# Case study of NREL

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**Table of Contents**

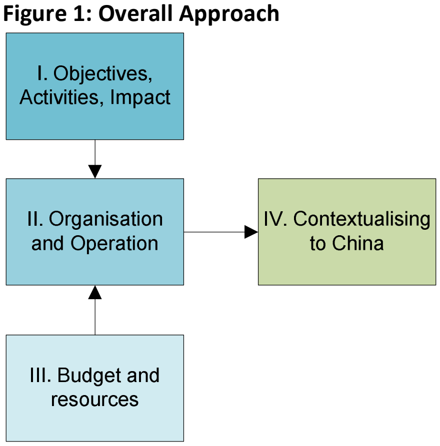


**Table of Tables and Figures**

## 1 Introduction

In accordance with the terms of reference and the inception report for this assignment, a case study of the National Renewable Energy Laboratory (NREL) has been developed. The case study aims to provide the reader with an understanding of NREL's (I) objectives, activities, impact and (II) budget and resources as well as how those two legs tie into (III) NREL's organization and operations (see Figure 1).

**Figure 1: Overall Approach**




The final chapter will contextualize the findings to China.

This case study of the NREL should be seen in conjunction with the Phase one report, which introduces the US renewable energy sector, thus describing and interpreting the context in which NREL exists.

Developed from desk research together with a series of semi-structured interviews, a case creates a contextualized picture of NREL. The interviews continuously brought forward the political, technical and broader public context in which NREL was created as important to the historic and current drivers of NREL's successes – and failures. Some emphasis has thus been placed on bringing out NREL's history. As per comments to the inception report, focus has also been placed on how NREL has had a policy impact in the US renewable energy sector. That said, NREL´s objective is not to lobby on policies, but to enable policy makers to make informed decisions on renewable energy.

The next chapter starts by shortly describing the US renewable energy sector. Against this backdrop, NREL is then introduced in a historic perspective, before chapter 3 goes more into depth with NREL's objective(s) and activities. A chapter is then dedicated to discussing NREL's policy impact. Chapter 5 looks at NREL's budget and resources, particularly also staff resources. Chapter 6 looks at the recent organizational change to a more integrated approach to innnovation. Chapter 7 touches on the monitoring and evaluation mechanisms, whilst chapter 8 contextualises the findings of chapter 2-7 to a Chinese context.

It should be kept in mind that whilst particularly objective, budget and organization are described separately, this is for analytical purposes; they are naturally intimately connected and can in reality be difficult to separate from each other.

It should also be kept in mind that the first and this second phase reports together serve as a foundation for a study tour, which will further strengthen the participants understanding of the drivers of a successful renewable energy centre in a complex and highly politicized area. Whilst traditional researchers tend to focus on technology only, a study tour centered around NREL's integrated and applied research approach would expose participants to a research environment, which thinks not only in terms of science, but also in terms of a laboratory in an almost market enabling and facilitating role in policy, knowledge sharing and public/private partnerships.

Visits suggested include scientific and policy research facilities, policy makers and industrial partners.

**Table 1: Potential study tour candidates and objective with visits**

| Potential study tour candidate | Objective with visit |
|---|---|
| **NREL** | Exposure to "applied science" in an integrated research-policy-market model in real life and experiencing the atmosphere and facilities of a successful renewable energy centre with close ties to the industry. |
| **Lawrence Berkeley National Laboratory** | The other major center of use driven research, but with perhaps stronger focus on basic science than NREL. Steven Chu, John Holdren and Dan Kammen all spent significant time at LBNL which has a much longer history than NREL. |
| **State of Colorado** | See the impact of a major renewable energy centre on the local community and the use of NREL's expertise at the state level. |
| **Industrial partner** | Exposure to industry's conception of NREL's role in renewable energy sector, industry's role in the same sector and public/private partnerships. |
| **WRI** | Discussions with experts on the role of public involvement in innovation. See annex 3. |

Lastly, we extend a special thanks to NREL and our other interviewees for letting us conduct interviews with no compensation for their time.

## 2 NREL in the US renewable energy sector

Drawing on the First Phase report, the first section serves as background by shortly describing the US renewable energy sector. Against this backdrop, NREL is introduced in a historic perspective, before placing NREL in the US renewable energy sector.

### 2.1 US renewable energy sector

Renewable energy (RE) broadly defined makes up 8% of the primary energy consumption in the United States[1]. RE powers about 10% of the total US electricity. Of that, hydropower provides the lion's share of electricity at 66% but wind has been growing significantly and provides 17% of the RE fueled electricity. Solar provides a vanishingly small 0.2% nationally. The United States Energy Information Agency (EIA)[2] estimates that RE will grow faster than other energy sources in the US between 2009 and 2035 and will make up 17% of the primary energy use by the end of the period, based on current policies and loan guarantees. This growth is supported by a tremendous resource base that is heavily concentrated in the western half of the continent.

The US political process has struggled to make consistent energy policy and this has shaped RE in two ways. First, the US federal policy has been very volatile and set for very short term horizons. Incentives are allowed to expire after two years and then are re-instated after months of debate. The industry has to weather these boom and bust cycles, making it very difficult to invest in manufacturing facilities and research and development (R&D).

Second, since making national policy has been challenging, the majority of US states have made RE policy using a variety of mandates and market mechanisms to create demand for renewables[3]. In many cases this is part of an economic growth strategy though in others it is directly related to a climate change and pollution mitigation strategy. The policies themselves are quite diverse in both design and level of economic support for industries. This lack of consistency between states potentially blunts some of the market creation power of the incentives. Only a few states, Texas and California for example, can create a significant market on their own. The fall 2010 elections also brought conservatives into office at the state level. This power shift combined with public budgetary pressures and

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[1] "EIA's Energy in Brief: How much renewable energy do we use?," http://www.eia.doe.gov/energy_in_brief/renewable_energy.cfm.

[2] The Energy Information Agency was formed in 1977 to "collect, analyze, and disseminate independent and impartial energy information in order to promote sound policymaking, efficient markets, and public understanding of energy and its interaction with the economy and the environment." (http://www.eia.doe.gov/about) In this role, the EIA is a key public data source for energy use in the United States. They undertake both historical analyses and modeling about future trends as well as in depth analyses of individual issues such as the the potential impact of a federal renewable energy standard on the nation's energy mix.

[3] "EIA's Energy in Brief: How much renewable energy do we use?".

continued slow economic growth has put many renewable energy portfolio standards and other incentives under pressure.

The RE sector has many players in the US. In policy making specifically the landscape includes:

- state and federal legislatures who set renewable portfolio standards (RPS) and other state incentives.
- state Governors who choose whether and how to champion RE in their states. For example, California's very aggressive RE goals have at times been executive actions rather than legislative actions.
- state economic development agencies such as those in the Mid-West who see RE policy as an opportunity to attract jobs and develop an industry and so may shape industrial policy to compliment RE policy.
- the national labs, who provide analysis regarding the potential impacts and feasibility of legislative efforts.
- regulators at every level who shape the energy markets and thus determine how a project may or may not be competitive.
- industry associations such as the American Wind Energy Association who lobby legislatures in state capitals and in Washington to provide subsidies or remove barriers for their constituency.

These two trends – boom and bust federal action and disparate state level action has created a very cost conscious industry that faces a fragmented and volatile market.

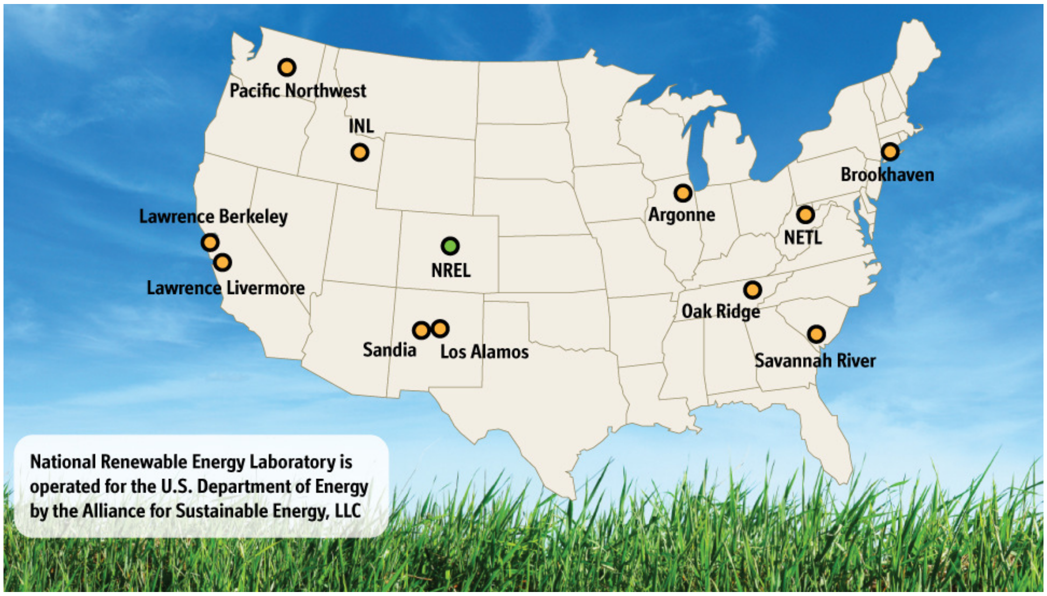
### 2.2 NREL's history

NREL is one of several US Department of Energy (DOE) national laboratories, but the only one of the laboratories dedicated to RE and energy efficiency.

The initiative to develop a research institution dedicated to energy efficient and RE sources became a priority when the United States' supply of oil became radically disrupted by the 1973 Arab Oil Embargo. This roused the government to actively seek measures to develop sustainable alternatives to fossil fuel dependency. An act of Congress, H.R. 15612: the Solar Energy Research, Development, and Demonstration Act of 1974 stated that it was the policy of the federal government to

> …pursue a vigorous and viable program of research and resource assessment of solar energy as a major source of energy for our national needs." The act's scope embraced all energy sources which are renewable by the sun—including solar thermal energy, photovoltaic energy, and energy derived from wind, sea thermal gradients, and photosynthesis.

**Figure 2: The DOE national laboratories**




*Source: Ron Benioff, "Welcome to NREL" presentation, received 25 January, 2011*

Two programs were established under the act - the Solar Energy Coordination and Management Project and a Solar Energy Research Institute (SERI). SERI's purpose was carrying out the R&D initiatives of the Energy Coordination and Management Project. The Energy Coordination and Management Project had 6 members: the National Science Foundation; Housing and Urban Development; the Federal Power Commission; the National Aeronautics and Space Administration; the Atomic Energy Commission; a member designated by the President[4]. Whilst providing charter and the seed funding for SERI, the act did not define the structure of the lab:

> (a) There is established a Solar Energy Research Institute, which shall perform such research, development, and related functions as the Chairman may determine to be necessary or appropriate in connection with the Projects activities under this subchapter or to be otherwise in furtherance of the purpose and objectives of this subchapter.
>
> (b) The Institute may be located (as designated by the Chairman) at a new or existing Federal laboratory (including a non-Federal laboratory performing functions under a contract entered into with the Project or with any of the agencies represented in the Project as well as a laboratory whose personnel are Federal employees)[5].

