program review results to ask for even more funding.

Political bodies try to counteract the technical superiority of agencies by creating special budgetary institutions that also have expertise but report to the political body (e.g., the White House's Office of Budget and Management). [54] Peters also notes that "even issues of a technical nature, when injected into the view of the public (and the politicians) may require nonbureaucratic resolution." Therefore, political bodies may try to use public opinion to regulate good behavior among agencies.

The relative success of the bureaucracies and political bodies in deploying their respective strategies determines the level of discretion awarded a bureaucracy in its decision making. Peters' heuristic is that "agencies that supply 'public goods' are more resistant to external control of their policies than are agencies that supply quasi-public or private goods."[55] This is because the repercussions of underfunding public good provision are greater than skimping on bureaucratically supplied private goods for which the market could compensate; additionally, without market indicators to guide appropriate funding levels, the public good bureaucracy can better exert its technical superiority as leverage over the political body.

Summary

The literature cited above is by no means an exhaustive compilation of theories and arguments about policymaking; instead, appropriate sources were selected with the particular circumstances of the military's foray into solar power in mind. It can be confusing to keep track of which theories are mutually exclusive—i.e., they generate contradictory implications—and which are symbiotic, and which theories deal with which aspects of the policy process. The

[54] 1. J. Burkhead and J. Miner, Public expenditure (Aldine De Gruyter, 2007). 174-205.
[55] Peters, 177.

following table summarizes these facts. The top row of the table lists the six stages in the Stages model, and each theoretical category in the left column has something to say about at least two of the stages. Some theories contradict; e.g., either punctuated equilibrium explains why a particular policy arose or multiple streams analysis does. Others are inherently compatible; Bounded rationality is behind Kingdon's prediction that the problems stream is responsive to focusing events. Cells colored white are the latter kind of symbiotic observations that do not interfere with other theories (excepting the Stages model); cells in the same column that are colored differently (and are not white) do conflict with each other. Merged cells denote simultaneity of the relevant stages; for example, multiple streams asserts that the first three stages are actually not sequential. Careful application of the theoretical insights summarized in the table will motivate our subsequent hypotheses about the origins and implementation of DoD solar energy policy.

Table 2-1: Various Models of Policymaking

Models	Issue Emergence	Agenda Setting	Alternative Selection	Enactment	Implementation	Evaluation
Stages	Exhaustive issue search.	Rational institutional agenda creation.	Rational decision agenda creation.	Rational choice between alternatives.	Lossless information transfer within the hierarchy and as-written implementation.	Accurate evaluation and responsive organizational structure.
Punctuated Equilibrium	Opposition coalition forms	Coalition breaks down policy monopoly by broadening scope of conflict, venue shopping.	Policy reversals become alternatives			
Multiple Streams	Independent Problems, Policies, and Politics Streams all converge.					
Problem Framing		Strategic representation of problems	Problem framing drives alternative selection			
Bounded Rationality, Incrementalism	Only some issues are considered. Interest groups, focusing events are drivers.		Alternatives are selected based on previous policy work and organizational conclusions	Policy enactment is incremental, building upon previous policies		
Executive-Legislative Relations			PPPB: Bureaucracy frames budget requests as programs, not line items.	Competition between bureaucracy and political body over budget allocation.		Tendency to leverage program evaluation for extra money.
Bureaucratic Politics					Information distortion, ritualistic fulfillment of orders.	Organizational inability to accurately evaluate successful performance, internal structure.

The table demonstrates that there is significant literature refuting each component of the Stages model, and most of the alternative predictions can logically coexist with each other.

Hypotheses

We therefore consider the following hypotheses as potential answers to the three questions we posed in the last chapter, which dealt with the initial decision to pursue solar, the subsequent implementation at the service level, and the recent revision of solar policy to incorporate renewable microgrids. Each of the subsequent three chapters will deal with one of these questions. Following the approach outlined by Birkland, we test the null hypothesis that the Stages model can give an account of each facet of DoD solar policy against alternative hypotheses that draw on the literature explained above.

<u>Question 1</u>: What explains the DoD's decision to begin to widely pursue on-site solar power installations?

H1a: DoD officials followed the Stages model.

H1b: Pursuant to the punctuated equilibrium model, negative attention and conflict scope expansion eroded a policy monopoly, causing a policy reversal.

H1c: Pursuant to the multiple streams model, a policy window conducive to solar power adoption opened.

<u>Question 2</u>: What explains the Air Force's implementation of the solar power directive?

H2a: Air Force officials followed the Stages model.

H2b: Pursuant to Peters' model of hierarchic bureaucratic structure and Allison's Model II (Organizational Processes), military bases only "ritualistically" followed DoD and Air Force directives without regard for any underlying purpose.

<u>Question 3</u>: What explains the DoD's recent interest and investment in renewable microgrids?

H3a: DoD officials followed the Stages model

H3b: Bounded rationality and incrementalism characterized DoD decision-making.

Chapter 3: The DoD's Solar Window

"Quite frankly, the Department of Defense was a little bit late coming to the topic of efficiency and renewables, but now it is at the forefront."

~Richard Kidd, Department of Energy Federal Energy Management Program, speaking about the military's 2009 decision to build a 500 MW solar farm at Fort Irwin, CA.[56]

The background introduced in Chapter 1 raises concerns about the motivation behind the DoD's sudden foray into renewable energy, highlighted by three trends. First, there is a sharp rise in reported renewable percentage in 2005, from 1.6% to 4.8%, coinciding with stronger federal mandates on the Department's energy consumption. Second, there was a concurrent shift in DoD renewable policy from buying REC's from private sources to investing in on-site installations. Third, concerns about grid instability and continuity of base operations have increasingly dominated the DoD's justification for employing renewable energy, starting in 2007 and culminating in SPIDERS and the following passage from the QDR in 2010:

> To address energy security while simultaneously enhancing mission assurance at domestic facilities, the Department is focusing on making them more resilient. U.S. forces at home and abroad rely on support from installations in the United States. DoD will conduct a coordinated energy assessment, prioritize critical assets, and promote investments in energy efficiency to ensure that critical installations are adequately prepared for prolonged outages caused by natural disasters, accidents, or attacks.[57]

It is curious that the dangers posed by grid outages were only recently recognized and given prominence by DoD publications and initiatives, since the architecture behind the electricity grid has remained largely unchanged for a century. Moreover, if operational continuity and energy security are the drivers for increased renewable adoption, the coincidence of federal mandates of

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[56] Quoted in: Jessica Leber, "Solar, Efficiency Projects Hurry Up and Wait at U.S. Military Bases," The New York Times, August 7, 2009, sec. Business / Energy & Environment.
[57] Quadrennial Defense Review (Department of Defense, February 2010), p 88.

a renewable portfolio and DoD deployment of on-site solar energy is puzzling. Recall the hypotheses postulated to answer:

> Question 1: What explains the DoD's decision to begin to widely pursue on-site solar power installations?
>
> > H1a: DoD officials followed the Stages model.
> >
> > H1b: Pursuant to the punctuated equilibrium model, negative attention and conflict scope expansion eroded a policy monopoly, causing a policy reversal.
> >
> > H1c: Pursuant to the multiple streams model, a policy window conducive to solar power adoption opened.

The following sections will strive to justify H1c as the hypothesis with the most explanatory success.

Stages Model

These insights will allow us to quickly dispense with the Stages model null hypothesis. The observed DoD policy process cannot be explained using the first four sequential stages (issue emergence, agenda setting, alternative selection, enactment) of the rational actor Stages model, because it fails to account for the three observations of note listed above. Consider the third observation – that the DoD has cited operational security as a rationale for investing in on-site solar. The Stages model would therefore predict that policymakers would have initially identified the dangers of grid insecurity, placed the issue on their agenda, generated possible alternatives, and selected the optimal policy. This account can explain neither the first observation, the sudden jump in renewably generated electricity in 2005, nor the second observation, a shift in policy from purchasing renewable energy credits to installing on-site solar. As we will see later, it is the case that there was a major blackout in 2003—could lag time in policy implementation have just delayed the appropriate response for two years but still present evidence for a Stages model account of the decision process?

The next sections strive to demonstrate that this is not the case. The rhetorical shift evident in DoD documents is abrupt and temporally uncorrelated with the 2003 blackout. The blackout certainly played an essential role in the adoption of the solar energy policy, but the following sections argue that it did not play the causal role that the Stages model would predict; rather, the blackout brought the issue of grid insecurity to prominence, allowing policymakers who for other reasons found solar to be an attractive policy to correlate grid insecurity with solar energy for added justificatory weight. This analysis will be further vindicated in the subsequent chapter when we demonstrate that the deployment of solar panels really does very little for energy security.

A skeptic might object that this argument is no repudiation at all of a rational actor model. Certainly it seems rational for a policymaker, with some objective in mind (say institutional preservation or even keeping his job), to pursue a policy that satisfies certain political constraints and justify the policy by appealing to some central interest of the organization. However, our rational actor Stages model is more narrowly defined. Recall that Stages model policymakers seek to accomplish "maximum social gain" in their policies, so the objectives of a Stages model policymaker are not unconstrained. Second, the Stages model makes a prediction not only about linear sequentiality, but also about the causality between stages. So even if it is the case that a problem has existed and is recognized at an earlier time than a solution is developed, the Stages model cannot account for the policy process if the problem did not motivate the development of the solution. On both accounts—policymaker objectives and causal sequentiality—we argue that the Stages model is violated by DoD solar energy policy.

Punctuated Equilibrium Approach

Can Baumgartner and Jones' punctuated equilibrium model account for the DoD's decision to adopt solar? The short answer is no—the circumstances of the policy process simply do not fit the model. It is important to consider this hypothesis, however, because punctuated equilibrium is a well-received explanans that purports to account for bursts of policy change, and the sudden proliferation of renewable energy rhetoric and DoD solar panels seems to be an appropriate explanandum.

Recall that punctuated equilibrium predicts that a policy monopoly will stifle change until an opposing coalition can break down that monopoly by "broadening the scope of conflict," venue shopping, and otherwise generating negative attention related to the current policies. In this case, however, the driving force behind renewable energy adoption does not appear to be negative attention to the issue of grid insecurity, but rather positive national and Congressional attention directed at renewable energy. Therefore, punctuated equilibrium fails to predict the observed phenomenon for the same reasons that we deemed the Stages model inappropriate: the problem did not drive the solution. Later, in the discussion of the legislative history of the Energy Policy Act, it will become clear that DoD solar energy policy was not a product of conflict between the policy monopoly of the DoD and external opposing actors, like Congress or the media; rather the process was surprisingly collaborative.

Multiple Streams Approach

The prima facie failure of the Stages and Punctuated Equilibrium models to account for DoD decision making suggests that we need a theory that does not require that the solution be uniquely motivated by the problem. A multiple streams analytical approach, examining independently the problems, proposed policies, and political conditions, might shed light, through a policy window, on the strategy and timing of the DoD's interest in solar power.

Problems Stream

The Department of Defense has, over the last decade, recognized three main problems related to its energy consumption practices: global warming, high cost of energy, and transmission grid vulnerability. None of these problems logically leads to the unique prescription of on-site solar power as a solution, but together, they have been used as justification for most DoD sustainable or renewable energy initiatives, including on-site solar. The problem stream cannot by itself explain the increased interest over the last five years in on-site solar; however, it is an integral part of the explanation, and it is instructive to examine each problem to discover its prominence in military discourse and the reasons for its identification as a problem, including the existence of any focusing events that might explain this interest.

Global warming is often cited by DoD reports as a problem that requires proactive action by the military. A 2000 DoD report identified civil strife, increased refugee count, and international wars as potential security-related impacts of climate change. [58] Similarly, in 2010, the QDR forecast instability resulting from climate-induced population displacement. The natural question to ask is why global warming is a problem specifically related to DoD energy consumption, rather than a problem arising chiefly from other sources. The DoD gives various answers to this question – since it is the largest energy consumer nationally, using 1% of all energy consumed in the US, the military asserts that it has a responsibility to reduce its emissions. DoD documents also refer to a long history of spurring private sector innovation, and thus seek to act in a leadership role to combat global warming; on a smaller scale, the DoD

[58]Climate Change, Energy Efficiency, and Ozone Protection (OUSD (Environmental Security), 2001).

intends to do its part within a larger scheme to reduce federal government emissions.[59] In fact, this last responsibility is derived from the federal laws discussed earlier which outline mandates for agencies' renewable portfolios. We will consider federal mandates in detail later when examining the political stream.

The second problem cited by the DoD is the cost of its energy consumption. Reliance on fossil fuels exposes the military to the volatility of international commodity prices and dictates costly measures to protect distribution channels, for example for fuel convoys at the frontlines. Furthermore, inefficient energy consumption—e.g., poor insulation at military bases—is simply expensive. Therefore, the DoD recognizes its current energy consumption practices as problematic for economic cost considerations.[60]

The argument structure of the two problems cited above has remained largely static over the last decade. Although more funding has been devoted to research on these issues, the problems of climate change and costly energy consumption have been generally accepted. Neither of these problems clearly implicates solar power as a solution; even a monumental effort to install solar panels across military bases nationwide would hardly impede global warming, and expensive solar technology would only exacerbate the problematic costs of current energy consumption. The only argument that really sticks involves DoD installations serving as a test-bed for different technologies and spurring private innovation, but certainly this must be an ancillary objective of military policy and not the primary purpose of its military installations. Here is where the third problem, military base vulnerability to transmission grid failure, fortuitously stormed onto the DoD's agenda, via one of Kingdon's focusing events.

[59] A Navy Energy Vision for the 21st Century (US Navy, 2010).
[60] More Fight, Less Fuel: Report of the Defense Science Board Task FOrce on DoD Energy Strategy (Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, February 2008).

The transmission grid insecurity "discovered" in 2003 has actually been a problem of roughly the same magnitude for at least the last half century. Large scale blackouts, affecting 30, 8, and 50 million people occurred in 1965, 1977, and 2003, respectively.[61] However, the most recent blackout served as a focusing event to alert policymakers throughout the federal government to a latent threat that had simply not been acknowledged. The House Committee on Energy and Commerce held a hearing a month after the 2003 blackout to discuss overhauling transmission infrastructure.[62] There, Representative Doyle (D-PA) asserted that "We need to promote use [of distributed generation technologies], so that at least our critical facilities like hospitals, police stations, our military installations are guaranteed safe reliable power, even in the case of blackouts like the one we recently endured." This sentiment was echoed in a series of DoD reports in 2005 on implementing renewable energy initiatives to increase energy security in the wake of the blackout. In 2008, the most urgent articulation of this problem was published in a widely publicized DoD report, "More Fight, Less Fuel," which compiled a (classified) list of military bases at risk of being cut off by the grid and summarized extensive research on the vulnerability of the grid.[63] It concluded that conventional back-up generators on military bases, diesel generators, are rated only for days of emergency use and therefore are inadequate protection against a prolonged grid outage. Such a failure could occur, the report asserts, as a result of natural cascading failure or malicious terror or cyberterror attacks.

This final problem, that of insecure grid-tied installations, provides a crucial link between the other problems related to DoD energy consumption and the policy of implementing on-site solar power. By emphasizing the need for distributed generation to create secure, islanded

[61] P. Hines, J. Apt, and S. Talukdar, "Large blackouts in North America: Historical trends and policy implications," Energy Policy 37, no. 12 (2009): 5249–5259.
[62] Blackout 2003: How Did it Happen and Why? House Committee on Energy and Commerce. September 3, 2003.
[63] "More Fight Less Fuel," cited above.

microgrids, renewable technologies are then attractive because they conform to the tenets of reducing emissions and price volatility, but also achieve an urgent security need. However, the prominence of installation security in DoD policymakers' minds fails to fully explain the adoption of on-site solar for two reasons. First and foremost, none of the solar projects pursued increased operational security because of the islanding and storage difficulties discussed earlier; in fact, DoD officials have admitted that even the future potential for self-sufficient solar arrays was not considered when constructing existing projects. So if the solution did not actually address the problem, we cannot conclude that the problem sufficiently explains the observed policy choice. Second, there is no clear reason why solar was selected over alternatives like fuel cells, windmills, geothermal, or microturbines. None of those alternatives have the intermittency problem that solar does, and the latter two are often more cost-effective than solar. After examining the other two streams, we will see that the problem stream is necessary but not sufficient to explain the choice of on-site solar.

Policies Stream

In this section we analyze the various policies proposed over the last decade to change conventional energy use. In 2000, the emphasis was largely on improving energy efficiency to comply with EO 13123; schemes like daylighting (maximizing natural lighting during the day) and roof insulation took precedence over renewable energy. The DoD Annual Energy Management Report in 2000 states:

> Since renewable sources of electricity generation generally have higher capital equipment costs, they usually do not compete well with the conventional utility supplier of electricity. However, the Armed Services have made significant progress in the purchase of renewable energy generated from solar, wind, geothermal, and biomass sources when cost-effective.[64]

[64] FY 2000 Annual Energy Management Report (Department of Defense, 2000.).

Purchasing REC's was therefore the dominant military strategy related to renewable energy. Indeed, the Senate Appropriations Committee expressed frustration with the DoD's sluggish investigation of on-site options, finding that the Office of the Secretary Defense (OSD) had displayed a "lack of leadership" in not even releasing funds appropriated for an investigation. On-site solar power was a proposal under consideration, since EO 13123 set a goal of 20,000 solar systems by 2010, but the economics were simply not considered favorable compared to other alternatives. A Sandia Laboratory report assessing the viability of solar power found that the energy payback time for solar PV and solar thermal was rarely competitive with that of daylighting and hot water systems, and therefore recommended the latter two technologies as areas of focus for efficient energy use.[65] In early 2005, a DoD report assessing various renewable energy technologies concurred, noting that the cost of solar PV was especially prohibitive, and the bulk of the potential for on-site renewable energy was in passive, daylighting applications.[66]

In 2006, a status update on renewable energy deployment announced several planned 100-500 kW solar PV and thermal projects.[67] This was a departure from the previous conclusion that these technologies were not economically feasible. Following this status update, both solar PV and thermal received more attention in policy documents and correspondingly higher proportions of renewable energy funding, a trend that has continued to the present day, evident from the fact that solar power today comprises the vast majority of DoD renewable installations (69%, as noted above). The change of heart of DoD policymakers between March, 2005, and February, 2006 is slightly puzzling, since the price of solar technology did not actually drop over that time period. However, the Energy Policy Act was passed during that interval, and it introduced a 30% Investment Tax Credit for solar energy systems. Additionally California's

[65] DoD Solar Energy Assessment (Sandia National Laboratory, 2004).
[66] DoD Renewable Energy Assessment Implementation Plan, 2005.
[67] DoD Renewable Energy Assessment Status Report Update, 2006.

AB32 was passed in 2006, creating a market for REC's in the largest electricity market in the country.[68] Despite these economic incentives to construct solar installations, the prohibitive capital cost of large arrays surpassed the amounts that federal grant programs, like Department of Energy "Energy Savings Performance Contracts" (EPSC) could allocate. Crucially, with the new investment tax credit, Power Purchase Agreements, under which a private developer sells power from a solar array to the installation on which the array is built, became a popular financial vehicle for solar projects; the DoD could thus build a solar power plant without spending a dollar up front on capital costs. All of these factors distinguished solar power from alternative renewable technologies and help explain the shift in interest among policymakers toward solar.

At this juncture, one might ask whether the problems and policies streams jointly explain the DoD's choice to implement on-site solar power; the answer, predictably, is no. Recall, the problems stream explained why on-site energy reform was prominent on the DoD agenda (for installation security) and the policies stream has partially explained why solar emerged as a competitive option among the renewable technologies. We still have not discerned why the Department of Defense would deploy renewable energy over cheaper, more effective, nonrenewable alternatives (like microturbines, or even backup diesel generators for the backup diesel generators[69]) to enhance installation security. For this, we turn to the final stream in our analysis.

Politics Stream and the Policy Window

The effect of renewable mandates from Congress and the Executive has been notably absent from our analysis. By this point, the careful reader will have noticed that the flurry of pro-solar attention and activity coincided with a shift in federal mandates in 2005 from an ambiguous

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[68] Department of Energy website: www.energy.gov

[69] At $24,000 for a 100 kW diesel generator, diesel is about an order of magnitude cheaper than a solar array. Source: Triton Industrial Retail Brochure, 2010.

goal of energy efficiency to a concrete requirement that a certain percentage of electricity be generated from renewable sources. This requirement from the Energy Policy Act, together with subsequent stipulations that the electricity be generated from new sources, and comprise 25% of DoD consumption by 2025, created a conducive atmosphere for quick ramping of renewable initiatives.

One might wonder if the DoD opposed the federal mandates at all, given that the legislation basically imposed an unfunded obligation to invest in expensive technologies. The executive-legislative relations literature introduced last chapter is useful here in explaining why the DoD did not obstruct the Energy Policy Act. Recall that technical superiority often gives a bureaucracy an advantage over a political body in negotiating budget allocations and program requirements, because an agency is better equipped to appraise its own needs than is Congress. In this case, however, facility electricity generation is not a core technical competency that the DoD has some special advantage in appraising. Rather, the DoD outsources the majority of its facility electricity needs to the local utility; moreover, the Agency that does in fact have technical superiority in this field is the Department of Energy, one of the core goals of which is the advancement of clean energy.[70] Therefore, none of the strategies introduced in the last chapter to exploit technical superiority and oppose the federal mandates were tenable for the DoD. Indeed, the literature predicts that precisely because facility electricity is a peripheral issue for the DoD, it would be amenable to Congressional mandates pursuant to the “satisficing” model of bureaucracies pioneered by Goodin.

An examination of the legislative history of the 2005 Energy Policy Act reveals not a single instance of military testimony opposing the federal mandates or even cautioning the Congress that the mandates might be costly and possibly counterproductive to the military’s

[70] US Department of Energy Strategic Plan, February 2011. 3.

national security objectives. A possible explanation for this is that the DoD expressed support for renewable energy early on, and in order to be consistent with this support could not oppose mandates for government renewable electricity generation. Consider this statement by Senator Jeffords (R-VT):

> Mr. President, on September 19, James Woolsey, former Director of the CIA, Admiral Thomas, H. Moorer, former Chairman of the Joint Chiefs of Staff, and Robert C. McFarlane, former National Security Advisor to President Reagan, sent a letter to myself and other Members of this body urging in the strongest terms that we take immediate action to address our energy security. Among other recommendations, they state that they "urge the Energy Committee to immediately adopt the Renewable Portfolio Standard."[71]

Alden Meyer, of the Union of Concerned Scientists, also gave testimony concurring with Senator Jeffords' remarks, asserting:

> There is also a growing recognition that renewable energy and efficiency can enhance energy security. An official banner at the Administration's Renewable Energy Summit in the fall of 2001 read: "Expand Renewable Energy For National Security." James Woolsey, former head of the Central Intelligence Agency, Robert McFarlane, President Reagan's former national security advisor, and Admiral Thomas Moorer, former chair of the Joint Chiefs of Staff, together wrote Congressional leaders in September 2001 urging enactment of minimum standards for renewable fuels and electricity, along with an increase in energy efficiency funding, in order to increase national security.[72]

The military therefore came out in support of a national policy requiring utilities to purchase renewable energy because it would enhance energy security. This is true because as the level of penetration of distributed generation increases in the electricity grid, the grid is less susceptible to a cascading blackout like the one which the traditional hub-and-spoke generation and transmission model suffered in 2003.[73] The federal purchase requirement was a product of calls like that by Senator Dayton (D-MN), who asserted that "Since we are talking about the future of

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[71] Congressional Record, National Laboratories Partnership Improvement Act (HeinOnline Legislative History, PL 109-58, 2002). S1569.
[72] Comprehensive National Energy Policy (HeinOnline Legislative History, PL 109-58, 2003).
[73] David Watts, "Security & Vulnerability in the Electricity Grid," in (presented at the 25th North American Power Symposium, University of Missouri-Rolla, 2003), 559-566.

energy in this country, we as a Federal Government must lead by example."[74] This is a tough exhortation to oppose, and while the military could have given a nuanced objection as to why it was optimal for the country to adopt renewable energy but not for the military to set the example, it apparently chose not to.

So Congress passed the Energy Policy Act of 2005 and mandated that the DoD invest heavily in renewable energy. Furthermore, nuances of the federal guidelines created incentives to invest in on-site renewables as opposed to buying private REC's. Recall that under the Energy Policy Act, every kWh of on-site renewable generation gets counted twice—once for the actual energy and again for the REC awarded. Additionally, there is an option to sell the REC and buy a replacement REC from elsewhere, enabling price arbitrage. Conversely, buying a private REC and obtaining conventional energy from elsewhere offers no arbitrage opportunity and only counts the renewable energy once, rendering it an inferior option to on-site generation.

The confluence of the three streams, beginning after the passage of the 2005 Energy Policy Act, opened a policy window for implementation of solar energy installations at military bases. To summarize, the 2003 Northeast blackout focused attention on installation security, improvements in the economics of solar power in 2005 piqued policymaker interest in that particular renewable technology, and the Energy Policy Act in 2005 began a string of federal mandates that required the DoD to invest in renewable energy, especially on-site generation. What resulted was a rush to match solutions to problems to satisfy federal mandates, and on-site solar emerged as the policy of choice.

Indeed, the progression of thought by policymakers that best fits the observed data is counterintuitive: the political imperatives prompted a search for the best renewable strategy, and

[74] Congressional Record, National Laboratories Partnership Improvement Act (HeinOnline Legislative History, PL 109-58, 2002).

upon identifying on-site solar, an appropriate justification was sought that transcended merely following federal regulations; certainly a military initiative should accomplish some objective of national defense in addition to complying with federal mandates. This progression explains why in 2003, the Director of Energy and Utilities for DoD Installations did not even mention solar power as a potential solution to the vulnerability of grid-tied military bases, enumerating a laundry list of alternative options; however, by 2008, solar was featured prominently in DoD reports as a technology for islanded microgrids.[75] Indeed, one report sums up the key components of the policy window and its effects on renewable initiatives:

> Renewable energy sources such as solar, wind, and geothermal are often economically advantageous and resilient, reducing the risk of mission interruption. Buying renewable energy credits, while an admirable step toward reducing carbon footprint, accomplishes nothing toward mitigating risks from power loss to critical missions.[76]

Furthermore, by framing the problem of installation security—à la Schon, Rein, and Stone—as a vulnerability arising from aging, polluting, fossil fuel technologies, the Department of Defense could naturally introduce innovative renewables as the other side of the dichotomy; this allowed for the rhetoric of climate change and economic security to accompany a purely security-oriented motive, padding the public justification for solar power.