[4] *Solar Energy Research, Development, and Demonstration Act of 1974*, 42 U.S.C. § 5553 – Solar Energy Coordination and Management Project.
[5] *Solar Energy Research, Development, and Demonstration Act of 1974*, 42 U.S.C. § 5559 – Solar Energy Research Institute; establishment; functions; location.

All though seemingly focused on solar energy, SERI´s charter thus did not confine it to work solely with solar, but also with wind, sea, thermal and photosynthesis as sources of energy.

**SERI is born**

Through a competitive bid process, the Midwest Research Institute (MRI) was granted the license to develop, organize, and manage the proposed SERI laboratory in 1977. The lab opened later that same year[6] with Paul Rappaport as Director (1977-1979), who had a long career in photovoltaic research behind him, also heading an RCA laboratory at Princeton, New Jersey[7].

SERI was designed to be the leading solar research, development, and demonstration branch of the DOE. This included both the oversight of external subcontractors as well as engaging in internal Research and Development (R&D). As President Carter emphasized SERI's mission, for instance personally attending the facility's opening ceremony, the cache of the institute grew. Carter continually stressed solar energy as a key contributor to the future energy mix in the US. In 1977, he set a goal of using solar energy in more than two and one-half million houses[8]. Denis Hayes, SERI Director from 1979 – 1981, described as a cross between the WWII Manhattan Project, which brought together the top physicist to build the nuclear bomb and the NASA effort to beat the Soviet Union to the moon. In the American scientific and engineering communities both of these efforts are considered the paramount examples of science rising to a complex and exciting challenge.

**Table 2: Department of Energy Civilian Energy Supply R&D Funding, FY 1978-81, FY 1982-90, FY 1991-95 (in millions of constant 1996 dollars)**

| Sub-group | Oil-crisis 1978-1981 | | Defense build-up 1982-1990 | | Post cold-war 1991-1995 | |
|---|---|---|---|---|---|---|
| | avg | % of total budget | avg | % of total budget | avg | % of total budget |
| Clean Coal | 0 | 0 | 165 | 6 | 442 | 20 |
| Energy Efficiency | 596 | 9 | 198 | 8 | 343 | 16 |
| Fossil fuels | 1538 | 24 | 412 | 16 | 483 | 22 |
| Nuclear fission | 2162 | 34 | 981 | 38 | 352 | 16 |
| Nuclear fusion | 716 | 11 | 545 | 21 | 349 | 16 |
| **Renewables** | **1290** | **20** | **253** | **10** | **209** | **10** |

* Does not add up to 100% because of rounding.
** Also called "energy conservation".
*** Also called "civilian nuclear".
*Source: American Physical Society: Priorities within the Department of Energy*

[6] McKelvey, John. *Research Activities at the Solar Energy Research Institute.* Environmental Science & Technology 13/8 (1979): 918-921.
[7] *Science 10 August 1979:* Vol. 205 no. 4406 pp. 563-566
[8] Jimmy Carter, televised speech on 18 April, 1977

In the wake of the 1979 oil crisis, solar energy gained further leverage with the Carter administration and Denis Hayes took over the post of Director of SERI to apply a "more aggressive and activist leadership"[9]. Besides being only 34 years old at the time, Hayes already had a long and successful history in environmental history, organizing *Earth Day* (today expanded to more than 100 countries) and *Sun Day* and creating the Solar Lobby. However, the first few years of SERI had also proven difficult in terms of financial management (see chapter 5).

When President Reagan came to office in 1980, he had campaigned with the promise of abolishing the Department of Energy entirely. While that proved politically impossible, SERI made a very easy target within the DOE. With a vibrant but still very small RE industry, there was not a strong constituency to fight for its political survival. Director Hayes saw his budget cut by two thirds, contractors terminated with no notice and a significant number of the permanent professional staff terminated with two weeks notice and no severance. Hayes clearly considers the dismantling of the lab a personal failure and a failure of the national government to plan for the long term. The staff moved on to other positions – many outside the solar photovoltaics field and in another area of physics. Two went on to win Nobel prizes.

As can be seen from Table 2, RE funding across the DOE was cut from an average of $1,290 million in the years 1978 – 1981 to staggering fifth of that of an annual average of $253 million. This was not only a reflection of a political move away from renewable energy, but also a reflection of severe cuts in the DOE overall budget; as percent of the overall budget, the RE funding went from 20 percent to 10 percent. Effectively, as percent of the total DOE budget, RE funding was "only" cut in half.

**From SERI to NREL**

These budget setbacks lasted from 1981-89, in which SERI's allocated budget plunged from $112 million to $58 million in unadjusted dollars and personnel were cut over 40%[10], but SERI persevered. In 1981, Dr. Harold "Hub" Hubbard took over as Director and narrowed SERI's scope of work significantly, returning to a focus on research and development. In testimony before xxx in 198x he said,

> "In its early stages, the Solar Energy Research Institute was involved in many different activities. It was involved in market-related studies, policy and program planning, management of international solar programs, socioeconomic and environment studies, public information dissemination, and projects aimed at commercialization in addition to the R&D function…. In early 1981, the management of SERI and MRI concluded that a greater concentration on research and development of solar technologies was appropriate…. Therefore, in the past year, we have redirected SERI's

[9] *Science 10 August 1979:* Vol. 205 no. 4406 pp. 563-566
[10] *National Renewable Energy Laboratory, NREL: The First 25 Years and the Future*. Refocus. September/October (2002). 54-56.

> mission and its activities. The redirection involved changes in program emphasis and in our skill base, and a reduction in staff."[11]

Dr. Hubbard is credited with persuading President Reagan to keep NREL in its reduced form and for producing useful research during the lean years. He stepped down as director in 1990. In 1991, under a renewed energy crisis, SERI received bipartisan support for an executive designation as the 10th national laboratory and was renamed the National Renewable Energy Laboratory (NREL). Hayes reported that the work could not return to scale though until President Clinton restored funding after he came to office in 1993. Though this redesignation retained the initial structures of management and operational oversight, NREL expanded its roles, objectives, and activities to suit a broader Renewable Energy (RE) field.

### 2.3 NREL's role in the US renewable energy sector

> "NREL develops renewable energy and energy efficiency technologies and practices, advances related science and engineering, and transfers knowledge and innovations to address the nation's energy and environmental goals.[12]"

Since its inception as a national laboratory in 1991, the role of NREL in the RE sector has expanded significantly. This has been driven by the development of a full-fledged RE industry in the US as well as increased interest and sophistication about RE in legislative and government bodies.

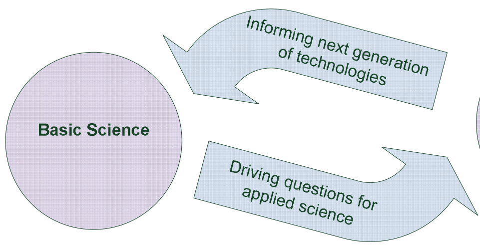
NREL today works as a semi-autonomous research facility under the management of the Alliance for Sustainability, LLC. (The Alliance)—a partnership between MRI and the Battelle group (see chapter 6). The Alliance seeks to establish and facilitate partnerships with universities, research institutions or think-tanks, and industrial leaders to advance understanding of energy efficient and RE technologies.

Operating under this role, NREL performs a full range RE R&D, including use inspired basic science and applied research; engineering; testing and demonstration with a strong focus on technology transfer to the RE market. This role, of supporting RE market objectives through the acceleration of innovation research to "market-viable alternative energy solutions," is intended to advance the science of clean energy innovations and guide deployment of technologies into commercial applications.

[11] Hubbard, H.W. "Renewable Energy in the Eighties: Needs for Further R&D: Research Needs for Solar Electric Technologies." House of Representatives, Committee on Science and Technology, Subcommittee on Energy Development and Applications. July 28, 1982. Washington, DC. Congress Session: 97-2. Hearing ID# HRG-1982-TEC-0080. Accessed March 18, 2011. Lexis Nexis Congressional

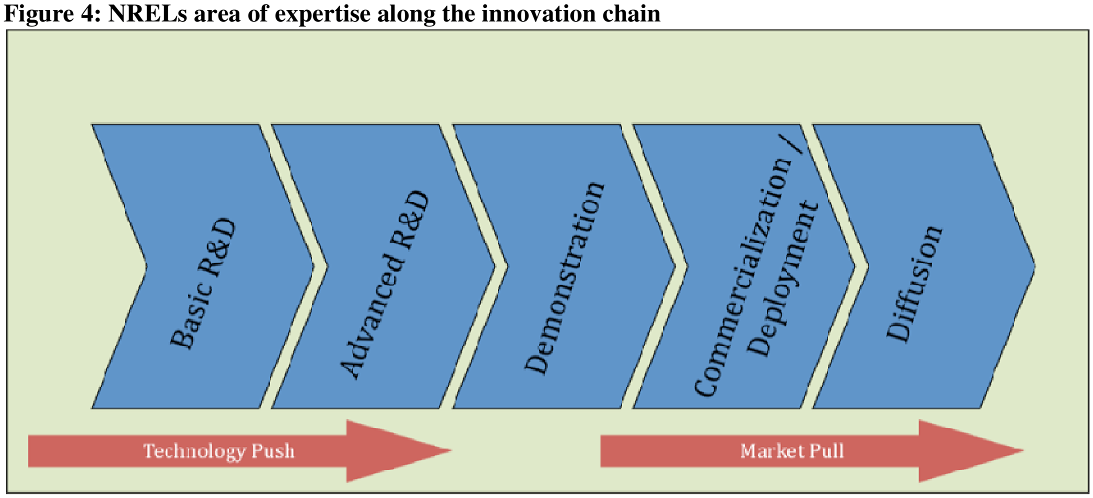
[12] *National Renewable Energy Laboratory: 25 Years of Research Excellence* 1977-2002 (2003)

**Figure 3: Research focuses on creating commercially viable solutions**




This work across the first half of the innovation cycle (from basic science to commercialization) is done in support of the President and DOE's larger goals for renewable energy. NREL is the primary RE research facility for the DOE Office of Energy Efficient and Renewable Energy. In this role, NREL is tasked with advancing national energy goals as passed down through various agencies. These goals come not just from the Administration through DOE but also from other departments such as the Department of Defense (DOD) and NASA (for whom much of the practical PV technology was adapted, for example, to power satellites in orbit).