Returning to the original puzzle that confronted us—why did the DoD suddenly begin investing heavily in on-site solar energy—the multiple streams approach has performed much better than the DoD's own justifications for the projects in explaining this phenomenon. None of the three reasons offered by the QDR for pursuing renewable energy—installation security, global warming, and energy price stability—implicate on-site solar as the best policy option and

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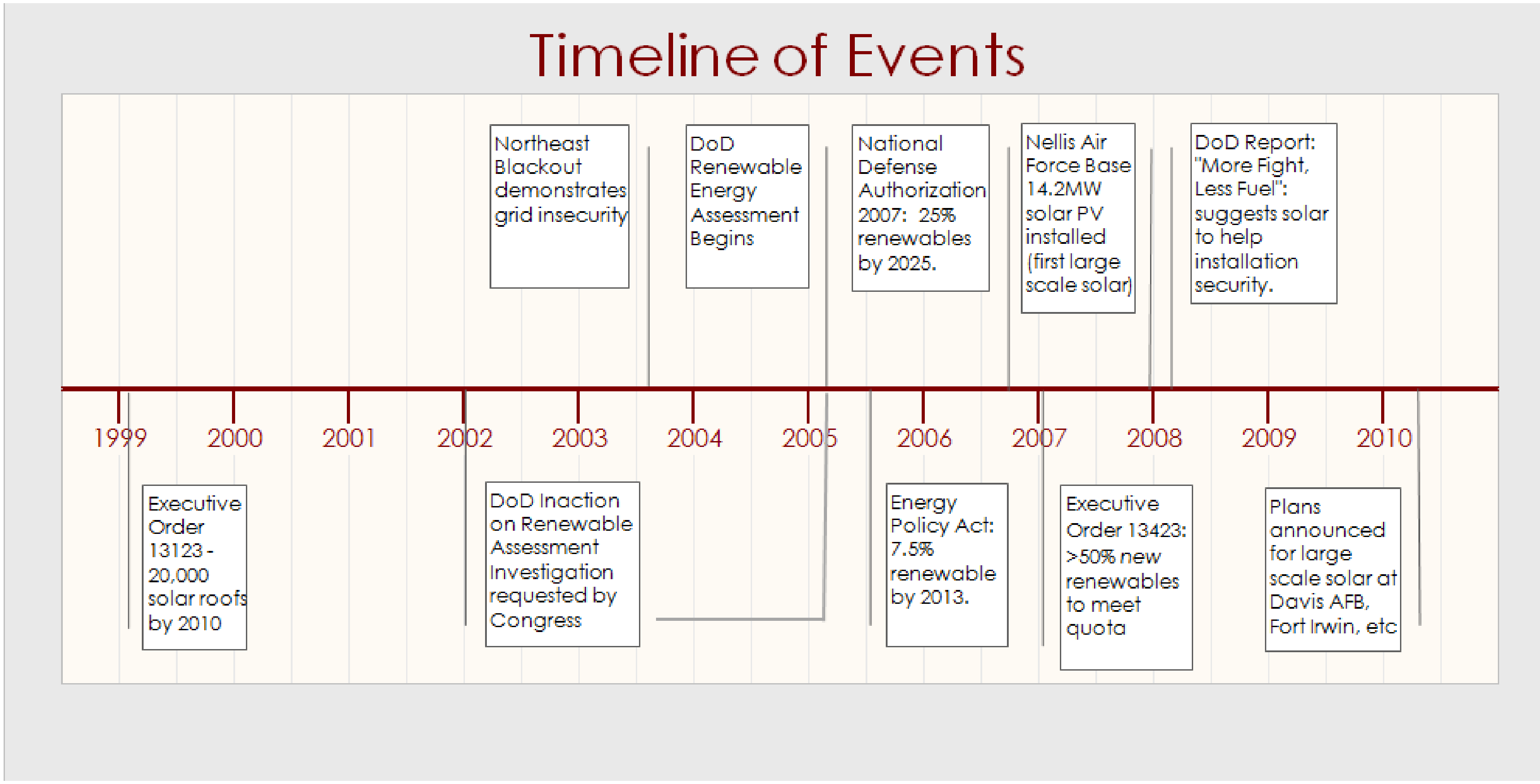
[75] Get Moy, "DoD's Dr. Get Moy on Energy Security," 2003.
[76] "More Fight, Less Fuel," cited above.

thus doom the rational actor Stages model that would treat the DoD as a policymaker that seeks to best solve the problems it acknowledges. Conversely, the policy window approach incorporates the auspicious temporal coincidence of three independent streams which allowed policymakers to rationalize policies necessary to accomplish a federal mandate in terms of security gains.

The above analysis rejects the first four steps of the Stages model, asserting that up until enactment of the DoD's solar energy policy, policymakers did not follow causally sequential and rational decision processes. The next chapter will choose one of the Services to investigate in order to analyze decision-making processes lower down the hierarchy and also judge whether the implementation of DoD directives can be explained by the Stages model.

Figure 3-1: Timeline of Events Relevant to DoD Solar Energy Policy



Chapter 4: The Air Force's Implementation of Solar Power

As part of our institutional effort to ***consider energy management in all that we do****, the Air Force requests $250 million for energy and water conservation projects in FY11.*

~2010 US Air Force Posture Statement (emphasis added)[77]

The FY 2011 Air Force Budget Request touts the service as the "federal government's largest green power purchaser."[78] The request for $250 million for facility energy projects in each of the next six years is aimed at meeting Congressional mandates, notably the 25% renewable electricity mark by 2025. Over the six years from 2005-2010, the Air Force set an example for the other services by building the largest solar installation in North America, at Nellis Air Force Base, and deploying sizable (~1MW) installations at several other bases. Currently, the Air Force has grander plans for solar, including upcoming installations of arrays at Davis-Monthan and Luke Air Force Bases, both in Arizona, that will surpass Nellis' record size.

As a leader in alternative energy production and an early military adopter of solar power, the Air Force is a model service to enrich the previous chapter's DoD-wide analysis. The nine existing major solar installations at Air Force bases provide a diverse but tractable set of examples to analyze; moreover, focusing on a single DoD component can elucidate the division of responsibilities between the DoD, Air Force leadership, and base-level command.

The present chapter analyzes the implementation of the central directive to pursue solar power. Many observations confirm the previous chapter's conclusion that multiple streams analysis best accounts for the military's decision to pursue solar.

By studying the Air Force, one sees evidence of:

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[77] United States Air Force Posture Statement (United States Air Force, 2010), 13.
[78] 1. FY 2011 Budget Overview (United States Air Force, 2010), 66.

a) Solar installations that do not mitigate grid vulnerabilities, but are nonetheless advertised as doing so.
b) Choices to deploy solar despite unfavorable economics, and in apparent contradiction of the spirit of Air Force procurement guidelines.
c) Acknowledgement of pressure to comply with stringent federal mandates
d) Recognition of the added weight (double-counted credits) of on-site generation.

The above findings strengthen the thesis that policymaker interest in solar was a result of the confluence of the problems, policies, and politics streams. Finding a) supports the claim that the problem of transmission grid vulnerability was conveniently employed as a justification for the solution of solar power, a solution motivated by the mandates the weight of which is evident from findings c) and d). Finding b) suggests that on-site solar was not chosen merely for favorable economics, but rather because it succeeded best as a solution that ostensibly bridged the chasm between an national security problem and political imperatives.

However, the forthcoming analysis of the Air Force does more than just reinforce claims made in previous chapters. Chapter 3 illustrated deviations in military policymaking from the first four stages of the Stages model; Chapter 4 seeks to establish a deviation from the fifth stage, that of implementation. The Stages model predicts that organizations will implement an enacted policy through lossless information transmission down the organizational hierarchy with absolute lower-level compliance with higher-level directives. However, the following observations undermine these predictions:

e) Entrepreneurship at the base level has been a necessary criterion for solar power adoption.

f) The largest (by far) solar installation was motivated originally by private sector interest, not DoD guidance.

g) The various installations are haphazardly deployed, some to minimize cost, others to maximize reported renewable credits, and others with no apparent objective at all.

Recall the proposed hypotheses in response to:

Question 2: What explains the Air Force's implementation of the solar power directive?

H2a: Air Force officials followed the Stages model.

H2b: Pursuant to Peters' model of hierarchic bureaucratic structure and Allison's Model II (Organizational Processes), military bases only "ritualistically" followed DoD and Air Force directives without regard for any underlying purpose.

Hypothesis H2b accounts for finding f), because the scant guidance given to individual bases consisted basically in the directive to pursue solar power, shielding the lower levels of the hierarchy from the complex decision-making process described in the last chapter. Peters predicted that "there is a tendency to comply ritualistically with rules and directives while possibly subverting the real purposes of the organization."[79] Without any guidance on how to prioritize regulatory, economic, and security constraints, bases implemented drastically different projects. Confirming Peters' prediction, base-level officials did not seek to clarify the purpose behind the directive to pursue solar, opting instead to implement it according to the unique circumstances confronting their base.

H2b does not, however, account for findings (d) and (e), although, recalling Bendor and Hammond's point that rule-compliance can beget many outcomes, it is compatible with those observations. As the case study of Nellis Air Force Base will demonstrate, when base officials ritualistically followed the directive to pursue solar, they took the initiative to find opportunities and see the projects through to fruition. This enthusiastic ritualism disconfirms the Stages model

[79] B. G Peters, The politics of bureaucracy (Psychology Press, 2001), 126.

prediction about centralized command of policy implementation. Instead it supports a decentralized model that relies on base-level entrepreneurship and also helps explain the observed variation in solar project outcomes.

Background – Air Force Energy Policy

In December, 2005, Air Force officials circulated service-wide guidance to comply with the federally mandated renewable generation requirements of the Energy Policy Act. The subsequent issuance of Air Force Policy Directive 10-1 and 90-17, motivated by DoD Instruction 4170.11, established the following responsibility structure for Air Force renewable energy initiatives:[80]

- The Deputy Under Secretary of Defense (Installations and Environment) oversees overall DoD energy goals and component compliance.
- The Energy Senior Focus Group, chaired by the Secretary, serves as "the single voice on energy related matters…to the Air Force."
- The Air Force Assistant Secretary for Installations, Environment, and Logistics (SAF/IE), supported by his Deputy for Energy (SAF/IEN Energy), implement the Air Force Energy strategy and advocate budget requests for the $9 billion energy budget.
- The Air Force Civil Engineering Support Agency (AFCESA) Facility Energy Center and Air Combat Command A7, Mission Support Energy Office (ACC/A7), coordinate renewable energy projects, securing financing and evaluating site-appropriate technologies.

[80] Air Force Policy Directive 90-17, Energy Management, July 16, 2009.

Department of Defense Instruction 4170.11, December 11, 2009.

Of note is the omission in these overarching policy documents of any responsibilities at the base level; renewable energy policy was conceived as centrally administered, but its implementation, at least with respect to solar projects, has not reflected this top-down structure. Rather, efforts by individual base commanders, energy managers, and private developers have driven solar procurement.

Nevertheless, documents and presentations from the offices listed above reveal an acute awareness of the challenging federal mandates and lagging progress toward on-site renewables. Facility energy consumption accounts for only 12% of the Air Force's energy use, which is dominated by aviation; however, at 48% of facility energy use, electricity accounts for a sizable 5.8% of total energy.[81] Electricity also costs proportionally more than other facility energy sources, accounting for 71% of facility energy expenditure; renewable electricity is especially expensive, with energy costs four times that from equivalent conventional sources.[82] In 2010, the Air Force claimed that 5.8% of its power came from renewable sources, but in reality only ~1% was from on-base renewables, while the other 4.8% came from purchased REC's. Since the Air Force will phase out REC purchases by 2012,[83] it has only made illusory progress toward its objectives, summarized in the table below.

Table 4-1: DoD Renewable Energy Goals

Goal	**5% renewable generation**	**7.5% renewable generation**	**25% renewable generation**	**3% on-base renewable generation**
Date	FY 2010	FY 2013	FY 2025	FY 2015
Legislation	EPACT 2005	EPACT 2005	USC 2911	Internal

The above data clearly demonstrate how far the Air Force is from achieving its 25% goal by 2025. Without additional purchase of REC's to replace expired ones and supplement sluggish

81 Air Force Infrastructure Energy Plan, 2010, 4
82 Air Force Civil Engineer Support Agency, "Air Force Sustainability & Energy" (St. Louis, 2010).
83 Air Force Instruction 65-501 (Air Force, November 10, 2004), 31

on-base renewable growth, the Air Force will need nearly 80 mammoth installations the size of Nellis' PV array, and the annual cost of those renewables, extrapolating from current costs, would equal the entire facility electricity budget (or ten times that figure in up front capital cost).

The Air Force has available five vehicles to fund an on-site solar power project, and we list them in order of increasing flexibility (and in general, decreasing capital cost to DoD). First, Congress can approve a direct appropriation through the DoD budget for a project; this entails long timescales, low flexibility, and high capital costs. Next, the Air Force can apply internally to DoD for an Energy Conservation Investment Project (ECIP) grant, which funds the entire capital cost of a project. According to DoD guidance:

> ECIP projects will have a Simple Payback (SPB) of 10 years or less with a minimum Savings Investment Ratio (SIR) of 1.25 to meet DoD criteria. (Estimated SPB time is the number of years required for the cumulative value of energy cost savings less future non-fuel costs to equal the investment costs of the building system without consideration of future price changes or discount rates.[84]

A closely related source is Research Development Test & Evaluation (RDT&E) funds, which support new technologies; consider these grants an ECIP for advanced solar arrays. Energy Savings Performance Contracts (ESPC) have become increasingly popular as a mechanism to avoid paying capital costs up front. Under an ESPC, the Air Force contracts to a developer to pay for the installation, and then pays the developer an equivalent amount to the cost of energy saved by the installation. Air Force guidance for ESPC's stipulates that:

> ESPC projects must be funded solely from the savings they generate. An ESPC has limited funding authority in that all ESPC costs including mid-contract replacement of capital equipment must be funded out of ESPC savings… Aggregate annual payments by the Air Force under an ESPC may not exceed the amount the agency would have paid for utilities without an ESPC during the term [of contract].[85]

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[84] Energy Savings Performance Contracts (United States Air Force, September 19, 2006).
[85] Mark Hunt, ACC/A7, "Renewable Energy Air Combat Command," February 3, 2009, 8.

Finally, a Power Purchase Agreement (PPA) enables a base and/or the Air Force to contract directly with a private developer without any restrictions. The various procurement options are summarized in the table below.

Table 4-2: Air Force Energy System Procurement Options

	Up Front Capital Cost?	Payback Time	Constraints	Authorizing Body	Operator
Appropriation	Yes	<10 years	Variable	Congress	Air Force
ECIP	Yes	10 years	1.25x SIR	DoD	Air Force
RDT&E	Yes	Variable	Variable	DoD	Air Force
ESPC	No	20 years	Annual cost ≤ previous costs	Air Force (Air Combat Command (ACC))	Private
PPA	No	Variable	Variable	ACC	Private

In order to meet federal mandates, the Air Force has prioritized development of on-base renewables, first by using third-party financing vehicles to avoid large up-front costs, and then only through DoD appropriations. Its second priority is buying off-site renewable power, and at the bottom of the priority queue is purchase of REC's.[86] Indeed, recall that REC's are valuable not only for federal goal attainment but also as replacement REC's to finance on-base installations whose REC's are sold to local utilities; therefore, goal attainment REC's are the second tier of the third priority and will no longer be purchased after FY 2011. This situation nicely substantiates the more general observation made earlier – that the DoD's renewable strategy shifted dramatically from purchasing REC's to pursuing on-base installations around 2005, when federal mandates like the Energy Policy Act created incentives for doing so, and the problem of operational security attained prominence. Concretely, the AFCESA forecasts that 60% of its renewable generation in FY 2015 will come from on base projects financed through a

[86] Mark Hunt, ACC/A7, "Renewable Energy Air Combat Command," February 3, 2009, 23.

third party, akin to the installation at Nellis. Over the next 5 years, 80% of the expenditures necessary to achieve 10% renewables by 2015 will come from third parties (neglected in this figure is the long-term electricity rate that the Air Force is locked into in order to finance the third party's up front capital cost).[87]

This aggressive roadmap toward increasing on base, third-party financed renewable generation appears to provide strong evidence for the thesis that federal mandates are driving Air Force energy policy. In a particularly instructive chart, the AFCESA projects 44% of the FY 2015 goal arising from "bonus credit," which, under a peculiarity of the Energy Policy Act, is a double-counting of on base renewable generation where the REC is either retained or compensated for by purchase of a replacement REC (recall that this creates arbitrage opportunity over state lines). The existence of the bonus credit incentive which arises from on-base installations is not enough to discredit the alternative hypothesis that energy security is the primary motivation behind abandoning REC's for on-base installations, but it does make the federal mandate story more compelling.

Finally, we briefly examine Air Force decision-making doctrine, specifically in relation to renewable energy and solar in particular. The Air Force prizes "value-focused thinking" (VFT) over "alternative-focused thinking," where the distinction is between choosing between existing alternatives in the latter case and insisting upon a threshold level of goal attainment in a solution using the former methodology. To use VFT, one assigns a percentage value to each Air Force priority corresponding to its respective importance and then chooses (generally concave) functions that translate parameters of a policy into scores for the various goals. Resultant numerical scores can be used both to compare alternatives and ensure that the optimal policy score surpasses that assigned to "do nothing." Duke applies VFT to various renewable

[87] Mark Hunt, ACC/A7, "Renewable Energy Air Combat Command," February 3, 2009, 33.

technologies, selecting cost, logistics, and performance as appropriately weighted goals; he finds that in three diverse locations (different wind speeds, insolation, terrain flatness, etc), solar scores lower than wind and geothermal, irrespective of the weighting of the priorities.[88] Kellner finds that only small applications of solar (e.g., parking lot shading panels) outperform "do nothing," whereas larger arrays are suboptimal.[89] This is strong evidence that VFT does not support the large (>100kW) Air Force solar arrays that this chapter examines. Notably, neither of the above analyses incorporated energy security as a goal for the Air Force, but as will become evident, inclusion of energy security would not have made solar more attractive.

This background should provide a rationale for the questions that this chapter seeks to answer. The central question is easily adapted from the hypotheses of previous chapters: why did the Air Force invest in solar power? Already, work by Duke and Kellner casts doubt on the hypothesis that the Air Force simply followed VFT and aimed for an optimal solution in terms of cost and performance. Federal mandates and energy security concerns are potential alternative drivers; did the Air Force's investment in solar really seek to address both its federal mandates and energy security concerns, or was the latter just a more attractive justificatory vehicle to achieve the former? Throughout the chapter, we also seek to determine if this foray into solar occurred as a result of central directives or decentralized, entrepreneurial efforts. There are nine cases of major solar installations on Air Force bases, all of which will be summarized later on; however, one particular installation, that at Nellis Air Force Base, stands out as the most important example, so we will begin our analysis with a case study of Nellis.

Nellis Air Force Base

[88] James Duke, Decision Analysis using Value Focused Thinking to Select Renewable Energy Sources, Thesis (Air Force Institute of Technology, 2004).

[89] Mostyn Kellner, "A Decision Model For Choosing Among Photovoltaic Technologies To Generate Electricity At Grid-Connected Air Force Facilities: A Value-Focused Approach" (Air Force Institute of Technology, 2006).

The PV array at Nellis is distinctive not only for its size—at 14.2 MW, it is an order of magnitude larger than all of the other installations—but also for its financing approach. The Air Force did not pay a penny up front for the installation, the capital cost of which was undertaken by a private contractor in return for 20 years of fixed electricity revenue from Nellis and the right to sell the REC's to the local Nevada utility. This Power Purchase Agreement (PPA) is the only one in existence for Air Force solar projects; however, as mentioned earlier, the Air Force's projected renewable energy plan will focus single-mindedly on PPA's to meet goals in FY 2015 and beyond. Therefore, the motivation and procurement process behind the Nellis array, while not necessarily representative of other completed Air Force PV arrays, is the most relevant pieces of evidence we have about the future of the Air Force's solar plan.

Air Force documents trumpet the efficiency of the Nellis acquisition timeline, the financial savings, and how the "project can be used as a model for other federal installations to acquire renewable energy facilities."[90] Concealed in this appraisal is a story of how the Nellis installation was largely driven by felicitous incentives, state regulatory limitations, and private profits. Since the installation had to conform to a host of exogenous constraints, it should come as little surprise that the installation is not optimized for military-specific energy needs, namely energy security.

The story starts with an unsolicited proposal from a private contractor in 2004. The developer had read a 2003 DoD (Pacific Northwest Lab) report that identified the base, situated in a high insolation desert and consuming 27 MW on peak afternoons, as an ideal site for a solar PV array. Crucially, Nevada's aggressive Renewable Portfolio Standard, under which the state must generate 15% of its electricity from renewable sources and half of that from solar, requires utilities to purchase REC's to meet their quotas. In Nevada, a solar kwH is statutorily worth 3.2

[90] Mark Hunt, ACC/A7, "Renewable Energy Air Combat Command," February 3, 2009.

times an equivalent amount of energy from another renewable source. Realizing the opportunity to charge two consumers simultaneously, the developer approached Nellis officials about a partnership.

Air Force officials recognized that three “compelling needs”—meeting federal mandates, stemming energy cost increases, and addressing “energy security, [which was] on the forefront of Air Force concerns”—could be met by entering a PPA.[91] They then proceeded to open a competitive acquisition process which took only 141 days, in contrast to the normal 2-4 years for a DoD appropriation. Three bids were considered, one contractor was selected on the basis of experience and value, and the construction was completed in 200 days. The array was built on a landfill, thereby not even wasting space. As a result, Nellis’ electricity bill actually dropped $1 million per year, since the developer charged a rate of 2.2 cents/kwH, a dramatic improvement over the prevailing 9 cents/kwH utility rate. The developer sold the REC’s and accrued federal tax benefits, which together account for 90% of the developer’s revenue from the project. Thus, Nellis achieved a cost reduction of 6.8 cents/kwH through a PPA that financed an installation whose real cost is roughly 20 cents/kwH through REC income from the local utility.[92]

This is a compelling story in terms of the efficiency of the process and the financial gains to the military. However, only two of the three “compelling needs” cited by the Air Force as justifications for the array were actually met: energy costs were certainly cut, and the Air Force can claim double the amount of energy produced toward its Energy Policy Act goal (it bought replacement credits for the REC’s sold by the utility), but the array actually does very little for energy security. This is surprising, considering assertions to the contrary from everyone from Air

[91] Thomas Leyden (Managing Director, SunPower), “Achieving Solar Systems at Scale on Federal Property: the Nellis AFB Case Study,” 2009.
[92] Hunt, 2009.

Force and DoD leadership to knowledgeable base personnel. Consider the following excerpt from an article in the *Journal of Energy Security*:

> According to base energy manager Bob Jones this solar array provides about 25% of Nellis' electrical needs. Even if the solar array were expanded four-fold to provide 100% of the installation's electrical needs, it is not in the interest of the base to disconnect from the grid. If terrorists struck or if a major eruption of Japan's Mount Asama were to darken western skies for a fortnight thus disabling solar power production at Nellis, the national grid serves as a backup source of power. Likewise, if the electrical grid is disabled, the power generated by Nellis' solar panels is sufficient to operate its critical infrastructure. In tandem, the existing grid and the new solar technology contribute to energy security at Nellis AFB.[93]

This is a very interesting locution. *Strictly speaking* Mr. Jones has not dissembled about anything (even the last sentence, we will see, has some justification), and it may well be true that critical infrastructure only accounts for 25% of electricity consumption. Therefore, the power generated by solar panels would be sufficient to operate the base in the event of the blackout. What he neglects to mention is that the array actually cannot power the base reliably in the event of a blackout because of its electrical configuration and its intermittency characteristics. Current base energy manager Jeffrey Blazi, in an interview, admits that a) "the solar array automatically shuts down if the grid loses power" and b) "The solar array does not store any energy" (i.e., there is no way for the array to generate electricity when sunlight does not reach the ground).[94] In fact, a spokesperson for the solar array's operator, Sarah Disch, explained in an interview that "the base never had any plans for grid-independent operation."[95]

So is there any contribution to energy security from the installation? Indeed there is; tucked away in a 50 page spreadsheet sent to the GAO for its Congressionally mandated 2010 report to Congress on DoD renewables progress is a sentence on how "reduced peak demand

[93] 1. Drexel Kleber, "The US Department of Defense: Valuing Energy Security," Journal of Energy Security (June 2009): 19.
[94] Jeffrey Blazi, "Interview with Nellis Base Energy Manager," Email, November 8, 2010.
[95] Disch Sarah, "Interview with Fotowatia Ventures Representative," Phone, October 21, 2010.

reduces stress [on] substation – lowers failure potential."[96] In other words, by reducing the amount of electricity that has to flow from the utility to the base in peak hours, the substation (which was designed to support the original peak load) is less likely to fail. Again, this is a strictly true statement, but it has very little to do with the grid-independence of which officials boasted.

There are probably several reasons why base officials never even considered grid-independent operation, or "islanding." First, it is technically difficult to design a system that automatically detects a grid fault without registering false positives as well, which could have electrically hazardous results. Second, Nevada state regulations, like most other states, follow IEEE guidance in requiring independent distributed resources to shut down in the event of a grid fault. Pursuant to 40 USC 591, the base had to ensure that the operator of its array complied with "state utility service laws and regulations."[97] Financial optimization also imposed a constraint on the size of the PV system. Sizable "wheeling tariffs" (a tax on energy outflows) in Nevada and the absence of net metering eligibility (net metering pays an energy producer back for energy generated in excess of that consumed by the producer) meant that the solar installation could not ever produce more power than was being instantaneously consumed at the base.[98] Therefore, a system that, even at sub-peak conditions, could power the base's critical infrastructure would likely exceed this size constraint—Nellis peak power usage is less than double the actual solar array's peak output. Energy storage was probably even farther from the minds of value-oriented base officials, who would have balked at the high cost of sufficient energy storage to compensate for the intermittency of solar. For all of these reasons, a PV installation in islanding

[96] Defense Infrastructure: Department of Defense Renewable Energy Initiatives (Government Accountability Office, April 26, 2010).
[97] James Snook, Air Force Facility Energy Center, "EUL Industry Forum, USAF Renewable ENergy," 2009.
[98] Hunt, 2009.

configuration that could reliably meet the needs of powering the base during a blackout was not feasible.

Despite the inability of the Nellis solar installation to appreciably increase energy security, the array has been touted as a spectacular success. The AFCESA includes “spreading success” as a vindicatory metric; it cites “conference presentations,” “briefings and tours for national leaders,” “professional periodicals,” and “even a video question on ‘Jeopardy’ game show” as measures of nationwide adulation for the project.[99] While operationalizing a public relations motivational variable is beyond the scope of this paper, it would be naïve to ignore the potency of such a variable in an analysis. Nellis has been trotted out as a showhorse to “position the Air Force as a world leader in implementing renewable solar power,” and there is a distinct possibility that the allure of encomia from Congress, the Executive, and the American public may have helped overwhelm energy security considerations.

The story of solar power at Nellis Air Force Base neatly illustrates the counterintuitive relationship between problems and solutions that John Kingdon postulated. The array was clearly intended to optimize two variables—cost and federal goal attainment—and the resultant constraints of this optimization (operating the array through a private developer and thus strictly adhering to state regulation, minimizing tariffs, etc) precluded the accomplishment of the third goal of energy security. The solution to optimize the first two variables, however, was then attached to the third goal, a Kingdon-esque “solution seeking a problem,” to provide added justificatory weight. An interesting question is whether the array would have been implemented without the possibility of advertising the purported energy security advantages. In the case of Nellis, the counterfactual is unclear, because of the lucrative PPA that was negotiated; however

[99] Hunt, 2009.

as we will see with other more financially disadvantageous installations, this justification may well have been a necessary condition for pursuing solar.

The other question under consideration in this case study—that of uncovering the mechanism of pursuing and implementing a solar project—cannot be decisively resolved in favor of either a centralized or decentralized model, but the latter seems to dominate. Air Force officials admit that without the serendipitous, unsolicited proposal by a private developer, the project would not have been pursued—in fact, had the proposal arrived just 3 months later, the Nevada Power Company would have filled its REC quota elsewhere. Moreover, Steve Dumont, the official at the Air Combat Command's Mission Support Energy (ACC/A7) office to whom the proposal was sent, nearly ignored the ostensibly infeasible idea because of an ignorance of Nevada RPS statutes. Once the financial incentives were realized, however, ACC/A7 and AFCESA officials instructed the 99th Contracting Squadron at Nellis to form a procurement team. From there, the team at Nellis, driven especially by the entrepreneurial deputy base civil engineer, initiated a speedy process. The base even set aside hundreds of thousands of dollars in funds to pay for environmental and legal investigations, toward the cost of which ACC only contributed a fraction.[100]

Therefore, centralized decision making really only happened at one crucial point in the process—reviewing the proposal and directing the base to start the procurement process. The impetus for the project did not originate with ACC/A7 or AFCESA, and the alacrity of the project was a result of a dedicated core team at the base. The central Air Force energy management structure was therefore certainly not a sufficient condition for the completion of the Nellis array, and it is unclear whether they were even necessary. Crucially though, centralized

[100] Curtis Henley, Nellis Air Force Base, Nevada Photovoltaic Project (Monterey, CA: Naval Postgraduate Academy, June 2008).

personnel were responsible for the translation of a PV proposal into an articulation of opportunities and goals, as well as formulation of an extensive strategy to publicize the project. Generalizing from this specific case study, we might expect that higher-ranking Air Force officials are keenly aware of renewable goals and the opportunity to justify projects through energy security gains, but rely on initiative taken by private actors and individual bases to begin and sustain a project. At this point, the particular case study of Nellis cannot generate many more inductively apt insights, but it has done a lot of explanatory work to illustrate the decision-making process at an important PV installation. Next, we step back for a more aerial survey of all Air Force solar installations and their characteristics.