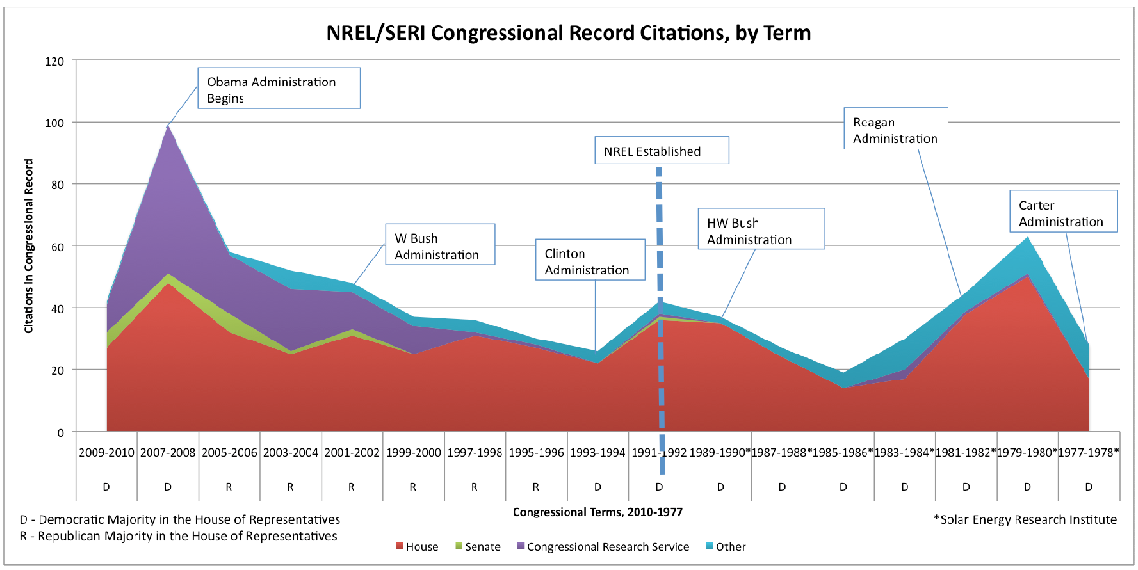
**Figure 4: NRELs area of expertise along the innovation chain**




Though not an independent lobbying interest, NREL also frequently works to inform government agencies and Congress on policy initiatives concerning RE, energy management, weatherization, and energy security. These analyses are sometimes formally solicited through legislative initiatives and sometimes solicited less formally. NREL's policy analysis branch addresses requests through papers on the practical considerations in implementation of policy and through more informal consultations with decision makers. For example NREL's policy analysis role is demonstrated through the emergence of the 2007 paper *Toward a 20% Wind Electricity Supply in the United States*, which directly referenced President George W. Bush's 2006 Advanced Energy Initiative as its impetus. Similarly, NREL was referenced 92 times in the 2009-2010 congressional record, either directly in testimony, through reports, in hearings or in press conferences[13]. The congressional record is a compilation of written and spoken testimony at hearings, reports by the Congressional Research Service commissioned by committees or members, and committee meeting summaries and minutes. How often NREL is cited in the congressional record is one small indication of how policy makers may lean on their expertise and analysis when considering energy policy. NREL's focus on research in the 1980's and their increase in funding and thus capabilities in the nineties traceable in the number of citations in the congressional record.

Since a reorganization in 2008, NREL has increased this analytical support role significantly. Experts in the Analysis division support state and local efforts across the US when requested and cultivate deep relationships with decision makers in other countries who may not have a domestic capacity like NREL. This new explicit capability in policy, plus a significant uptick in interest with the energy priorities of the Obama administration have led to a significant increase in congressional interest in NREL.

**Figure 5: Congressional citation fo NREL analysis[14]**



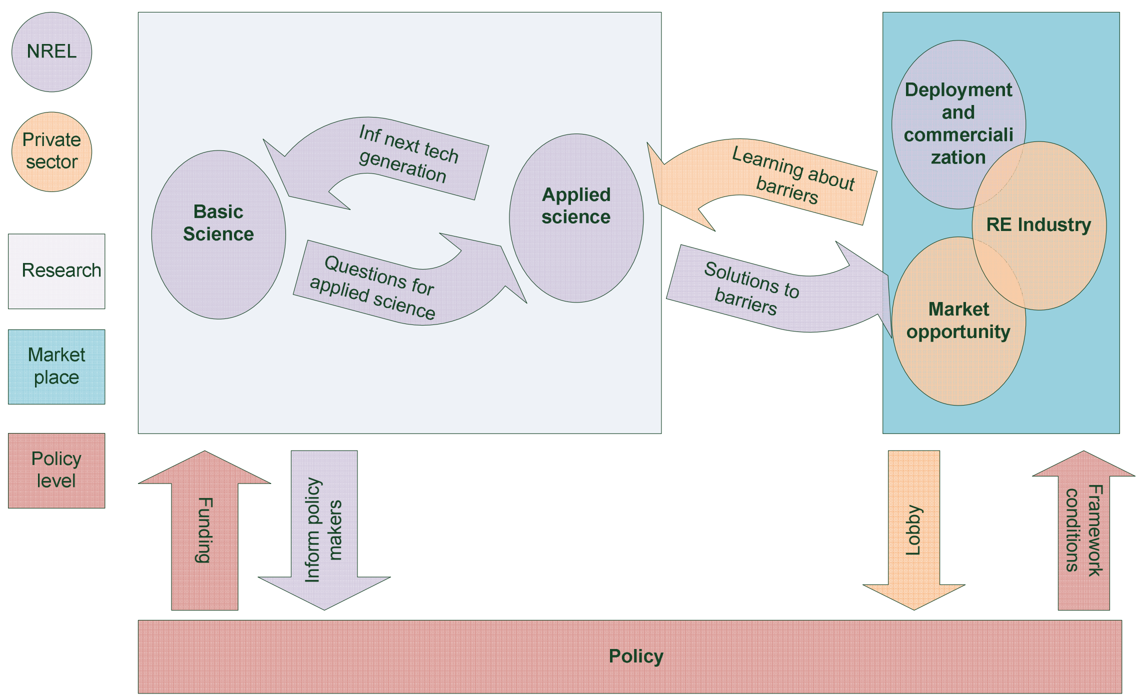

NREL also has a key role as an information hub for RE technology, policy and markets. Through operating and overseeing knowledge transfer amongst academia, government labs, and the private sector, NREL maintains national and international education, cooperation, and communication endeavors. The staff do this via publications, seminars, extensive public speaking, web sites, and policy analysis.

This expansion of roles since its inception as SERI, places NREL centrally within the web of RE innovations as a key, multifaceted hub. For example, today NREL works much more closely

[13] Lexis-Nexus search, January 25, 2011
[14] Lexis-Nexus search, March 22, 2011

with industry partners in part because there is a vibrant industry to partner with. In 1979 companies in the renewable energy industry were quite small but now large-scale multi-nationals such as General Electric and Siemens are key partners. The analysis required by decision makers is more extensive because their own sophistication has grown. As the RE community of practice has matured NREL has adapted its roles to try to best support the next stage of growth, thus changing with the context in which it operates.

**Figure 6: Simplified illustration of the research/policy/market interaction**




*Source: Interpretation of chapter 2 research*

Figure 6 is interprets the interaction between research, policy and markets, placing NREL in that context. NREL exists in a R&D sphere with the objective to push technology to reach deployment and commercialization at a quicker pace than in a baseline scenario. The market place - through direct industry collaboration and market analysis – in turn influence NREL R&D by defining future market demand. What are the industry's sensitivities, what risks can the industry take and how close to market parity does a technology has to be. Answers to such questions are not gained by just asking –it might be a trade secret or it might be industry have not even thought of the questions. So NREL does collaborative research that involves industry in the analysis and infers the answers to the questions from there in an attempt to lift new ideas into the market place faster.

The policy level – that is federal and state decision-makers - delivers the framework conditions for the market place as well as the vast majority of funding for NREL, whilst NREL informs policy makers on RE as part of their decision making process.

# 3 Objectives and activities

## 3.1 The road to today's objectives and activities

With the restructuring of SERI to NREL in 1991, pivotal operational changes occurred to enable a larger set of objectives, beyond enabling U.S. development of solar energy programs, to fulfill the demands placed upon a national laboratory. While NREL's objectives have grown, generating new avenues of research, NREL has maintained the principle root of SERI intentions. That is that it operates as a government branch of DOE that works to foster technological advances in the RE industry. Most recently this has required NREL to embrace objectives around supporting market creation and ensuring successful commercialization – objectives much farther along the traditional innovation chain than other national labs have undertaken. Looking forward, NREL staff are considering how to effectively promote better integration of various renewable technologies as integrated design is considered the next step to support cost-effective RE use.

These changes have created a demand for greatly expanded sets of activities crossing a great many fields of study and research, social applications, communication and information channels, and educational/knowledge-sharing priorities. These, moreover, shifted research objectives beyond the initially proposed avenues into new, emerging technologies in the RE/energy efficiency field. Also, international partnerships and the emerging global economy have reshaped the concerns and applications of NREL's objectives beyond the United States' needs through increased international commercial and technological transfer.

**Key Activities**

NREL's activities are closely linked to NREL's roles within the RE sector. The Key Activities have changed as under several pressures:

- Some technologies have matured – requiring less basic science input and more demonstration and testing efforts;
- New policies, such as mandates for federal installations to use renewable energy have created new "customers" for NREL's expertise;
- Administration and congressional priorities have dictated funding changes – for instance recently emphasizing electric vehicles of prior hydrogen vehicle programs.
- International competition in these technologies has increased significantly putting new pressure on American firms in this sector but also opening new markets to those firms.

In 1979, SERI operated 4 key areas of focus: Photovoltaics, biomass, industrial heat, and economic or social policy. Dr. Hubbard narrowed this in the early 1980's to just three programs, all focused on areas of solar research. This stands in some contrast to more expansive NREL of today.

NREL, in 2009, operated under a fiscal year budget of $521.1 million USD designated to fund an ambitious card of 12 Key Program Areas, which incorporated 45 avenues of R&D, spread between four organizational "arms":

1) Outreach, Planning & Analysis;
2) Science & Technology;
3) Laboratory Operations; and,
4) Commercialization & Deployment.

The 12 Main Programmatic Areas are:

1) Analytic Studies,
2) Biomass,
3) Building Technologies,
4) Distributed Energy,
5) Federal Energy Management,
6) Vehicle Technologies,
7) Geothermal Technologies,
8) Fuel Cell and Hydrogen Technologies,
9) Industrial Technologies,
10) Solar Energy Technologies,
11) Weatherization and
12) Wind and Hydropower Technologies.

This expansion occurred gradually, with the greatest singular expansion coming shortly after SERI's designation as a national laboratory and subsequent increase in funding and resources. NREL now directly operates state-of-the-art laboratories and test facilities, multiple offices in Colorado and Washington, D.C., a visitors' center, and a wind technology center. The size of expansion demonstrates the effectiveness of the NREL model in adapting to exterior demands placed on the institution, whether through government initiatives, technological innovation, or market demand.

The most recent change in activities came in 2008 when the Alliance had to compete once again to win the DOE contract to run the lab. In a deep reevaluation of which activities would be necessary to meet the DOE mission and objectives, the Alliance chose to newly emphasize outreach, planning, analysis, commercialization and deployment (see chapter 6). As the technology has advanced on many fronts, there is a deeper need for support for market creation policies, systems integration planning such as in transmission, and commercialization support for industry. The lab was reorganized to create two new arms and after the bid was won, these arms began to staff up. This has brought a new mix of skills to NREL, drawing economists, entrepreneurs, financiers and policy specialists.