Observations: Air Force solar installations

Table 4-3: Major Air Force Solar Installations

Location	Size (KW)	Date Operational	Project Designed to Supply DoD Independent of Grid?	Total Capital Cost ($ thousands)	DoD Capital Cost ($ thousands)	$/W	Funding type	Double-counting?	Energy Security Impacts	Reported toward National Defense Authorization	Reported size (kW)
Luke AFB	350	10/26/2006	No	3125	3125	8.93	ESPC	No	Flexibility	1484	216.7
March	460	12/6/2006	Yes	5000	5000	10.87	ECIP	No	Offset reduced the amount of electricity purchased from local provider	2	0.3
Ascension AAF	150	11/5/2007	Yes	1127	1127	7.51	Appropriated	No	All energy from onsite generation, renewables replace fuel oil usage for generators.	149	21.8
Nellis AFB	14200	11/20/2007		110000	0	7.75	PPA	yes	Reduced peak demand reduces stress substation - lowers failure potential	115814	15499.2
Los Angeles	145	11/5/2008	Yes	853	853	5.88	Appropriated	no	The solar PV system can provide approximately 5% of the annual facility electric consumption.	144	21.0
Fresno-Yosemite ANGB	660	2/24/2009	No	6450	6450	9.77	ECIP	No	Could provide partial Energy Security Support. Because of grid tie, if grid goes down, generation system is shut down to prevent back feeding.	3002	438.3
Hill AFB	200	5/27/2009	Yes	2679	2679	13.40	ESPC	No	Reduced purchase requirements. Onsite generation capability.	463	67.6
Toledo ANGB	783	6/17/2009	No	8200	8200	10.47	RDT&E	No	Could provide partial Energy Security Support. Because of grid tie, if grid goes down, generation system is shut down to prevent back feeding.	2672	390.1
Buckley AFB	1000	N/A	No	7294	7294	7.29	ECIP	No	Reduced base load, increases energy security	9956	1453.5

Table 2-2 summarizes all “major” Air Force on-base PV installations, where “major” is defined as >100kW. By inspection, none of these arrays are sized on the same order of magnitude as Nellis, which is clearly the exceptional case over the last five years. One installation, at Buckley AFB, Colorado, was included in the table even though it has yet to become operational; since it is near completion and similar data to that of the completed projects was available, we include it to boost the observational sample size.

Much of the data in the table was obtained from a DoD submission to the GAO.[101] The GAO, following direction by the FY2010 National Defense Authorization Act to report on DoD progress on renewable energy, solicited data from DoD on ongoing and completed projects. The GAO included in the report this disclaimer about the received data:

> Because DOD did not provide the energy initiative data in sufficient time to allow assessment of their accuracy and completeness before the mandate deadline, these data are of undetermined reliability.

Indeed, there appear to be either rampant inconsistencies or surprising revelations in the submitted data. Where possible, figures have been corrected through independent research, and the rest of the data will be analyzed with a grain of salt.

The first interesting set of observations comes from the columns: “Project designed to supply DoD independently of the grid?” and “Energy Security Impacts.” With the exception of Ascension AAF (located on an island without grid access), it would be surprising if any of the affirmative answers to the first question are honest. The other bases listed as capable of providing power independently of the grid, March, Hill, and Los Angeles AFB’s, all are located in states (California and Utah) that subscribe statutorily to IEEE Regulation 1547, a national standard that mandates that distributed generation sources shut down in the event of grid failure.

[101] Defense Infrastructure: Department of Defense Renewable Energy Initiatives (Government Accountability Office, April 26, 2010), 7.

Indeed, the arrays at Hill and March are both connected directly to the base grid, which in turn is supplied and serviced by state utilities, and thus the arrays must comply with interconnection codes. In the unlikely contingency that the military sought special permits to circumvent state laws and design intentional islanding circuits, the "Energy Security Impact" column would certainly have reflected the effort. Instead, the contributions to energy security are limited to "decreas[ing] purchase requirements," and "onsite generation capability," both of which are tautologically obvious from the definition of grid-connected on-base solar.

Reading through the other "Energy Security Impact" answers sheds scarcely any more light on how the various installations increased energy security. The DoD's energy security report card includes self-referential statements at Buckley AFB (Energy Security Impact: "Increases energy security"), irrelevant information at Los Angeles AFB ("can provide 5% of annual facility electricity consumption"), and downright counterintuitive reasoning at Toledo and Fresno ANGB's ("Could provide partial Energy Security Support. Because of grid tie, if grid goes down, generation system is shut down to prevent back feeding"). We briefly postpone the discussion of these observations, but note that they are in line with a model of military decision making that superficially attaches problems to solutions without any substantive connection between solar and energy security.

The next set of observations is the quantity of renewable energy generation reported toward federal requirements. As a brief aside, note that the "Reported Size in kW" column is an approximate translation of the actual reported energy generation into units of power, as a rough check against the rated size (in units of power) of the installation. The size of a solar array is most easily measured in units of power, because solar panels are rated for their power output at optimal irradiance conditions (1000W/m^2). However, the federal goals are measured in generated energy per year, which has units of kWh per year. The conversion formula between the power rating and annual energy generation is relatively simple:

$$\frac{Energy\ (kWh)}{year} = Rated\ Power\ (kW) * \frac{Peak\ Sun\ Hours}{Day} * \frac{365\ Days}{Year} \qquad (1)$$

(where peak sun-hours per day varies from 5-6 in the areas of interest, so 5.5 was used as an average.) This formula actually can be quite a bit more complicated, with additional factors like “availability,” “DC-AC inverter loss,” “module mismatch,” etc., but in aggregate those factors tend to decrease the energy output by ~20% at most, so they were omitted. Incidentally, Nellis’ actual output agrees well with our simplistic formula, suggesting that a conservative estimate of peak sun-hours probably balances out the other loss factors to first order.

This rough conversion column illustrates how drastically some of the reported sizes and rated sizes disagree. At one extreme, March AFB reported virtually no energy generation—inverter losses certainly cannot account for a 1,000x shortfall on its rated output. In fact, 4 of 9 bases reported less than half of the energy output that their arrays should have produced. Why might this be the case? We entertain three hypotheses:

a) The figures are simply incorrect.
b) The Air Force chose to sell some or all of the REC’s for the array (and not purchase replacement REC’s).
c) The arrays suffered poor output due to bad weather, technical difficulties, etc.

Explanation a) is unlikely because the figures are reported to a high degree of precision (many significant digits), and Nellis’ figure is very accurate, so either the data were flagrantly fabricated or it actually is what was reported to meet federal mandates. Explanation c) is simply unlikely—geographically separated and technologically diverse arrays would have all had to fail, and this seems like too much of a coincidence. Explanation b) seems the most plausible, given that selling REC's can make the project more profitable, but preclude the corresponding generated energy from being counted toward federal goals. Indeed, on a per Watt basis, the arrays at March and Hill are clearly the most expensive, and both bases reported abnormally low energy generation, so sale of REC's to defray capital cost is a plausible explanation. Unfortunately, the granularity of DoD REC data is far too low to derive any useful insight about the particular bases in question, but the proposed hypothesis b) appears to be the most likely by far.

These observations dovetail with the column "$/W," which is the standard metric by which solar costs are compared. For reference, the current price of utility scale solar is about $3.50/W, with an LCOE of 17.07 cents/kWh;[102] since 2005, the highest average price (including installation) has been $9.00/W. Four of nine solar installations at Air Force bases exceeded that upper bound. In addition, the DoD paid the entire up front capital cost of each array funded by direct appropriation, RDT&E, or ECIP. In the two cases of ESPC's, another developer could have paid part or all of the capital costs, but the DoD disclosure reports that DoD still paid substantial capital costs—in the case of Hill AFB, to the tune of over $13/W.

Apparently, for bases other than Nellis, solar was not economical. Indeed, at Hill AFB, which suffered from the highest cost per Watt for its array, officials admitted that switching to solar was not economically advantageous as compared to purchasing from the local utility.[103] Recall that in order for an ESPC to gain approval, a base must demonstrate that the costs to the base per year will never exceed the previous amount paid to the utility. Since solar failed this test, Hill AFB bundled the array with a much larger and cheaper landfill gas-to-energy project; in aggregate, the two projects together met the ESPC guideline.

[102] DOE Open PV Project, available at: http://openpv.nrel.gov/.
[103] Joseph Price, "Clean and Green Power - Renewable Energy Innovations; Ameresco, Inc.," November 10, 2010.

The last observation of note is the "Double-counting?" column, which indicates whether the reported energy generation was counted twice toward Energy Policy Act mandates. Recall that the Air Force projects that 44% of its 2015 goal will be met by "bonus credits," or counting both the energy and the REC's of an on-site installation. No base registered any bonus credits, save Nellis, which is curious. Importantly, this is *not* for the same reason (sale of REC's) that fewer units of energy were reported than generated, because selling REC's disqualifies reports of both the REC's and the actual energy generation. It seems obvious that the Air Force would want to count as many credits as possible, and any reported on-base credits should be eligible for bonus credits unless the energy itself is sold elsewhere. Regardless of why the Air Force was unable to double-count its credits, the fact that it did not is a blow to the theory that the bonus credit feature of federal legislation incentivized on-site solar.

Analysis

The observations above reinforce many of the insights that arose from our case study of Nellis, but there is some perplexing new data to account for. Apparently, the Air Force is aware that its arrays do virtually nothing to enhance energy security, but nevertheless some of its documents give the appearance that they do (e.g., reporting that arrays were designed to function independently of the grid). Consider also a classification scheme currently employed by the Air Force where "directly connected to base-grid" improves an array's energy security rating; Nellis is a prime example of an installation that feeds only into the base grid (to avoid wheeling tariffs) but shuts down in the event of a grid failure.[104] This disingenuousness helps to cement our hypothesis that the solution of solar PV was not attractive because it actually solved the problem of energy security, but rather because it gave the appearance of doing so.

[104] Air Force Civil Engineer Support Agency, "Air Force Sustainability & Energy" (St. Louis, 2010).

So was cost a driver of Air Force solar adoption instead? The high cost of the solar installations examined above contrasts starkly with the financial benefits accrued by Nellis' PPA-financed array. DoD bore the brunt of the capital expenditure for most of the arrays,[105] and the cost per watt was higher than the private sector average – financially disadvantageous according to officials like those at Hill AFB. The evidence therefore suggests that the Air Force certainly did not follow a VFT-like approach and select large solar arrays over "do nothing" due to cost considerations.

We are left with federal mandates as a possible driver for Air Force solar interest. But the arrays analyzed had to report fewer credits to bring down costs (through REC sales), and for some reason were not even eligible for double-counting. Therefore, they did little toward goal attainment, while we would expect a policy motivated solely by federal mandates to at least optimize for that goal. At this point, recall the multiple streams theory discussed in previous chapters; multiple streams predicted that no single driver precipitates policy action, but rather a confluence of felicitous circumstances opens a policy window. Analysis of the Air Force supports the first insight—energy security, cost, or federal mandates cannot alone explain the observed phenomenon.

Thus, delving into the Air Force's implementation of solar power has strengthened the multiple streams conclusions reached in the last chapter. Additionally, the data support a modified version of hypothesis H2b in response to Question 2, which solicits a theoretical model to account for the observed implementation practices. Namely, some bases entrepreneurially pursued solar in response to guidance that skimped on details; therefore, implementation was decentralized and lacked unified guidance as to the purpose of the solar panels.

[105] Actually, all of them, according to the DoD submission; even ESPC's generate high capital costs for DoD according to the data DoD submitted to GAO. This may be an example of data unreliability, however.

At Nellis, we concluded that private interests and base teams were necessary parts of a sufficient condition for the array's completion, supporting the decentralized model suggested above. There is some evidence to support the same kind of insight about the rest of the bases. For example, ESPC's come in two varieties—regional grants, pursued by AFCESA and intended to promote energy initiatives at several proximate bases, and base grants, for which bases individually apply. To date, all solar ESPC's have been of the second variety, suggesting that base-level entrepreneurship drives solar projects. The Air Force Science Advisory Board concurs, noting that:

> The Air Force's significant strides in the alternative energy area came from advances in policy and individual base initiatives. However, neither the policies nor the deployment activities have engendered a systems-level view of which technologies make sense, where they make sense, and what benefits they bring to the Air Force enterprise.[106]

This finding supports our conclusions at Nellis, that central command structures like ACC/A7 set and interpret policy, but it is up to the base to apply for funding, coordinate logistics, find private partners, and accomplish the construction.

This decentralization helps to explain why Air Force solar initiatives cannot be assigned clean, problem-motivated justifications. The central directive to pursue solar emerged from multiple streams policymaking; that direction trickled down to the base level, without clear guidance on exactly what problem it was supposed to solve. As a result, we observe a hodgepodge of expensive, insecure installations that do not really support goal attainment. At the base level, the installations promise some level of good press, positive bargaining leverage and good will with central command structures, and they conform to direction to pursue solar whenever possible. The Conclusion will suggest how the Air Force and DoD in general should

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[106] Alternative Sources of Energy for US Air Force Bases (United States Air Force Scientific Advisory Board, August 1, 2009), 20.

revise their decision-making on solar, and this chapter should provide evidence that overarching coordination and clarity of overall goals are integral to effective policy.

Chapter 5: DoD Policy Revision and Renewable Microgrids

"Critical national security and homeland defense missions are at an unacceptably high risk of extended outage from failure of the electric grid."

"The Department should take immediate actions to "island" the installations listed in [classified] Appendix G and increase the efficiency of critical equipment to reduce the burden for backup systems."

~ The Defense Science Board Task Force on DoD Energy Security, February 2008. "More Fight – Less Fuel"

Previous chapters have concluded that the military's deployment of solar power to date has failed to accomplish the goals put forth in the Defense Science Board Report quoted above. Earlier, we briefly noted why it is technically difficult for intermittent, distributed energy sources to contribute any energy security value, especially in a cost-effective manner. However, 2010 saw a nascent effort by the DoD to turn the rhetoric of security-enhancing green technology into a demonstrable reality.

This chapter will investigate the current potential for self-sufficient microgrids at military installations and the relationship between this research effort and the previously discussed efforts by DoD to adopt solar power. We proceed by first examining a case study of the military's research and development into renewable microgrids, the SPIDERS microgrid demonstration project. Subsequently, we will summarize the current research outlook on the technology and economics of microgrids. This will enable us to comment on the feasibility of DoD-wide adoption of the lessons learned from SPIDERS, as well as the compatibility of the goal of energy security with those of meeting federal renewables mandates and holding down costs.

Fundamentally, we seek to answer:

<u>Question 3</u>: What explains the DoD's recent interest and investment in renewable microgrids?

H3a: DoD officials followed the Stages model

H3b: Bounded rationality and incrementalism characterized DoD decision-making.

Just like previous chapters, this chapter refutes the Stages model, applying alternative theoretical models to account for the DoD's decision to revise its solar energy policy and integrate panels into microgrids. The fact that policymakers failed to even consider and, *a fortiori*, invest in nonrenewable microgrids provides strong evidence that officials revised the policy by building upon the already established association of the problem of grid insecurity with the solution of renewable energy.

SPIDERS

Analysis of the SPIDERS project—to demonstrate a renewable microgrid that would power a base in the event of utility grid failure—is elucidated by recalling the conclusions from previous chapters on the DoD's multiple streams decision-making behavior. We make the following argument:

1. Recent focusing events demonstrating cyber-vulnerability brought the problem of transmission grid insecurity back to prominence.
2. Solar power had already been designated as the preferred solution to the problem of grid insecurity (as demonstrated in previous chapters), creating a strong association between renewable electricity and grid security.
3. Officials sought to fully address the security concern by building a microgrid based on generation from solar PV and other renewable sources.

This explains why an exhaustive effort was not made to compare renewable and nonrenewable generation alternatives. The DoD took as its starting point solar power and other renewable technologies and then sought to build a microgrid suited for the intermittency that characterizes solar power. We will see that the result is an impressive technical agenda, but an expensive project whose reproducibility at other military bases, given financial constraints and federal mandates, is dubious.

Background

In October, 2010, a wave of publicity followed the DoD's announcement that it would initiate a research and development project to build a demonstration microgrid.[107] The project, entitled SPIDERS (Smart Power Infrastructure Demonstration for Energy Reliability and Security), sought to address the "unacceptably high" risk of grid failure. In justifying the program, officials cited not only the (naturally caused) Northeast Blackout of 2003, but also attacks on grid operating systems by Chinese and Russian spies and other cyber-hackers.[108]

Therefore, the program was formulated to pursue two parallel tracks: development of a smart grid and implementation of advanced cyber-security protocols. Individually, the systems will be tested at smaller demonstration sites, first Pearl-Hickam Joint Base, Hawaii, and then at Fort Carson, Colorado. The third stage and technical culmination of the SPIDERS project, planned for FY 2014, will be a full-scale microgrid at Camp Smith, Hawaii, supplying a 10 MW load; the microgrid will be able to supply emergency power to 33% of the total installation, which covers all critical loads. The final, fourth stage of the project is to facilitate the transfer of the newly developed technology and protocols to other military bases. A Department -wide effort pursued in collaboration between the military's Northern and Pacific Commands, the project is intended to generate results with wide prospects for transferability to domestic bases.[109]

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[107] 1. Dina Maron, "DoD Plans Project to Thwart Cyber Attacks, Tap Renewable Energy," New York Times, October 18, 2010.
[108] Dr. George Ka'iliwai, SES and Mr. Bear McConnell, SES, "SPIDERS Energy Security JCTD Proposal," February 2010, 6.
[109] Mr. Ross Role, "PACOM Energy Security Initiatives," September 2010, 19.

SPIDERS comprises an ambitious agenda of technologies to test and integrate. The following is a list of equipment and features that the project will incorporate:

1. Generation sources: Solar PV panels and wind turbines will serve as the renewable, distributed electricity generators.
2. Backup Power: In order to smooth intermittencies of the distributed generation sources, the project will include a Fuel Cell for baseload power, and batteries and an electric car fleet for energy storage at night.[110]
3. Smart Grid, Demand Side Management: The project will upgrade the energy efficiency of installation equipment. Also, by using smart meters and two-way communication between electric devices and control systems, the base will incorporate dynamic load shedding—the ability to cut power to idle or nonessential parts of the grid to instantaneously optimize the total electrical load.
4. Islanded Microgrid: If the main utility grid fails, the base grid will transition seamlessly to intentional islanding mode. The microgrid will feature load balancing—storing excess generation for use in peak periods—so that generation capacity and critical needs can be matched for prolonged periods of islanded operation.
5. Cyber Security: The project will implement Virtual Security Enclaves, or protected control networks that can be isolated for islanded operation, among other defensive protocols against cyber-intrusion.[111]

<u>Cost</u>

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[110] Richard Kidd, Federal Energy Management Program, GreenGov Symposium (Department of Energy, October 2010).
[111] Dr. George Ka'iliwai, SES and Mr. Bear McConnell, SES, "SPIDERS Energy Security JCTD Proposal," February 2010, 11.

As a research-oriented endeavor, one expects SPIDERS to cost more than the reproducible microgrid system it hopes to develop. Still, an analysis of the program's budget reveals high costs even after taking into account research, development, and operations expenses. The following table lists costs for the parallel smart grid and cyber security tracks:[112]

Table 5-1: Cost Estimates for SPIDERS Project

Smart Grid	($millions)	**Cyber Defense**	($millions)
System Design and Development	3	System Design and Development	0.72
Grid Operations Support	1	Training	0.4
Energy Management System	1.8	Cyber Operations Support	0.7
Wind, Solar, Fuel Cell, Energy Storage	3.2	Hardware	2.9
Islanding Hardware, Software	2	Installation	0.92
Total	11	*Total*	5.64
Total (only capital cost)	7	*Total (only capital cost)*	3.82
Total capital cost	**10.82**		
Generation Sources % of capital cost	**29.57%**		

The "Total (only capital cost)" column strips all funding from research, development, and operations from the project cost calculation. The idea is that capital costs, including the solar panels, wind turbines, advanced energy meters, and power electronics, are reasonably representative of the final capital cost for a microgrid. Conversely, the "System Design and Development," "Training," and "Operations Support" may all decrease or vanish after the research effort is completed.

The total capital cost of SPIDERS, therefore, can be regarded as a minimum cost for an equivalently sized microgrid (which will incur at least nominal operations and maintenance costs). Alarmingly, the electricity generation sources (solar, wind, and fuel cells) and energy

[112] "SPIDERS Energy Security JCTD Proposal," cited above.

storage comprise *less than a third* of that cost. Even if there were no cyber security defenses—arguably a microgrid still provides some security benefit without such defenses—the generation and storage equipment would still account for less than half of the total capital cost.[113] The implication is that microgrids will cost vastly more than simply deploying renewable generation to military bases.

Motivation

The DoD formally derives its license to invest in a microgrid research effort from Congress' FY 2011 National Defense Authorization Act; the Act stipulates that DoD "demonstration projects should include…micro grid and smart grid technologies."[114] However, this is not the first time that Congress has urged the DoD to develop secure microgrids powered by distributed generation. Immediately after the 2003 blackout, the House Committee on Energy and Commerce held a hearing entitled, "Blackout 2003: Why Did It Happen and How?"[115] In that hearing, Rep. Darrell Issa (R-CA) exhorted the military to use distributed generation to ensure that "our military installations are guaranteed safe reliable power, even in the case of blackouts like the one we recently endured." So the idea for military microgrids did not originate

[113] Perhaps the high costs are a result of contractor markup, and when microgrids are deployed on a larger scale those costs will vanish. The SPIDERS Request for Information (RFI—a precursor to a Request for Proposals) advertises for twelve functionalities, seven of which are directly tied to capital equipment purchase (e.g., "the ability to integrate technology to control demand-side management") and only one of which involves the renewable generation equipment. So contractor markup may well have inflated the price tag of the SPIDERS microgrid, but the cost breakdown seems justified by the various functions that the military wants to accomplish with the microgrid; thus, the conclusion that there is a significant cost to integrate renewable energy into a microgrid is still valid. As we will see later, many of these functions are unique to renewable microgrids. See:

Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS), Request for Information (US Army Corps of Engineers, August 19, 2010).

[114] S 3615. Sen. Johnson, Military Construction, Veterans Affairs and Related Agencies FY 2011 appropriations bill, n.d.

[115] "U.S. House of Representatives: Committee on Energy and Commerce. Blackout 2003: How Did It Happen and Why?," 2003. http://archives.energycommerce.house.gov/reparchives/108/Hearings/09032003hearing1061/print.htm.

in the 2011 Defense Authorization Act, and the minimalist language in that act could have been met by a much smaller project, such as the Fort Carson demonstration alone.

This suggests that the primary motivation for the SPIDERS project was internal to the DoD, not external pressure from Congress. Moreover, DoD officials cite recent demonstrations of threats that help explain the timing of the project—why it was pursued seven years after the 2003 Northeast Blackout. In a joint presentation introducing the project, NORTHCOM and PACOM officials cited four problems related to dependence on the electricity grid:

1. Danger of cyber attacks affecting mission critical assets.
2. Vulnerability of critical operations to prolonged power outages.
3. **Failure to "integrate renewable and other distributed generation electricity."** (emphasis added)
4. Inefficient electricity consumption, carbon "bootprint," and cost.

Together, they asserted, these problems pose "a significant threat to national security." Given our prior discussion of multiple streams policymaking, this language is very interesting. Recall that earlier (between 2005 and 2010), DoD rhetoric sought to connect the solution of solar power and, more generally, renewable electricity, to the problem of grid vulnerability. But in its justification for SPIDERS, the military is billing renewable power as a solution to *an absence of renewable power* (problem 3). Somehow, renewables have attained an intrinsic value that obviates instrumental justification. In other words, the military is not justifying renewable energy in terms of its contribution to energy security or some other objective. This reasoning eliminates the need to compare the impacts of renewable energy (to energy security, cost, etc.) to those of nonrenewable energy, *independent of the impact of the microgrid components common to both*.

As we have already seen in the case of Tinker AFB and its natural gas turbine, a nonrenewable microgrid may well be cheaper, simpler, and more feasible.

Cyber Terror Threat

Cyber terror events and reports documenting cyber vulnerabilities between 2007 and 2009 explain the timing of the SPIDERS project very well. Just as the 2003 blackout served as a focusing event in the problems stream to catalyze the military's initial adoption of on-site solar power, recent cyber events served as a reminder that grid vulnerability had not actually been addressed yet.

In 2007, the Department of Energy carried out Project Aurora, a test of control systems security over electric infrastructure. Researchers at the DOE's Idaho National Laboratory delivered a cyber attack to a replica of a power plant's control architecture and succeeded in changing a generator's operating cycle, sending it out of control until it self-destructed. Media reports extrapolate that if the hacking techniques were coordinated over multiple targets, the effect could be "equivalent to 40 or 50 large hurricanes all striking at once."[116]

In 2008, the GAO published a report documenting the vulnerabilities of the Tennessee Valley Authority (TVA), the electric utility that supplies much of the Southwestern United States. The report alleged that TVA had failed to secure its control systems, the hardware and software responsible for issuing instructions to the grid, from intrusion. No quick fix was apparent, since the insecurity stemmed from missing software patches, several weak interconnections with the TVA corporate network, antiquated physical hardware, and an institutional failure to train employees in secure protocols. The GAO concluded by questioning

[116] Jeanne Meserve, "Staged cyber attack reveals vulnerability in power grid," CNN.com, September 26, 2007.

TVA's ability to respond effectively to a cyber attack that could affect millions of electricity customers.[117]

Subsequently, between 2008 and 2009, Chinese and Russian hackers gained access to various parts of the US electricity grid. [118] US officials admitted that the breaches had been "pervasive" across the US, although the intent was espionage and not sabotage. Still, an investigation found traces of software that could have been deployed to destroy infrastructure components.

DoD officials justifying the SPIDERS project appealed to all of these incidents as reasons to invest in microgrid research and plan for a malicious grid failure. Although the 2003 Blackout was extensive, power was restored within days; the threat of malicious sabotage with an unknown upper limit of damage increased worries about prolonged outages. Recall that the diesel generators that most military bases employ as emergency backup sources of power are not rated for prolonged use. Therefore, by demonstrating an increased likelihood of grid failure—from natural and malicious causes—the spate of cyber events and exposed vulnerabilities drew DoD policymaker attention once more to the problem of grid insecurity.

Analysis

The DoD response to the cyber threat was not to set up microgrid demonstrations using nonrenewable and renewable sources of electricity—the latter was preferred with little additional justification. In its 2010 Strategic Sustainability Performance Plan, the DoD claimed that a combination of renewable energy and microgrids would mitigate vulnerabilities from utility grid dependence. It then went on to assert that, "The Department is committed to renewable energy not only because it is dedicated to showing leadership in sustainability, but also because it

[117] TVA Needs to Address Weaknesses in Control Systems and Networks (Government Accountability Office, May 2008).
[118] Siobhan Gorman, "Electricity Grid in US Penetrated by Spies," Wall Street Journal, April 8, 2009.

improves resilience and thus mission readiness."[119]However, the renewable energy only contributes to resilience insofar as it is connected to a self-sufficient microgrid. The circularity of this argument—that renewable energy is a security addition to microgrids because it promotes security through integration into a microgrid—is evidence that the security benefit of renewables *independent* of microgrids was not a major factor in DoD strategy formulation.

There is another security benefit that renewables contribute to military bases, which is freedom from fuel supply requirements. Basically all nonrenewable distributed generation sources, like diesel generators or small natural gas turbines, require a fuel input, in contrast to wind and solar power. However, it is a farfetched claim that renewable energy is the optimal technology for a microgrid because during a simultaneous disruption of utility power and fuel lines to the military base, a nonrenewable backup source would not function. In fact, DoD documents and policy articulations never actually follow this line of reasoning to its logical conclusion, choosing instead to cite petroleum dependence abstractly as a security concern.

Consider that the US only imports 15% of the natural gas it consumes, and 90% of those imports come from Canada.[120] So international supply disruptions simply cannot affect domestic base energy security if microgrids are built around natural gas turbines. Moreover, given a dedicated emergency natural gas supply line to a military base, with control systems independent of the utility, a successful cyber attack on the utility grid and the pipeline simultaneously is exceedingly unlikely. By applying the exact same cyber security protocols to the pipeline command as SPIDERS hopes to implement with its microgrid control systems, the military can make a natural gas based microgrid at least as secure as the Camp Smith project—thus, there would be no unique cyber security advantage of a renewable microgrid over a nonrenewable one.