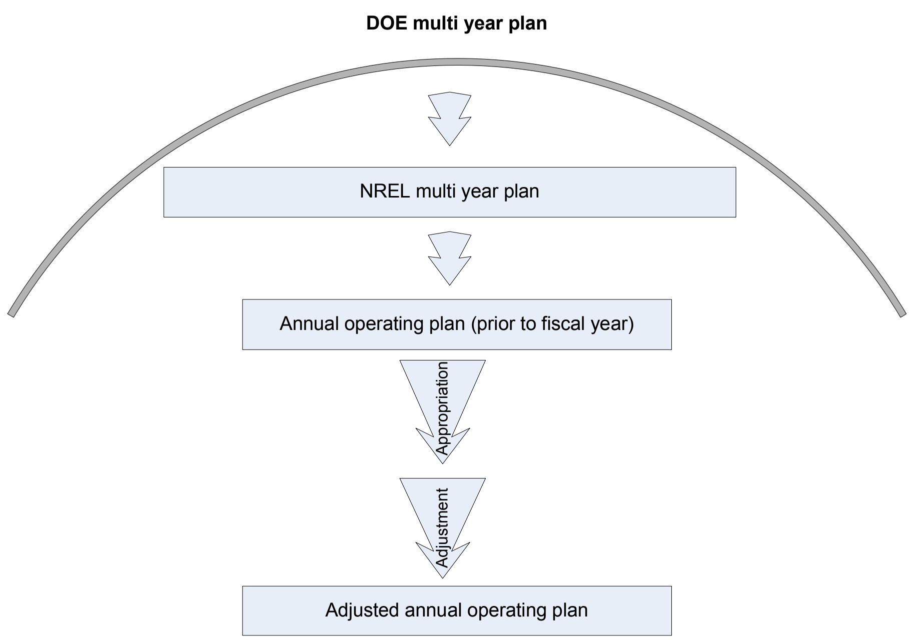
### 3.2 . Current objectives and activities

NREL aligns its work very directly with the DOE goals. DOE, in partnership with the Administration and with input from NREL and other experts, sets cost and performance goals for technologies and roadmaps to reach these goals. NREL aligns its multi-year research plans with these goals. From the multi-year plan they produce annual activity plans for the Federal appropriations process. These must be somewhat adjusted when the final appropriations decisions are made by Congress, but NREL strives to maintain continuity within the multi-year plans and the overarching goals.

The DOE typically has contractors to do most of the overarching plans with a 5-10 year horizon. They are based on stakeholder consultations and occasionally targets from the White House, e.g. recently President Obama launched the SunShot initiative, which has a target of enabling solar electricity to be on par with more conventional forms of energy in 7 years. NREL did the analysis to help DOE understand how that is an achievable goal and to find objectives along the way to reach that goal.

Based on the DOE official overarching goals (but also influenced by other drivers as seen in Figure 6), NREL develops a multi year plan, which guides the annual operating plan. An annual operating plan is developed prior to each fiscal year and then tweaked once actual funding is received[15].

**Figure 7: Operating plans are adjusted after appropriations are known**




*Source: Adapted from interviews*

For solar, wind and water, biomass, several laboratories will be working together in integrated fashion to reach the overarching targets. An example could be the 2010 DOE

[15] Robert Noun, Interview February 24th, 2011 and Denis Hayes, interviewed March 2nd 2011

investment in advanced biofuels, placing USD 33.8 million towards cutting-edge research to develop biomass-based hydrocarbon fuels that follow a sustainable, cost-effective production process and maximize the use of existing refining and distribution infrastructure. Secretary Chu:

> Advanced biofuels are crucial to building a clean energy economy. By harnessing the power of science and technology, we can bring new biofuels to the market and develop a cleaner and more sustainable transportation sector.

Known as the National Advanced Biofuels Consortium (NABC), NREL and DOE's Pacific Northwest National Laboratory leads the research. Other members of the consortium include Albemarle Corporation, Amyris Biotechnologies, Argonne National Laboratory, BP Products North America Inc., Catchlight Energy, LLC, Colorado School of Mines, Iowa State University, Los Alamos National Laboratory, Pall Corporation, RTI International, Tesoro Companies Inc., University of California-Davis, UOP, LLC, Virent Energy Systems and Washington State University. The partners contribute a total of USD 8.4 million of non-federal cost share contributions, bringing the total NABC project size to USD 42.2 million[16].

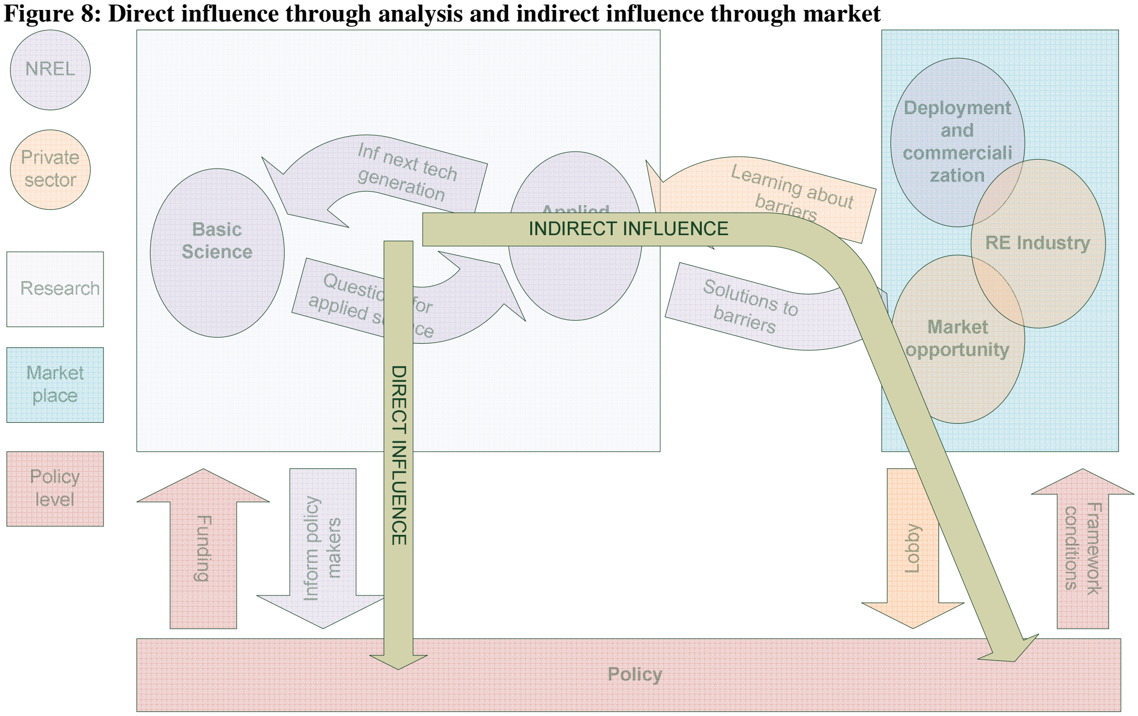
[16] News Release NR-0210, January 13, 2010

# 4 Key drivers of policy impact

## 4.1 Key drivers of policy impact

The key role NREL plays as an agent impacting policy—at federal, state, and local levels—is through the analysis of existing and proposed legislation. These policies, related to renewable energy/energy efficiency standards, practices, deployment or implementation, are being considered by Congress, federal administrators, state governments, or local administrative bodies with specific concern for financial (economic) and environmental impact within a framework of sustainability. Objective analysis is critical to successful policy that meets its stated goals and avoids unintended negative consequences. NREL fields these requests through their recently expanded analysis and planning team. Often the window of opportunity for impact is quite short and the team works to be nimble and provide quick responses to decision makers. The team applies NREL's modeling tools, resource maps and other information products to the specific policy debate. For example, NREL provides an interactive GIS driven map of renewable energy resources across the United States (http://www.nrel.gov/gis).

**Figure 8: Direct influence through analysis and indirect influence through market**




*Source: Interpretation based on chapter 4 research*

NREL also provides the Regional Energy Deployment System (ReEDS) model, a computer model that optimizes the regional expansion of electric generation and transmission capacity in the continental United States over the next 50 years. The model is unique in its ability to evaluate the contribution of intermittent electricity sources, such as wind and solar and is meant to assist utilities, regulators and other capacity planners in evaluating the contribution RE can make in their specific situation (http://www.nrel.gov/analysis/reeds).

NREL plays a few indirect roles in policy. By continuing to push the technologies forward and highlighting analysis such as historic cost reductions, NREL showcases how renewable energy is a viable energy option and this can lower the barriers to action on the part of decision makers who are worried cost-effective options are simply not real. Similarly, the NREL's education efforts increase the capacity of decision makers to work with renewable energy. As their understanding of the strengths and weaknesses of RE becomes more sophisticated and their comfort level with the technologies increases they are more able to skillfully shape energy markets to allow RE to compete effectively.

**Ties to broader stakeholder community**

NREL clearly sees that their deep connections to stakeholders are a primary transmission path for their influence. Since NREL is not directly lobbying for policy or even making policy, they seek to impact the development of the renewable energy marketplace through equipping their stakeholders. The fundamental relationships between NREL, the government, business, and civil society have maintained the initial conceptualization of the laboratory as not only an incubator for R&D as is the case in other national labs, but as a hub of communications and deployment of key innovations and strategies in the RE field.

NREL, and its progressively more integrated model of innovation, has far deeper connections with industry than many other national labs. NREL undertakes research directly with industrial partners to ensure a smooth commercialization. These partners may be chosen by DOE or by NREL itself but in every case the private sector company commits resources to research to signal their long term commitment to commercialization. NREL values these partnerships because they ensure the research is use focused and broadly applicable and that NREL can understand the technical challenges RE faces in the field. This helps ensure a highly responsive lab and increases the chances of success in the larger renewable energy mission.

NREL's role in providing objective analysis also brings it into contact with a larger cross-section of state, local and international decision makers than is typical for a national lab. This relationship is particularly important for ensuring NREL has a grounded understanding of where energy markets are going and how RE must change to compete effectively.

Finally, NREL actively competes for basic science contracts from the US government and others with University partners. This ensures that NREL is integrating closely with the larger academic community of practice – staying abreast of advances and providing cross-fertilization where possible.

This model is dramatically different from most of the national labs, many of which are engaged on classified nuclear research or very early basic science. While these labs are certainly engaged with their communities of practice and their outputs have an impact on defense policy, they are not striving to shape policy or the marketplace through their stakeholder relationships.

### 4.2 Examples of policy impact

NREL administrators themselves are concerned with impacting policy and the rapid deployment of renewable energy but say that their impact is difficult to identify. They do not want to simply produce articles and patents – however, tracing their fingerprints to the end product of a functioning market for renewable energy is very difficult[17].

Often their influence is blunted by the larger politics of energy policy in the United States. Denis Hayes wryly recounts NREL's efforts to define the policies necessary to meet a national RE goal in 1980. In the face of deep skepticism and efforts to dismantle SERI in the early Reagan administration, the team published a guide to recommended policy through photocopies and finally a private publisher while the administration actively tried to bury the text. While the team considered it a triumph to produce the analysis, in the end renewable energy policy in the US was unable to move forward politically until President Clinton at which point the analysis was over 10 years old and of little use.

NREL has had perhaps more impact in assisting state and local governments craft policies, as they have been a critical source of information for administrations that are too small to maintain their own capacity. An example would be in January of this year, where NREL was asked to provide a testimony in Florida on options for RPS and what impact it would potentially have to adopt RPS in Florida[18].