[119] Strategic Sustainability Performance Plan (Department of Defense, FY 2010).
[120] Short-Term Natural Gas Outlook (Energy Information Administration, March 8, 2011).

A physical terrorist attack on a pipeline is possible, but difficult given that most pipelines run underground. Again, the coordination necessary to conduct a successful attack (cyber or physical) on both the electricity grid and the natural gas pipelines connected to a military base would be difficult to achieve, and even then, natural gas can be trucked or flown into a base. This analysis is speculative, but largely because the military has not taken the time to investigate the joint probability of successful attacks on electricity transmission and natural gas transportation. This oversight suggests that the military has not effectively compared the energy security benefits of renewable and nonrenewable microgrids.[121]

It is therefore natural to ask why the military chose renewable generation without giving much thought to nonrenewables, since renewable sources add little security benefit to a microgrid but make the system much more complex due to storage and load balancing requirements. The conclusion from prior chapters that solar power was matched to the problem of grid insecurity explains why, upon the problem resurfacing, the same solution was pursued albeit in more exhaustive fashion. Solar power had already been selected as the policy of choice to address grid vulnerability, and it would take another open policy window for an alternate policy to supplant solar power. The confluence of the problems, policies, and politics stream that opened a policy window for solar power in 2005 was a rare event, requiring several variables to felicitously coincide temporally; in that window, the DoD articulated its clear advocacy of solar

[121] Other government entities have published threat assessments on natural gas pipelines. The Congressional Research Service acknowledged that even though pipelines run underground, certain components (e.g., river crossings, control centers) are vulnerable to physical attack. The Transportation Security Administration reports that there is a conceivable cyber security risk, although it is not aware of any current threats. Further study is required to determine whether the two are jointly vulnerable, but they do not appear to be so (they are not co-located, and a dedicated military pipeline with cyber security protocols would be controlled independently of utility pipelines). See:

Paul Parfomak, Pipeline Security: An Overview of Federal Activities and Current Policy Issues (Congressional Research Service, February 4, 2004).

Pipeline Threat Assessment (Transportation Security Authority, October 23, 2008).

power and its intended use to combat energy insecurity. This supports the earlier insight that policymakers, limited by information-processing and other constraints on their time, utilize an incremental approach to policy change, building upon previously determined conclusions.

The incrementalism and bounded rationality of policymakers described above leads to policy stability and institutional inertia, hallmarks of punctuated equilibrium. Recall Baumgartner's theory of punctuated equilibrium, which we introduced as an opposing framework to Kingdon's multiple streams analysis. Punctuated equilibrium was not useful in explaining the DoD's decision to pursue solar, because the policy shift toward solar was a result not of negative attention breaking down a policy monopoly, but rather of positive attention paid to renewable energy. Punctuated equilibrium is likely more useful in accounting for why the current practice of addressing grid insecurity problems with renewable solutions is not changing; no opposing coalition has mounted a concerted effort to venue-shop, broaden the scope of conflict, and otherwise concentrate negative attention on the use of renewable energy.

The final stage of the SPIDERS four-part implementation plan (circuit tests at Pearl-Hickam, Fort Carson microgrid, Camp Smith Energy Island, transition) involves replicating the Camp Smith model at facilities across the DoD. Since the project is only slated for completion in FY 2014, details concerning transition are sparse, and the program only budgets a paltry $2 million for transfer of technology. The question arises: given the high costs of renewable microgrids, how reproducible is such a project, and how will it interact with current DoD renewable technology efforts? We defer resolution of this question in order to first investigate the current costs associated with enabling grid-independent renewable generators compared with nonrenewable alternatives.

Economic Prospects for a Renewable Microgrid

The following analysis will compare the costs of renewable microgrid components to a nonrenewable benchmark. The benchmark—Tinker Air Force Base's natural gas peaking turbine—was introduced in the last chapter. In 1988, Tinker AFB partnered with Oklahoma Electric and Gas Corporation to install, at no additional capital cost to the Air Force, a natural gas turbine on site. The generator has intentional islanding capability and can meet all critical power needs of the installation in the event of grid failure. That intentional islanding capability could be achieved over two decades ago attests to the simplicity of the nonrenewable microgrid paradigm. Still, to avoid false comparisons, we cannot simply compare the cost of an advanced microgrid like the SPIDERS project, complete with cyber defense and smart meters, to that of the 1988 Tinker configuration. Instead, it suffices to compare only the different generation and storage components and make note of any other grid elements that are unique to the renewable or nonrenewable case.

There is scant publicly available cost information on the Tinker natural gas turbine, except that the utility constructed the generator and did not change the prevailing electricity rate charged to the base. They could do this because the peaking turbine was useful to the utility as a dispatchable power source during normal (non-islanded) operation.[122] So we assume that through an appropriate partnership with a utility, the generation source itself adds no expense to the military if it intends to build a microgrid around a natural gas turbine. Moreover, since the turbine has variable power output and no intermittency problem, there is no requirement for energy storage during islanding mode. Renewable generation sources require energy storage in order to supply power when the renewable resource is unavailable or when the renewable output is mismatched with the load; both of these shortcomings are solved by a variable output plant

[122] Federal Utility Partnership Working Group Meeting (Williamsburg, Virginia: Virginia Natural Gas, November 19, 2008).

with high capacity factor (a measure of how close to full capacity a generator can continuously operate). The favorable economics of natural gas generation have spawned new efforts to design sophisticated microgrids around this nonrenewable power source. One of the most prominent is at the University of California, San Diego, where a 26MW natural gas based cogeneration plant supplies over 75% of the campus electricity needs.[123]

On the contrary, we have already discussed how renewable sources, notably solar, are significantly more expensive than prevailing utility rates on a per kWh basis. Then in the last chapter, we noted that with the exception of the PPA at Nellis, Air Force installations have tended to pay a higher than average price for installed solar panels. On top of this, renewable microgrids require energy storage. Energy storage systems can comprise over 33% of the total system cost (including installation), and are often the most expensive component of a standalone solar PV setup.[124]

The ideal battery system for a PV or wind system has high energy storage capacity and density, high discharge rate, and low cost. Battery sizing guidelines for off-grid applications advise a battery bank that can power the load for five days, necessary in case of an extended storm that renders PV inoperable. Moreover, deep cycling of the battery is inadvisable for prolonged periods of time, so if a microgrid intends to have indefinite islanding capability, only about 20% of the battery's capacity should be cycled to conserve its lifetime. Since conservation of land is important, especially given the large footprint from renewable generation sources, high battery energy density is important. Also, in order to smooth instantaneous intermittencies, the battery must have the ability to discharge power quickly. It is difficult to simultaneously

[123] Eric Wesoff, "EDSA Makes Microgrids, Energy Independence Real," Green Tech Media, July 26, 2010.
[124] John Boyes, Energy Storage in Photovoltaic Applications (Sandia National Laboratory, n.d.).

optimize these latter two requirements; for example, a lithium ion battery's power discharge rate is about 3 times less than that of an ultracapacitor, but its energy density is 20 times superior.[125]

Following is a brief list of prominent battery technologies. We measure costs in terms of kwH stored, which is not necessarily instructive compared with the price of utility electricity (dollars per kwH consumed). Life cycle cost analysis is fairly complex, but we will make a back of the envelope calculation for batteries later on. For now, the figures presented should inform relative comparisons between battery technologies.[126]

1. Flooded Lead Acid: This mature technology has been successfully commercialized and is the technology of choice for PV applications. However, it suffers from low energy density and high maintenance. **$150/kwH**
2. Valve-Regulated Lead Acid (VRLA): This technology is still undergoing research to lower costs, but may eventually result in increased cycle life, efficiency, and reliability all at the same or lower cost than flooded lead acid batteries. **$200/kwH**
3. Nickel-Cadmium: With reduced maintenance and higher energy density, these batteries are superior to lead acid except in terms of cost. **$600/kwH**
4. Lithium-ion: Currently the most expensive battery, Li-ion also boasts the most impressive electrical characteristics with high energy density, efficiency, and power discharge. Continuing research may reduce prices considerably over the next ten years. **$1,333/kwH**

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[125] Burke, Andrew. "Batteries and Ultracapacitors for Electric, Hybrid, and Fuel Cell Vehicles." *Proceedings of the IEEE* 95.4 (2007).

[126] Susan Schoenug, Benefit/Cost Framework for Evaluating Modular Energy Storage (Sandia National Laboratory, February 2008);

Dan Ton, Solar Energy Grid Integration Systems - Energy Storage (SEGIS-ES) (Sandia National Laboratory, July 2008); and

Basic Needs for Electrical Energy Storage (Basic Energy Sciences Workshop on Electrical Energy Storage, April 2, 2007).

5. Newer technologies with high growth potential: Li-$FePO_4$, Zebra battery, Na/S, Vanadium Redox. **$450-800/kwH.**

The point of this discussion is to demonstrate that while battery research is an exciting scientific field, energy storage is still very expensive, especially when land constraints, environmental considerations, and maintenance requirements eliminate the cheapest alternatives. Indeed, for a system intended to meet a 10MW peak load, the SPIDERS energy storage system could cost anywhere from $18 million to over $100 million; the higher bound includes more efficient batteries to save space and greater energy storage capacity to provide greater redundancy.[127] Incidentally, this implies that the budget request made by the project is either unrealistically low, asking for only $3.2 million for generation and storage combined, or the cost is being financed over a much longer period of time than three years, which is the extent of the proposed budget. To compare the storage cost with the generation cost, the lower bound of the battery cost adds ~$2/W to the cost of a 10MW renewable installation. Assuming industry averages, if the military manages to install its solar panels at $4/W, the batteries will have added at least 50% of the cost of the solar panels.

On top of the cost of batteries, there are various other costs that are unique to a renewable system compared to a nonrenewable alternative. Wind and solar PV both produce DC power, which has to be converted to AC power using inverters; similarly, the battery bank's DC discharge must be converted to AC power. This entails not only purchase of more equipment but also power loss in the conversion, neither of which afflicts a natural gas turbine. Additionally, many of the features required for the renewable smart microgrid—like load balancing and load

[127] Assumptions:
a) Lower bound: average installation load is 50% of peak load (below Hawaii Electric Commission average), batteries alone can power base for one whole day, cost = $150/kwH.
b) Upper bound: average installation load is 75% of peak load (above Hawaii Electric Commission average), batteries alone can power base for five whole days, cost = $500/kwH.

shedding—can be much simpler with a natural gas turbine that delivers reliable and adjustable power. Therefore, the cost of the control electronics, metering, and other equipment in the SPIDERS microgrid could be expected to decrease if the renewable components were replaced by nonrenewable ones.

We conclude that a microgrid based on nonrenewable generation is significantly less costly than one that relies on wind and solar power, like the SPIDERS microgrid. The former basically entails no extra costs for the generation source, little to no energy storage requirement, and simpler control electronics. Conversely, solar and wind power are more expensive than utility power, and the cost of generation is significantly increased by the need for energy storage, which is still an expensive proposition.

Implications for SPIDERS Transferability

Even a successful microgrid demonstration at Camp Smith will not lead straightforwardly to widespread adoption at other military bases for the following reasons:

1. Renewable microgrids are too expensive.
2. Secure control and operation is incompatible with the third-party financing model increasingly embraced by the Services.
3. Implementing renewable energy in a secure manner impedes federal mandate compliance.

Current military energy policy is to procure renewable energy when it is life cycle cost effective. ECIP grants require a five year simple payback time, and guidance for ESPC and PPA agreements stipulates that energy savings fully offset capital costs. The above analysis suggests that renewable microgrids do not come close to meeting these requirements. Consider that even without energy storage, the solar PV array at Hill AFB was considered uneconomical and had to be bundled with another project to secure a DoD grant. With expensive energy storage that, as we saw, can add at least 50% of the cost of a PV system, and other capital costs which in the SPIDERS microgrid total over three times the generation and storage costs together, there is no way that a renewable microgrid can promise a reasonable payback period or acceptable financing agreement. This stands in stark contrast to the Tinker microgrid, a simple but cost-neutral and security-enhancing solution devised two decades ago.

Our investigation into the Service-level implementation of DoD renewable policy revealed that the Air Force, facing steep federal targets, has pinned its hopes on third party PPA's. Fully 80% of the renewable expenditures over the next five years will be through PPA's in the image of Nellis AFB, the Air Force contends. Contracting with a third party to install and operate solar panels is one thing, but doing so in a larger context of microgrid construction may prove much more difficult. Recall that the Nellis PPA optimized on the cost dimension to the detriment of security benefits that the base might have reaped from its solar array; by subordinating islanding capability and size to state interconnection regulations and utility wheeling tariffs, Nellis deferred to the third party's bottom line. In contrast, a project like SPIDERS must not compromise security concerns for third party cost concerns or regulatory constraints. A base that hopes to maintain secure control over its microgrid cannot afford to simply purchase power from a third party-operated solar array or wind farm, but must rather operate the system as a component of a complex network.

Recall that the solutions stream converged with the other two streams in part because of private sector financial innovation in PPA's; the Air Force hopes to capitalize on this blossoming industry to install over a gigawatt of renewable electricity over the next 15 years. The same private sector infrastructure does not exist for microgrid installers and operators. Avascent, a leading defense consulting firm, remarks that, "Firms in the defense space have made tentative small-scale moves in the broader smart grid market."[128] Mainstream solar installers have no experience with stringent security demands and would likely balk at signing an ESPC for an installation with components, like backup energy storage, that could not generate revenue through normal grid-tied operation.

All of this suggests that DoD-wide efforts to meet federal mandates may be at odds with successful implementation of renewable microgrids. Indeed, the manager of the DOE's Federal Energy Management Program, speaking about the DoD's effort to construct Net Zero [Energy needs] facilities, noted the "challenge of security versus compliance," adding that the "compliance mindset [is] not always optimal."[129] The reasons are clear: meeting ambitious renewable targets on a limited budget obligates deference to third-party profitability and utility constraints to build the cheapest renewable system possible, without storage and security frills. On top of this, the current Service implementation pattern, observed at least in the Air Force, is a haphazard, frenetic, base-level rush to install renewable energy whether or not the projects meet security, cost or even federal mandate targets. Without a culture change that streamlines the decision-making process for renewable installations, the even more arduous task of installing complete renewable microgrids will be impossible to coordinate.

Conclusion

SPIDERS is a story of a path-dependent and possibly suboptimal solution to reminders of the grave dangers facing the electricity grid. The logic behind combining renewable energy with microgrids is suspect, because the security gains are minimal and the cost and logistical disadvantages are significant. Yet in its most expensive and advertised research project, the DoD

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[128] The Military Smart Grid: Leader or Laggard (Avascent Group, June 16, 2010).
[129] Bob Westby, Net Zero Energy Installation Activities (Department of Energy, NREL, June 14, 2010).

has given nonrenewable microgrids short shrift. The floodgates of renewable energy policy opened when the three streams met in 2005, leading policymakers in 2010 to trumpet the synergies between solar energy and energy security and ignore the obstacles renewable microgrids might pose to Department wide adoption. Unfortunately, the current trajectory of renewable energy deployment in the military, motivated by federal mandates at the highest levels of the organization and driven by doctrine and convenience at the lower levels, is unlikely to veer toward integration of renewables into microgrids. SPIDERS may result in an impressive technical demonstration of islanding, but the renewable microgrid paradigm may remain islanded from mainstream military use.

Chapter 6: Conclusion

This thesis is not intended to heap blame upon policymakers for irresponsible spending and false promises. In fact, it seeks to classify this specific phenomenon—the puzzle of why the military is investing in solar power—as an instantiation of a general trend that emerges from the actions of many individuals under organizational constraints. The successful application of the multiple streams model or vindicated predictions about information transfer in bureaucratic hierarchies would exonerate military officials from charges of being exceptionally bad policymakers. By asserting that this is a case of a larger set of phenomena, this thesis tells a story of well-intentioned officials whose information-processing limits and constraints on their budgets, goals, and media relations guide their collective policy decisions to socially suboptimal outcomes. By recognizing the deviations from an idealized policymaking process, the military can strive to autocorrect toward better policy outcomes. This does not imply that the organization was to blame for those deviations, because the idealized Stages model is unrealistic; rather, effectively using feedback to correct deficiencies is the best an organization can hope for.

The previous five chapters drew three distinct conclusions about the enactment, implementation, and revision, respectively, of DoD solar energy policy. First, Kingdon's multiple streams analysis best accounts for the DoD's decision to encourage widespread adoption of solar power at its domestic bases. Each of three streams—problems, policies, and politics—converged in 2005 to open a policy window favorable to solar power. Importantly, the Stages model prediction that a problem would be recognized and consequently drive the search for and enactment of a particular solution is not borne out by the observed data. In reality, federal mandates for renewable generation introduced peculiar technicalities that incentivized on-base renewable energy; concurrently, private sector financial innovation and federal tax credits elevated solar power as the most attractive renewable energy solution; and DoD officials identified the problem of grid insecurity—recently prominent due to the 2003 Blackout—as an effective justification for the solution of solar power.

Second, the Service-level implementation of the DoD directive to pursue solar power resulted in a haphazard set of installations because, pursuant to Peters' theory of bureaucratic hierarchies, military bases ritualistically followed scant guidance. In other words, higher-level officials failed to transmit a clear, underlying purpose (such as enhancing grid security) and base-level officials, in compliance with the directive to install solar, did so according to the contextual constraints facing the base. So for example, Nellis Air Force Base configured its installation by sizing it to avoid utility tariffs and interconnecting with the grid to comply with state regulations, neither of which enhanced the security of the base. Other bases had cost overruns or sold renewable credits instead of reporting them for federal mandate fulfillment. The decentralized, base-driven approach to installing solar power pursuant to contextual restrictions constitutes an implementation of a policy that strictly adheres to the skeletal guidance transmitted, but in aggregate fails to accomplish any particular purpose.

Third, bounded rationality and incrementalism best account for the revision of the DoD's solar policy, to integrate solar panels and other renewables into self-sufficient microgrids. The resultant pilot project in Hawaii has astronomical preliminary cost estimates on a per kwH basis, compared to both conventional utility generation and renewable generation. An analysis of the components (e.g., energy storage, load balancing electronics, etc.) necessary for a renewable microgrid and their cost demonstrates the unlikelihood of widespread transfer of the technology from Hawaii to other domestic bases. Mysteriously, the DoD failed to consider a nonrenewable generation option for the SPIDERS microgrid, despite the cheap and effective model of the 1988

Tinker AFB natural gas turbine-based microgrid.[130] Incrementalism explains the policymaker predisposition to apply a renewable solution to grid insecurity because it had resolved to do so before; bounded rationality explains why policymakers did not consider other solutions.

Theoretical Implications

In order to assemble the facts of the DoD's multi-level solar energy policy into a coherent story, we have drawn upon a diverse set of theories and constructed an explanatory scaffolding. The observed phenomena confirm exactly what some authors predict and add new considerations and qualifications to other segments of the literature. The contribution of adding one more data point to already well established patterns may be marginal, but a counterexample to a respected theory can generate important modifications. In two of the three policy phases—the DoD's enactment and implementation of solar policy—the pattern of decisions adds new insight to the theoretical understanding of policymaking.

Our analysis of the DoD's enactment of solar energy policy reveals a compatibility between multiple streams and punctuated equilibrium along with new research avenues for the latter theory. We concluded that Kingdon's multiple streams analysis best accounts for the DoD's enactment of solar policy, but Baumgartner and Jones' punctuated equilibrium model did not describe the dynamics of the decision-making process. While Baumgartner and Jones asserted that negative attention drives the dissolution of policy monopolies, in this case positive attention toward renewable energy was the most important driver of DoD solar energy policy. In our examination of the legislative history of the Energy Policy Act, Congressional testimony expressed high hopes for renewable energy. As a result, the 2005 statute enacted the solar

[130] One could argue that it is difficult to lay a natural gas pipeline to Hawaii. However, this does not address the fundamental point that in its only large-scale microgrid demonstration project, the military chose to use renewable generation and in none of its documents displays any consideration of nonrenewable alternatives. If Hawaii's location privileged renewables but the military recognized that nonrenewable generation was cheaper and simpler, it could have easily moved the demonstration project.

investment tax credit as well as the federal renewable mandates—crucial components of the policies and politics streams, respectively.

Even though the mechanism for policy change was different, the observed outcome matches the punctuated equilibrium prediction quite well; a flurry of DoD policy change occurred around 2005, separating intervals of bureaucratic incrementalism. This suggests that multiple streams analysis is still compatible with Baumgartner and Jones' prediction that policy change only happens rarely and in bursts; however, the mechanism postulated in punctuated equilibrium must be revised. Punctuated equilibrium has been the foundation for a rich literature based on negative attention driving policy change (cf. Schattschneider, Gaventa), and could play the same role for a new theory of how policy can also be driven by positive attention. Multiple streams analysis appears to handle such scenarios well, but offers no specific predictions on what kind of issues elicit positive attention or how policy monopolies factor into these decisions. In the present case, there was no leadership overhaul and the DoD's rhetoric was in line with Congressional exhortations to adopt renewable energy; so perhaps when positive attention drives policy change, the policy monopoly itself adapts to harness enthusiasm for an issue, instead of ceding to an expanding scope of conflict. The policy implications of positive attention constitute an exciting new research direction.

The Air Force's implementation of the directive to install solar energy accords with theories of ritualistic compliance but highlights Bendor and Hammonds' caveat that there can be large variation even with perfect compliance. Peters and Allison, among others, predicted that lower levels of a hierarchy would blindly follow orders and standard operating procedures, and that is exactly what we have observed. Between the central offices of the Air Force and the various bases, information was filtered on its way down the hierarchy, and only the directive to pursue solar power was transmitted to base officials. Individual bases found idiosyncratic ways to comply with this directive, each optimizing for cost, mandate fulfillment, or energy security and together contributing to incoherent implementation. The theoretical contribution here is that the idea of ritualistic compliance needs further unpacking; depending on how many variables have been fixed by an order or a standard operating procedure, the number of possible outcomes can be radically different. Therefore, even in the most rigid hierarchies, ritualistic compliance can either result in perfect implementation of a well-conceived order or haphazard implementation of skeleton guidance. The process of information transfer, describing the filters between levels of the hierarchy, needs to be illuminated through further research.

Finally, the DoD's revision of its solar energy policy does not add significant new insight to theoretical predictions, but rather strongly confirms the literature on incrementalism and bounded rationality. Indeed, the single-minded pursuit of renewable microgrids to the exclusion of an arguably superior nonrenewable alternative is a strong blow to rational actor predictions of exhaustive alternative selection in the policy revision process. This final stage of DoD decision making is strong evidence for the well-studied phenomenon of path-dependence. Once the military chose a renewable path to energy policy reform, future decisions would be characterized by a narrow set of policy options.

Policy Recommendations

The conclusions above seem to suggest that suboptimal DoD solar energy policy is a *fait accompli*. If the problem is not exceptionally bad policymakers, but rather that the DoD is behaving just like theory predicts any other organization would, then this thesis might seem to be an epiphenomenal analysis rather than a collection of insights that policymakers could use to improve the organization.

I reject such cynicism. As Air Force Lieutenant Colonel Leif Eckholm remarked in an interview after reading the above findings, "This is the kind of analysis that would make [high-level DoD officials] think twice before blindly installing the next solar panel."[131] Sharing this optimism, this thesis proposes the following policy recommendations to the DoD to improve the effectiveness of its solar energy policy. Given that these recommendations are written from the perspective of a policy outsider, they may well fail to take into account exigencies of the role or classified information hidden to civilians. Therefore, the reader should regard these recommendations not as prescriptions, but merely effective summaries of the insights developed in the preceding chapters.

1. **Clearly and publicly prioritize the goals and evaluative metrics of solar installations.**

The narrative of DoD solar initiatives has been laced with goal confusion and square solution pegs struggling to fit into round problem holes. The DoD needs to first sort out internally how to rank order the goals of meeting tough federal mandates, reducing electricity cost, reducing petroleum dependence on bases, and reducing electricity grid dependence on bases. The haphazard implementation of Air Force solar panels demonstrates how these seemingly dovetailing goals can pull apart in practice; at Nellis, an installation configured to minimize cost also minimized energy security enhancement.

Upon prioritizing the goals, the DoD should make the prioritization public. This seems like a redundant measure, perhaps a self-serving recommendation by an author who would love to study a more transparent decision-making process. The reason, however, for publicizing these priorities is to solve the information transfer problem demonstrated in Chapter 4. Base officials had scant guidance to implement their solar panel installations, and therefore failed to advance

[131] Lt. Col Leif Eckholm, Interview, Stanford University, CA. March 22, 2011.

any particular DoD objective. By publicizing the objectives, base officials have access to clear objectives and metrics by which to judge the success of their efforts. But why not increase the scope of the guidance within the hierarchy without publicizing the goals, one might ask; for example, the DoD could internally transmit to bases that they are to keep panel costs below $A/W, report B units of energy toward federal mandates, and enhance energy security by implementing a microgrid with X, Y, and Z functionality. However, the details and constraints of an installation are extremely context specific, dependent on state regulations, local utility fees, geography, etc, so the DoD will likely be unsuccessful in transmitting precise but widely applicable guidelines. Now recall the entrepreneurship and enthusiasm of base officials in deploying solar panels in accordance with context-specific constraints—leaving base officials to innovate and make their installations meet the general, prioritized objectives will likely yield the best outcomes. Another advantage of a publicly available prioritization of goals is that public relations incentives would be aligned with positive policy outcomes. As we saw with Nellis, base officials bask in the positive press that results from unveiling a renewable energy installation; officials like base energy manager Bob Jones like to point to vague goals enshrined in public DoD documents to prove that, for example, Nellis is advancing the military objective of energy security. If the DoD were to publicly list its priorities, along with evaluative metrics, the only way officials could proudly point to goal accomplishment is if the highest priority goals were actually accomplished.

2. **Invest in nonrenewable microgrid demonstration projects**

As Chapter 5 emphasized, the current DoD effort to develop renewable microgrid technology appears misguided. On top of the high cost of generation, a renewable microgrid will incur energy storage costs; even if SPIDERS succeeds in an impressive technical demonstration—with complicated electronics to smooth transient response and enable load balancing—it cannot escape the harsh economics that disadvantage renewable microgrids.

The military is justifiably concerned with the problem of grid insecurity, arising from the danger of natural cascading failure or cyber-terror attack. Nonrenewable microgrids may not allow the military to count credits toward meeting federal mandates, but they are simpler, cheaper, and have already been demonstrated. Ensuring continuity of military base operations in clearly identified emergency contingencies should be a top priority of the military, since it directly relates to the core mission of national defense.

3. **Testify to Congress about the shortfalls of renewable energy for military applications**

The first recommendation might appear to simply miss the exigencies of meeting federal mandates. When Congress delivers an edict to federal agencies enjoining them to generate renewable electricity, one might argue that the agencies cannot place the fulfillment of those mandates in the hierarchy of priorities just like any other goal; rather, since Congress controls their funding, these mandates must be taken as absolute requirements. So if the DoD has identified a crucial security vulnerability (grid insecurity), it really has no choice but to implement an expensive and complicated solution (renewable microgrids) to patch the vulnerability *and* meet the mandates.

This fatalistic account of executive-legislative affairs fails to consider the influence and leverage that the military has with Congress. Recall that in the legislative history of the 2005 Energy Policy Act, Senator Jeffords (R-VT) quoted military admirals to support the enactment of a renewable portfolio standard. Not a single military official delivered negative testimony about the cost or intermittency of renewable technology, and, as stated in Chapter 3, military support for national renewable adoption was distorted into support for federal purchase requirements.

Recommendation 3 urges the military to use influential and respected DoD officials to lobby Congress to change the federal mandates. The mandates, if absolute, are counterproductive to national security. Only with significantly more money to implement widespread renewable microgrids can the military alleviate grid insecurity and meet its mandates. Perhaps Congress will not budge on its exhortation to all federal agencies to lead by example, but the point is that this hypothetical need not be hypothetical. The military needs to make Congress aware of the shortcomings of renewable energy for promoting energy security.

The literature predicted that the military would not fight for a greater budget allocation for renewable energy upgrades because electricity appears peripheral to the organization's core goals; this was called the "satisficing" model. As the military has gradually recognized that the generation and distribution of electricity is actually closely tied to national security, it needs to start treating energy security as a core goal and make a stand for sensible and rational energy policy.

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