[17] Dale Gardner, Interview February 24th, 2011
[18] Robert Hawsey, Interview February 24th, 2011

# 5 Budget and resources

## 5.1 Budget and resources in the beginning

As largely covered in chapter 2, SERI seed money came from the DOE as a response to the 1973 oil crisis. SERI started operating in 1977 after a DOE request for proposals in 1976.

**The first contract**

Specifically, each state that wanted to make a bid for SERI had to have a partnership with a contractor. Midwest Research Institute (today MRIGlobal) launched a bid for SERI with Colorado – and was up against major institutions in cities such as San Francisco, Boston and Atlanta in their bid for the SERI contract. Boulder, Colorado was not much of a city back then, but had a combination of all key resources; sunshine, wind and some geothermal activity as well as a Ph.D. granting university. Placed next to Denver, the site also had easy access to a very well connected airport and hotels. To top it off, the state's governor then offered 300 acres of land in Colorado on which to place SERI for the sum of 1 dollar[19].

The first contract was USD 4.7 million, out of which political concessions had to be made; four satellite offices had to be set up to accommodate political supporters. One in Minnesota and one in Massachussetts – for Senators Humphry and Kennedy, who both supported the solar energy legislation. Another one had to be set up in Georgia for President Carter (his home town) and the last one in California, simply because the state was so big. On top of that, Louisiana State and University of Mississippi had to be sub-contracted for two major projects, taking the budget further down some.

**Facilities**

SERI interim office was set in the Denver West Office Complex; as such SERI was not born a top notch research facility. It took seven years before the first research test facility opened. Until then, laboratories were largely rigged up in office buildings[20].

NREL's facilities today incorporate 20 buildings, with more than 600,000 square feet (55,000 square meters) of lab and office space. The overall campus encompasses 327 acres (132 hectars). NREL's National Wind Technology Center is located on a separate site south of Boulder[21].

**Human resources**

As for human resources, the winning contractor in 1977, MRI, sent some of its best people to start up SERI.[22] Further, the company looked around the country for talents, primarily from universities and research centres, but also analysts from big consultancy firms were

[19] Robert Noun, Interview February 24th, 2011
[20] Robert Noun, Interview February 24th, 2011
[21] Information received from Joe Verrengia March 23rd, 2011
[22] James Spigarelli, interview from July 15th, 2002: http://www.w3w3.com/Interview/NREL/25_CELEB.htm

approached. The idea was to bring in a strong management team to create an exciting research environment for the appropriate technical people. By 1979, SERI had expanded from approximately a dozen professional staff to over 700 with a budget of over $60 million USD. Denis Hayes, SERI director from 1979 through 1981 personally recruited many of these top professionals, drawing them from tenured positions at universities to join a nascent organization in the remote Golden, Colorado[23].

Whilst not competing on salary back then, the prospects of entering something exciting and new largely drove a talented crowd to SERI at the time – the special treat and rush of starting up something new[24]. At that point talent was thus really drawn by the excitement of the mission: SERI received a lot of favorable press and high level political backing. It could be said that this initially made the sum substantially more than the parts. There was something that appealed to the scientific community at the time, an intellectual excitement[25], which to some extent is still found there today.

**On Management and operations contracts**
The national laboratories under the DOE were established to attract the best minds in the country to conduct scientific R&D of national significance operated through management and operating contracts (M&O) with private sector companies, universities and non profit organizations. This was done because the government wanted to take advantage of the private sector capabilities to carry out research of critical national importance.

The government owns all the land, facilities and equipment, whilst the contractor manages the facility and employs research, development and production staff as well as various support and maintenance personnel. There is no capital investment required from the contractor. Each laboratory is unique in location, physical arrangement, size and mission.

An M&O contract typically includes:

- long-term, core scientific and technological research or production missions;
- special one-time R&D projects and
- support functions and daily operations and maintenance activities at the installation.

Typically, the M&O contract will be on a cost reimbursement-type contract that covers five-year periods with options for contractor renewal, typically for another 5 years.

Congress appropriates funds for R&D by programme (not by laboratory) – DOE programme mangers then direct the funding to the specific laboratories they believe are best able to carry out the work based on proposals from those laboratories[26].

[23] Interview, Denis Hayes, March 2, 2011
[24] Robert Noun, Interview February 24th, 2011
[25] Denis Hayes, interviewed March 2$^{nd}$ 2011
[26] Department of Energy: http://govinfo.library.unt.edu/npr/library/reports/doe03.html

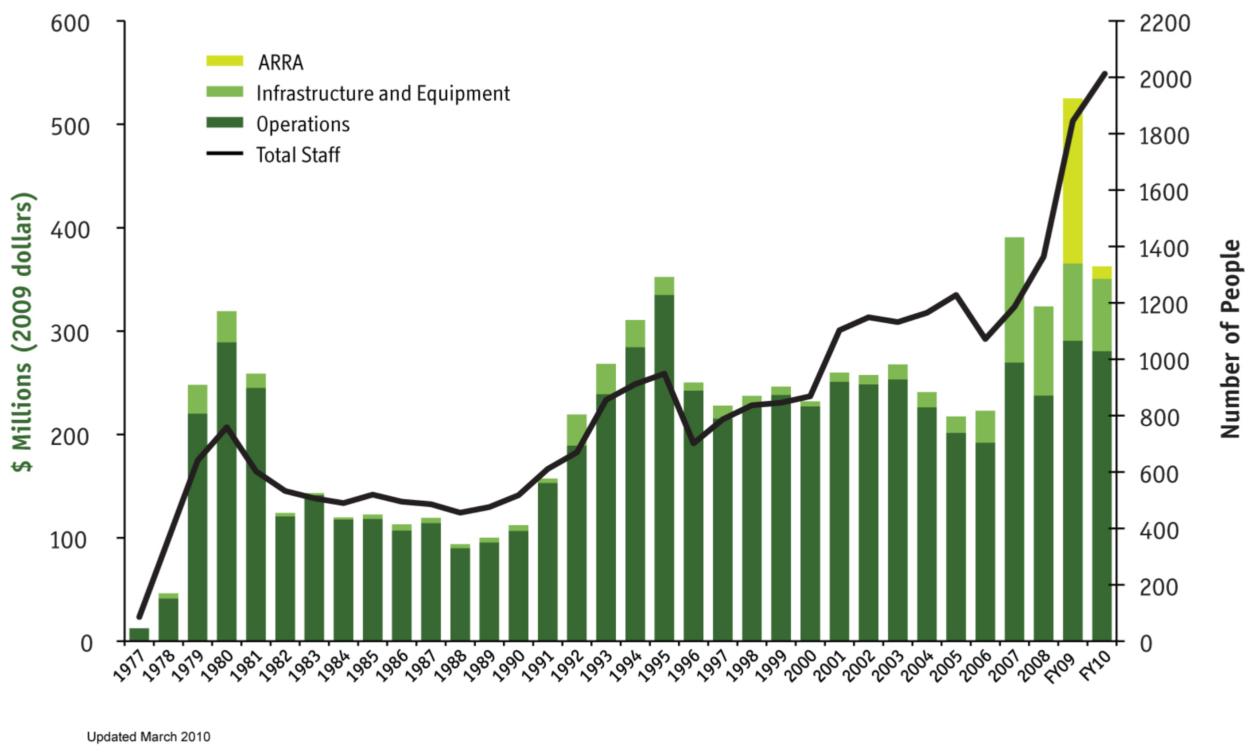
NREL is thus as such owned by DOE and managed by a third party, the M&O contractor. NREL's M&O contractor today operates using a cost plus award fee contract. This means that if NREL and the M&O contractor achieve DOE's goals, the contractor is awarded a fee from DOE.

Whist MRI won the contract in 1977 alone, MRIGlobal has today formed The Alliance with Battelle with the sole purpose of being NREL's M&O contractor. The Alliance won the bid in 2008. Consequently, at least MRI has been the M&O contractor for SERI and later NREL since the inception in 1977[27].

### 5.2 Budget and resources through the years and today

Appropriations for NREL are done year by year, which means the NREL's financial resources are largely dependent on the political mood at any given point in time.

**Figure 9: Actual funding and staff on board**




*Source: Ron Benioff Presentation*

Figure 9 shows the actual funding through the years; quite clearly, the funding is very volatile. During the Carter administration (1977 – 1981), the centre received very strong

[27] http://www.allianceforsustainableenergy.org

backing; there was a national goal to reach 20% RE by 2000 which was underpinned by big energy efficiency commitments to keep energy demand flat. NREL's budget doubled repeatedly – up to $130 million.

As brought forward earlier, the Carter was followed by the Reagan administration (1981 – 1989), which brought serious challenges with it for NREL and for the DOE in general, experiencing severe budget cuts. To illustrate the downgrade of the DOE, President Reagan appointed all Secretaries but the one for energy; there being no secretaries from the US South, which had voted heavily for him, a deal was struck with Senator Strom Thurman (a prominent Senator from the South) and Reagan appointed Jim Edwards, former governor from South Carolina. Jim Edwards had no energy background but was a big advocate of nuclear because of South Carolina's investments into nuclear power. Consequently, within a strained DOE budget, NREL came under particularly severe constraints for survival.

**Figure 10: Requests for fiscal year 2012**

| (Discretionary $ in millions) | FY 2010 Current Approp | FY 2012 Request | FY12 vs FY10 % | $ |
|---|---|---|---|---|
| *Energy Efficiency and Renewable Energy............* | 2,216 | 3,200 | + 44% | + 984 |
| Solar Energy........................................................ | 243 | 457 | + 88% | + 214 |
| Wind Energy....................................................... | 79 | 127 | + 61% | + 48 |
| Biomass and Biorefinery Systems RD&D......... | 216 | 341 | + 57% | + 124 |
| Geothermal Technology..................................... | 43 | 102 | + 135% | + 58 |
| Water Power........................................................ | 49 | 39 | - 21% | - 10 |
| Hydrogen and Fuel Cell Technologies................ | 170 | 100 | - 41% | - 70 |
| Vehicle Technologies......................................... | 304 | 588 | + 93% | + 284 |
| Building Technologies........................................ | 219 | 471 | + 115% | + 252 |
| *Hub: EE Building Systems Design.................* | *22* | *24* | *+ 10%* | *+ 2* |
| Industrial Technologies....................................... | 94 | 320 | + 239% | + 226 |
| *Hub: Critical Materials....................................* | ---- | *20* | ---- | *+ 20* |
| Weatherization.................................................... | 210 | 320 | + 52% | + 110 |
| Other.................................................................... | 588 | 337 | - 43% | - 251 |

*Source: Sec. Chu Budget Briefing 2/14/11*

With President Clinton came some relief and certainly with President Obama and particularly the American Recovery and Reinvestment actor of 2009 (ARRA), NREL got a tremendous budget boost. The request for FY 2012 further underlines the current president's commitment to sponsor renewable energy. 600 jobs have been added to NREL in the past 3 years. However, last year's surge in Republican voters took away the House majority from the Democrats, leaving the House in a position to take funding away NREL.

Fact remains that the year by year budget cycle doesn't go well with the research life cycle, so NREL has to do its own creative thinking in strategic planning, trying to infer what is going on in Washington and talking to stakeholders and industry about where the technology areas need to go - and then set up a planning mechanism around that. From there it is just hoping the annual budget from DOE fits into that planning. If not, then it is back to the drawing board and re-adjust the plan (see also Figure 7).

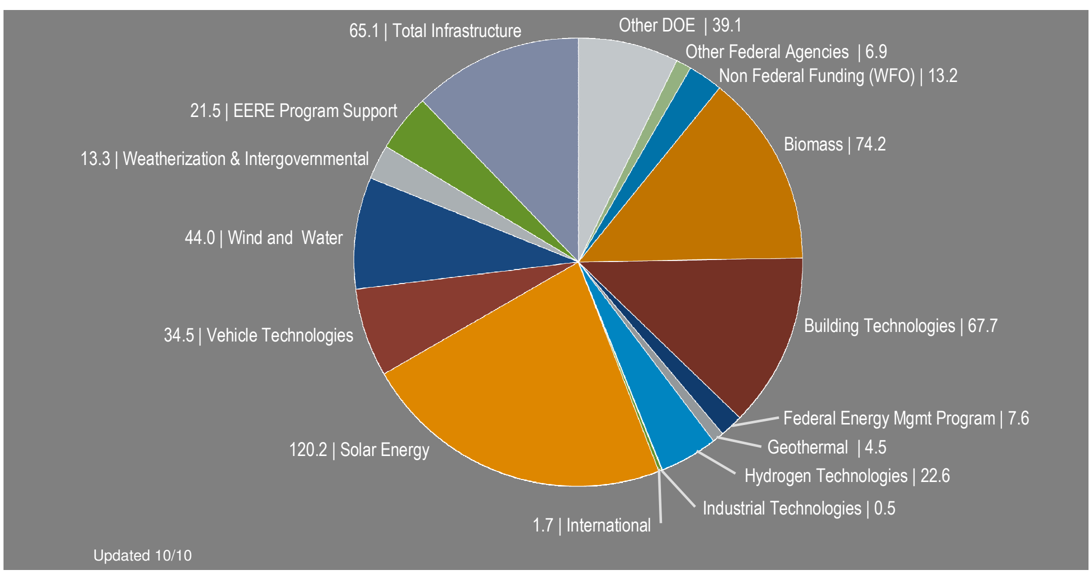
That said, the DOE does have multi-year performance plans, e.g. in hydrogen, which gives a better understanding of where the research is heading; this helps the planning process, however still without earmarking future payments.

**NREL's 2010 budget**
The 2010 budget totals over USD 500 Million. The largest proportion of the renewable energy funding went to solar energy, biomass and wind, whilst also particularly building technologies received substantial funding (see **Error! Reference source not found.**).

*Programme based funding*
The funding is mostly programme based, which means that e.g. the $ 44 million for "wind and water" stems from the Wind and Water Power Programme. The Wind and Water Power Program works with industry, the national laboratories, state and local governments, and other federal agencies to advance wind technology and accelerate the deployment of wind power[28].

All though not 100% of the funding today stems from DOE, planning is still done around the DOE: 85-90% of the budget comes from DOE with the remaining 10-15% from other agencies and industry partners[29].

**Figure 11:** NREL FY2010 Funding by Program, Total $536.5M




*Source: Bob Noun Presentation*

[28] US Department of Energy´s Wind & Water Power Program, Plans, Implementation and Results: http://www1.eere.energy.gov/windandhydro/plans_implementation_results.html
[29] Dale Gardner, Interview February 24th, 2011

*Other sources of funding*
This smaller proportion of the NREL budget comes from outside the DOE. Other public offices contribute some, e.g. the Department of Defense (DOD) and NASA (for whom much of the practical PV technology was adapted, for example, to power satellites in orbit). Also States may contribute to specific projects or for specific services, e.g. the California Public Utilities Commission has tapped experts at NREL to help the state stimulate solar energy research and build a sustainable solar industry, awarding NREL close to $ 4 million in grants.

Historically, NREL has always been encouraged by the DOE to partner with industry. In fact, NREL is often required to propose projects conducted in partnership with industry. Consequently, all though NREL is one of the smaller national laboratories, it has more active industry partnerships than any of the others. What can also be said about the NREL/industry partnerships is that it has changed over the years given the maturity of the RE technologies; in 1977, RE technologies were not at a stage of commercialization as we find today and RE policy tools not as sophisticated – the RE market needed a helping hand to get started, whilst NREL today spends time listening to the RE market demands.

A key to attracting industry partners are (a) the publicly available prime expertise of NREL and (b) testing capabilities of the NREL facilities, e.g. blade testing at a scale not available or done elsewhere[30]. Industry is thus offered the use of top notch facilities to test the performance of their technologies. It is inherently difficult for industrial partners to have the scale of human and technical resources as NREL has today – one basically needs a government investment to lower the risk and obtain a reasonable return on investment.

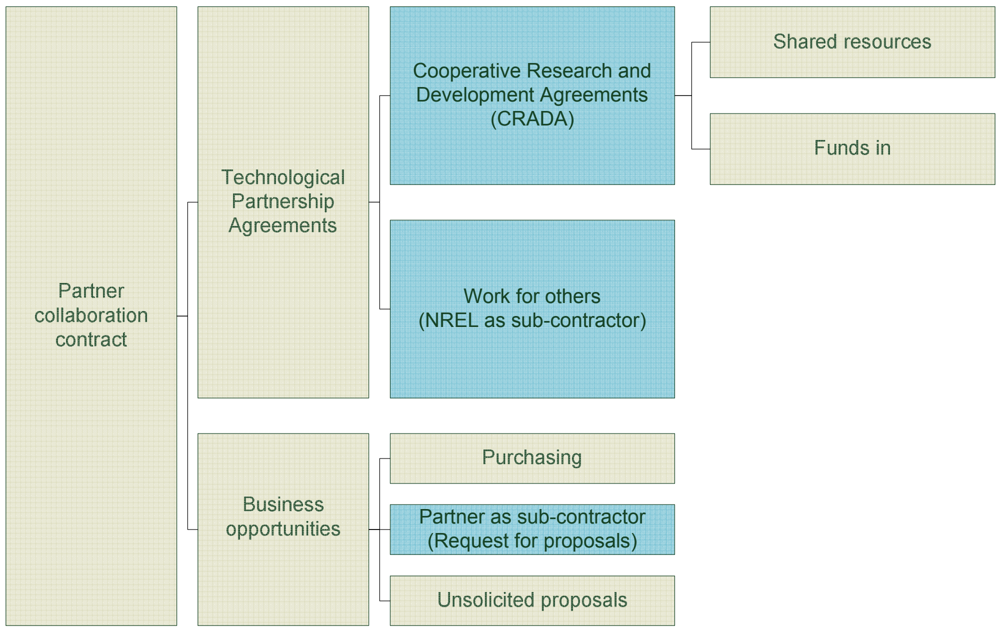
In working with industry, a "cost sharing" approach is generally adopted to ensure they are committed and the technology in fact is ready for commercialization. There are generally three kinds of contracts when collaborating with a partner (see Figure 12):

1. CRADA – cooperative research and development agreement.
2. NREL as subcontractor
3. Partner as subcontractor

*Ad 1) CRADA*
There are two kinds of CRADA agreements; (a) funds-in where the partner pays some or all of the project cost and (b) shared resources, where the partner provides "in kind" resources in terms of researchers that team up with NREL researchers, i.e. no cash changes hands. All though non-disclosure agreements are usually signed with the partner, the key challenge in CRADA agreements is most often intellectual property rights: The partner typically need time to bring a NREL/industry developed technology to market in a way that ensures return on its investment, whilst the objective of NREL is to spread research results to push the RE market ahead.

[30] Andy Paliszewski, Interview March 8th, 2011

**Figure 12: Partner collaboration contracts**




*Source: Created on information from NREL website on commercialization & technology transfer and Interview with Dale Gardner*

Agreements have been made by allowing NREL to publish all findings after a specified period of time, allowing the industrial partner time to utilize the findings before NREL pursues its objective of building and nurturing the renewable energy sector in the US. An example could be NREL's collaboration with DuPont to design the first generation bio-refinery, an agreement which came to an end last year, at which point NREL published all material related to the work with DuPont[31].

In an interview with Siemens' Andy Paliszewski[32], Director of Wind Turbine R & D Office in Boulder, the issue of intellectual property rights also came up and it quickly became clear that trust is a major factor when entering CRADA agreements with NREL; a long history of working with the DOE has lead the way, as well as the daily encounters with NREL staff that proves they are well versed in compliance issues of protecting confidentiality agreements, treating Siemen's equipment with respect – and cautioning against entering specific sites at NREL if other partners are working there. NREL and Siemens in 2009 signed an agreement to test basic turbine characteristics and verify new performance enhancing feature of a pilot 2.3 MW turbine – one of the largest land-based turbines deployed in the US - installed at NREL. A meteorological tower to the west of the turbine will at the same time collect data on wind, temperature, dew point and other key features that may influence the performance and lifespan of a wind turbine. In a separate, but with Siemens coordinated,

[31] Bob Noun, Interview February 24th, 2011
[32] Andy Paliszewski, Interview March 8th, 2011

agreement with Renewable Energy Systems Americas, a study on the design and performance of turbine foundations is conducted, with goals of increasing reliability of non-turbine components and reducing turbine installation costs. Lastly, the turbine will deliver electricity to the NREL campus.

Siemens will bring $ 9 million to the table and NREL 5 – "this is the best place in the world (for these kinds of tests), this is the hot house of aerodynamic and atmospheric research," Siemens Chief Technology Officer Henrik Stiesdal said[33].

National laboratories typically do technology transfer, whilst NREL in collaboration with industry follows the technology out of the lab and into the marked place. NREL is the only national laboratory with an entire division devoted to commercialization and deployment of RE technologies. The deployment side works with communities and other public entities on clean energy projects – from demonstrations to rebuilding entire communities based on sustainable principles and technologies. The commercialization and deployment division has a senior vice president and two vice presidents for commercialization and deployment respectively and about 100 employees in the division. However, the division does not operate on a separate budget, but gets funding from a mix of (a) each of the scientific areas of NREL in which the specific staff is embedded and (b) from federal programmes that pay for the performance of certain functions and duties that are then carried out from the division.

*Ad 2) NREL as sub-contractor: Work-for-Others agreements*
The partner pays a technical service from NREL, i.e. no joint research. There are several kinds of Work-for-Others agreements, e.g.

- Interagency Agreement-Government (contracts with federal agency other than DOE)
- Funds-in agreement (Non-federal entity pays for research oriented project and can obtain title to inventions)
- Technical services agreement (consulting and basic technical assistance)
- Analytical services agreement (Specialised and narrow analytical service of max 3 months time period and $ 25,000 budget)

The process of entering a Technological Partnership Agreement has been broken down to 11 steps from discussing the project proposal to implementation and project management (see annex 3).

NREL today has partnership agreements with more than 300 industry partners, 70 universities and 80 not-for-profit organizations and more CRADAs with industry partners than all the other DOE national laboratories combined[34].

[33] NREL news room: Largest Wind and R&D study underway at NREL, October 23, 2009
[34] Information received from Joe Verrengia March 23rd, 2011

*Ad 3) Partner as sub-contractor*
NREL widely uses sub-contractors – about 50% of NREL´s budget goes to sub-contractors. The majority of sub-contractors are found through requests for proposals (RFPs), a competitive process of selecting the sub-contractor. RFPs are usually sent out by NREL in collaboration with R&D partners that are part of one of the technology programs, e.g. wind[35].

Also licensing agreements should be touched upon - NREL developed technologies and products are available for businesses to take it to the end of the commercialization process. NREL currently has 33 technologies available for licensing.
Market summaries providing descriptions of the technologies with their benefits, applications, industries and development stage can be found at http://techportal.eere.energy.gov/lab.do/labID=10
Sample license agreements can be found on the NREL website http://www.nrel.gov/technologytransfer/licensing_agreements.html

In annex 4 is an overview of the seven steps that NREL has broken the licensing agreement process into.

Interviewees continually pointed to the importance of engaging with the local community to develop and sustain a positive reputation. NREL engages with the local community, not only through the Visitor Center, but also through participation in local and state government economic development organizations, where NREL may contribute with technical advice, workshops, speakers, hosting facilities etc.[36] It should also noted that a recent University of Colorado study points to every new job created at NREL adding roughly five jobs to the local economy.

**Human resources**

Today, approximately 2,300 people work at NREL today, but the number has fluctuated over the years, pretty much following funding and today's number is at the height of NREL in terms of staff (and funding). Figure 9 indicates the number of staff through time, from a few dozen people in 1977, quickly hitting 1,000 in 1980 and doubling that number the last couple of years.

**Compensation and hiring procedures**

Interviewees repeatedly mentioned that working at NREL was essentially driven by excitement about the mission – from what ever level the specific staff chose to think about it; from "saving the world" to "for my country" to "make a better life for my children". Rather than a 8 to 5 job, where you wonder what you have accomplished, the feeling is that NREL has a mission and a real impact on the world around it.

[35] NREL,Working with Entrepreneurs, http://www.nrel.gov/technologytransfer/entrepreneurs/gfp.html
[36] Interviewees and Sustainable NREL at http://www.nrel.gov/sustainable_nrel/community_outreach.html

Compensation is 3rd priority. NREL employees are employees of the Alliance for Sustainable Energy and are thus not paid at the government scale, but in theory are paid market rates. Still, a few years ago, compensation was 80-90 % of private sector pay. In 2010, the lab completed a market salary survey that established 6 job classifications as well as stages within those levels to better reflect comparable jobs in the private sector. The salary ranges in each level are quite broad, in the tends of thousands of dollars, and placement within the level will depend on experience and qualifications. Salaries also were adjusted as necessary to be competitive. The attempts to match market salaries was in part to make sure staff does not “worry” about money, but are focused on the task at hand. Salaries are supposed to be no lower than 80 percent of the market rate and now higher than 120 percent. At the moment, the pay level is an estimated 95% of industry salaries across the board. NREL also offers competitive benefits to its staff. For an overview of the 2010 benefit package see http://www.nrel.gov/docs/fy10osti/46487.pdf

For select positions that are considered to be essential or highly specialized, hiring managers can go beyond the pay scale for the job classifications, but those decisions need the approval of the lab director. For these key positions, staff is also typically head hunted – and offered competitive compensation packages. Key positions are senior and principal level employees, as well as administrators who are center director and above. There are 50 people at center director or above, and about 100 senior and principal scientists, engineers and administrators, so about 150 people or less than 10% of total staff. In recruitment of these staff, NREL can offer packages above the scale to compete with private industry. These have to be approved by the Department of Energy. Another category outside the pay scale is a level of senior researchers called fellows, which are like professors with endowed chairs at universities. Their salaries also are exceptions to the standard pay scale and must also be approved.

Compensation is also based on performance: Every year, each employee has a set of job performance goals and specific assignments to reach for that given year. At the end of the year, the employee’s performance is reviewed and measured against those goals, as well as standard criteria such as on-time performance, upholding safety rules, etc. An employee’s annual raise is then based on that review. The actual annual raise is inflations plus a small performance based increment – raises above 3 percent are rare. Currently because of the federal budget issues, NREL staff is on a two year salary freeze.

Depending on the type of position, NREL advertizes in professional publications, online job board and with professional associations. All jobs also are also listed on the NREL website. The Human Resources department also has its own “recruiters” that work with the specialized departments in the laboratory to find, recruit and review potential employees. All applicants must apply online, even if they are recruited internally[37].

[37] Information from Joe Verrengia March 3rd, 2011 and March 23rd, 2011,

However, NREL employs a multi-faceted approach, also running a number of programmes to attract staff:

- Post-doc and graduate student programme to attract new professionals
- Close working relations with local and other universities in the US
- Increasingly working with community colleges to improve these as well
- And as first mentioned - by offering an attractive environment of working on longer term research, nice location, excitement about the mission and working in a climate with likeminded people.

In fact, interviewees repeatedly mentioned the location – Boulder – as a key to attracting quality staff; it holds the ingredients to lead a healthy life style with access to great nature, skiing, nice weather and an on average extremely well educated community. Attracting research institutions has been a state strategy and it does seem that Boulder has succeeded; there is not only NREL, but also the National center for Atmospheric Research, the National Oceanic and Atmospheric Administration (NOAA), National Institute of Standards and Technology (NIST) and Institute for Telecommunications Sciences – and of course the universities.

Industry R&D seems to follow for the purpose of access to a critical mass of knowledge – Siemens wind turbines R&D opened a research facility in Boulder in 2008 and are today 24 research engineers an on tract to roughly double that in another couple of years. They are today working closely with NREL to utilize in particular NREL's knowledge of aero dynamics and on tract to have 40-50 researchers in the Boulder office at the office's 5 year point[38].

**Staff profiles**
Of the about 2,300 staff today, about 1,800 are permanent staff with the remaining 500 on time limited contracts. About 60% of the staff is research staff with the rest non-research, i.e. administrative, maintenance etc. staff.

NREL staff today represents 70 different countries and have attended 600 different universities worldwide. The staff holds 2,600 college degrees, including 450 PhDs and JDs. The median age is 43 years old.

Looking at the four legs of the organization, the staff profile is roughly:

1. Science and Technology: Scientists, mainly PhD and engineers.
2. Out reach, planning and analysis – Strategic : PhD and masters degrees in economics, public policies and a few scientists who have migrated over from Science and Technology.
3. Commercialization and deployment: Engineers, MBAs, finance degrees.

[38] Andy Paliszewski, interview March 8th, 2011

4. Business operations: MBAs, finance degree, lawyers, other basic business degrees or skills.

At the individual laboratory level, an example is the “Renewable Fuels and Vehicle Systems” laboratory. The laboratory has 250 staff

- 38% PhD,
- 25% masters,
- 32% bachelors and
- 2% associate or non-degreed.

**Change in staffing through the years**

Research is the largest portion of the laboratory – two to three times as many people in S&T as in the other sections. However - the other sections are the fastest growing. There are several reasons for this.

As collaboration with other institutions and organizations began, a stronger support structure was needed to be on their toes in engaging companies and accommodate policy makers as well as improve communication. So this leads to more support staff to effectively make an impact.

As an organization, NREL seems to believe more and more that the “other pieces” – that policy and market are critical to success. This change in objective (see also chapter 3) is obviously reflected in the organization and operation of NREL and thus the staff.

# 6 Organisation

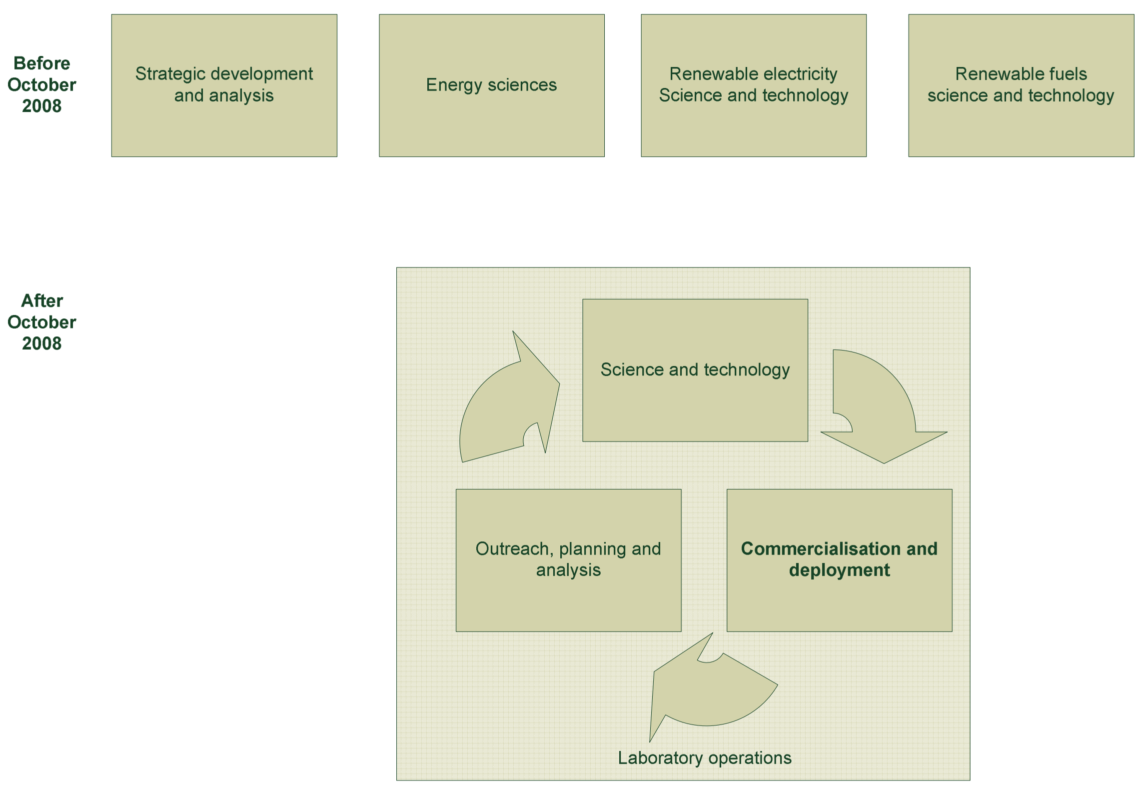
## 6.1. Organisation through time

In the beginning, NREL was organized much as a university. This had much to do with the maturity of the technologies; none of the technologies were really ready to hit the marked, everything was new and untested. Many of the changes in the organisation through the years can be said to be a reflection of the maturity of technologies, which the past 10 years has sent he organization evolving into more of an entrepreneurial focus on how to deploy and bring the maturing/mature technologies to the market place. This means that the organization has moved from something like a university organization to an organization with closer resemblance to the industry.

## 6.2.Today's organisation and operations

Besides the 1991 substantial shift when moving from SERI to NREL, the Alliance 2008 bid for NREL presented something of a paradigm shift in the organization, reflecting the integration of policy and market with the technologies also in the organization and operation of NREL.

**Figure 13: Towards a more integrated organization and operation**




*Based on organization charts from before and after October 2008 and*

Before the change in 2008, the organization was divided into four tiers (see annex 1)

- strategic development and analysis
- energy sciences
- renewable electricity, science and technology and
- renewable fuels science and technology

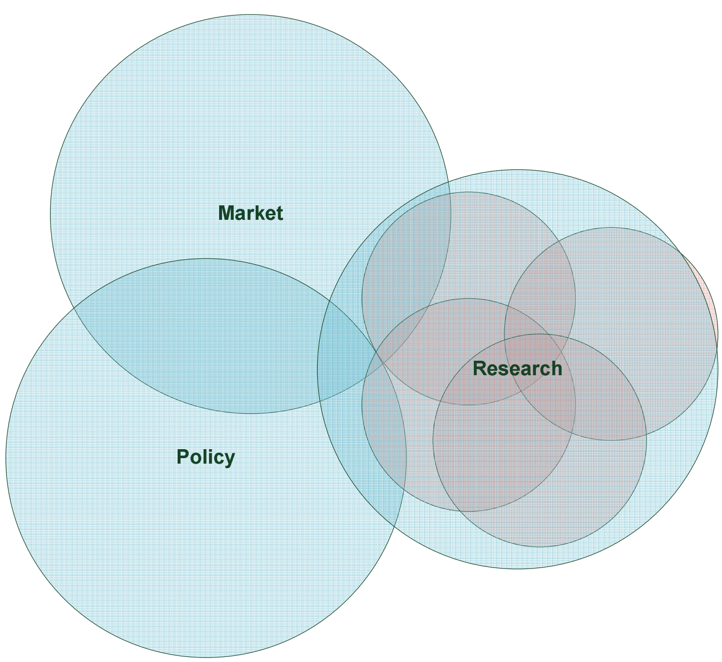
The organization was thus much set-up as a traditional research laboratory, with three technology research legs.

The switch to a more integrated approach in 2008 gave birth to four peer organizations (see annex 2):

- Outreach, planning and analysis
- Science and technology
- Laboratory operations and
- Commercialization and deployment

The science thus became one leg out of the four, adding a leg of commercialization and deployment to the organization, as well as laboratory operations, which holds all the support and enabling functions of NREL.

**Figure 14: Integration at two levels**




Integration in this sense happened at two levels – both by integrating research, market and policy, but also through the significant upscale in work and interplay between departments and thinking in integrated solutions on the science and technology side, e.g. vehicles plugged into RE and solar panels on buildings: Bottom line of the organizational approach seems to be that the market cares about energy delivery and not what the technology looks like or which department it came from.

**Why change the organization?**

Several particularly political signs after 2005 were showing a move from R&D towards ensuring technology acceptance in the market place:

> The Wind and Hydropower Technologies Program has interpreted the Presidential directive to "change the way we power our homes and businesses" and the implementation focus of EPAct 2005 as a mission to provide leadership to the wind industry and assign higher priority to removing barriers to the use of advanced wind technology, which is intended to speed deployment into all wind regimes[39].

With the 2008 M&O contract bid for NREL, the current holders of the contract felt that the reorganization to a more integrated approach was necessary to meet such a mission and win the contract again. Whilst research is still the largest proportion of the laboratory, the other functions are the fastest growing – and it was believed that those other functions have become critical to NREL's success: Research needs good analysis to say what research needs to be done and to figure out how a given technology will work in the marketplace. Macro level analysis is needed to see how the technology might change things in the broader world.

> As a technology becomes commercial, the greatest economic efficiency is found in an approach which balances RD&D and policies that push the technology to become competitive while encouraging adoption. For this reason, both R&D and policy support are required until wind technology can be considered mature and the need for this external support disappears[40].

A stronger focus on policy and markets was needed to push for the goal of substantially increasing the nation's share of RE in the production of electricity.

The operations of NREL changed with the organization for the operations to push forward such a mission. This meant that e.g. researchers from different technologies today are placed much closer to each other to facilitate the emergence of integrated solutions. The reorganization also better integrated across the innovation cycle from R&D to commercialization as described in chapter 2. . The changes also meant expanding the support structure to ensure that e.g. analysis can be delivered within the timeframe needed by particularly policy makers.

As such, NREL today often refers to itself as an applied laboratory. Whilst other laboratories are doing discovery "for discovery's sake", without an application in mind and time perspectives of often decades to actual application, an applied laboratory is different in that the technology is aimed at distinct goals and targets.

[39] EERE Information Center: Wind and Hydro Power Program Overview, August 2007, p. 2
[40] EERE Information Center: Wind and Hydro Power Program Overview, August 2007, p. 12

**Governing body**

As mentioned a few times, NREL is managed by the Alliance, formed by Midwest Research Institute and BATTELLE with the purpose of managing and operating NREL.

About Midwest Research Institute

> MRI, a not-for-profit scientific research organization with 1,800 employees nationwide, performs contract research and laboratory consulting services for clients in government, industry, and academia. Established in 1944, MRI is one of the nation's leading independent research institutes conducting research in the areas of national security and defense, energy and environment, life sciences, agriculture and food safety, and infrastructure. With headquarters in Kansas City, MRI also has facilities in Palm Bay, Fla., Frederick, Md., and Rockville, Md. As a not-for-profit, MRI has a board of directors and a management team but not shareholders as a private corporation might. MRI's board of directors includes a cross section of members from universities with deep research capacity and others private sector backgrounds in finance or development. William Hall, president of the Hall Family Foundation is the chairman. MRI has managed the National Renewable Energy Laboratory (NREL) in Golden, Colo., for the U.S. Department of Energy since 1977. The Institute's mission is to benefit society by providing solutions to national problems through scientific research, technology development, and technical services.
> .

About BATTELLE

> Battelle is the world's largest non-profit independent research and development organization, with 20,000 employees in more than 120 locations worldwide, including six national laboratories Battelle manages or co-manages for the U.S. Department of Energy. Headquartered in Columbus, Ohio, Battelle conducts $4 billion in R&D annually through contract research, laboratory management and technology commercialization. Battelle provides innovative solutions to some of the world's most important problems including global climate change, sustainable energy technologies, high performance materials, next-generation healthcare diagnostics and therapeutics, and advanced security solutions for people, infrastructure, and the nation. Battelle has a long history of developing successful commercial products in collaboration with its clients, ranging from products to fight diabetes, cancer, and heart disease to the development of the office copier machine (Xerox). As a non-profit charitable trust with an eye toward the future, Battelle actively supports and promotes science and math education.

The Alliance is governed by a 15-member Alliance Board of Directors composed of five executives each from MRI and Battelle (who together from the Alliance), as well as senior-level officials from five key collaborating universities: Colorado School of Mines, Colorado

State University, University of Colorado-Boulder, Massachusetts Institute of Technology, and Stanford University[41].

[41] http://www.battelle.org/spotlight/7-29-08NREL.aspx

# 7 Monitoring and evaluation

> I remember lots of management systems were kept on the backs of envelopes. A headquarters program manager would call wanting to know a number and somebody would give some number off the back of an envelope to the project manager. Then the official accounting report would come out, light years apart from what we had! We got into a lot of trouble. It took 2 and half years to clear that up. We became very strict about having only one source and one system of information so mistakes like that could not be made again.
> In the beginning we were pretty rigid with milestone reports and quarterly program reviews. I thought it would take a couple of years to instill a disciplined financial management approach to managing research. It took a little longer (John Kersten, Acting Manager of DOE Golden Field Office) [42].

Managing the finances seems to have been a challenge in the first years – it took some years to instill disciplined financial management to the projects in terms of research dollars spent and technical outcome. Also problems of mismanagement were cited in two reports of the DOE Inspector General – a number of them minor accounting mistakes and others more substantive[43].

Today, very detailed analysis e.g. improvement analysis is carried out for given level of technology - how much efficiency can you develop for a given amount of money? I.e. if we invest $ 10 million, then how much reduction in cost or efficiency can be reached? DOE then uses this information as a basis to figure out how to optimize their dollar spending using risk analysis as well. The process is thus fairly sophisticated today. That said, doing that kind of optimization analysis when it comes to overcoming other market barriers, there is much more uncertainty in what can be reached. Estimating impact at e.g. the policy level consists of multifactor judgments about policy action at particularly the federal, state, local and utility levels. At the same time, efforts are also made in providing support to new solar installers, technical assistance to project developers on design optimization, awards to builders – essentially reaching out to everything from policy makers to developers, installers and to some extent the finance community. Ultimately, impact will be reached when the technology is ready, the policy in place and the market actors in place.

**Performance targets and linkage**

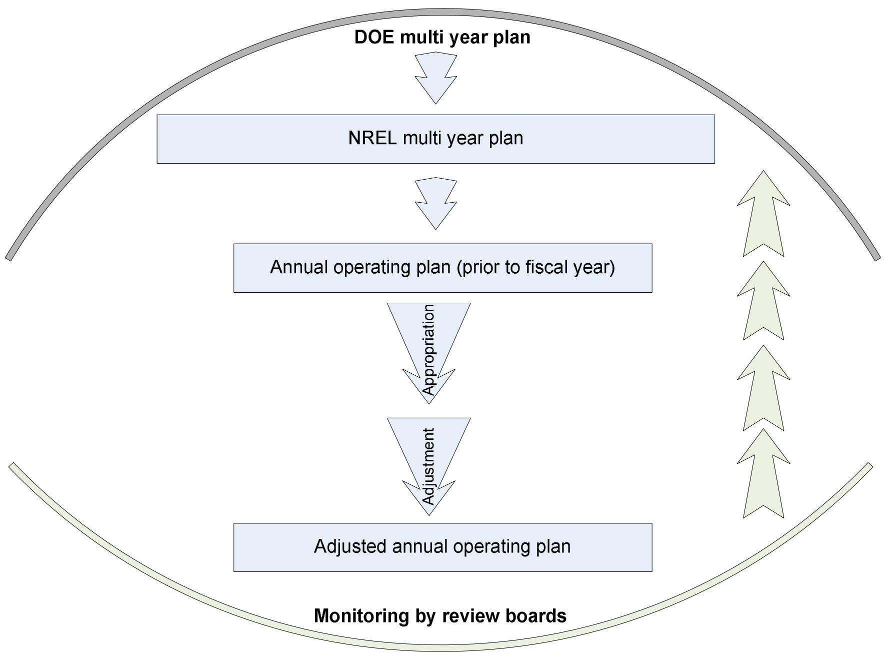
The DOE sets out a target, e.g. installed cost of PV and then road map on how to overcome technical, legal, cost, performance etc. is developed and continually updated and revised. E.g. the Wind Program goals and performance targets fit into the US Energy Strategic Goals and in that context in the US Energy Security Goals. Performance targets are established

[42] John McKelvey, interview from July 15th, 2002: http://www.w3w3.com/Interview/NREL/25_CELEB.htm
[43] *Science 10 August 1979:* Vol. 205 no. 4406 pp. 563-566

within the programme. Annex 5 shows a "Program Logic Model" for the Wind Program. Individual projects within the programme must then link to the programme level.

On a practical level, projects at NREL face an annual peer review of experts from academia and industry. This review considers work completed and work planned over the annual and multi-annual horizon.

**Figure 15: Feed back mechanism from peer reviews**




*Source: Adapted from interviews*

The commentators are addressing whether the projects are tackling the right challenges for the technologies and whether the methodologies used are sound, which feeds back into the plans of both DOE and NREL (see Figure 15). A peer review is defined as

> A rigorous, formal, and documented evaluation process using objective criteria and qualified and independent reviewers to make a judgment of the technical/ scientific/business peer, the actual or anticipated results, and the productivity and management effectiveness of programs and/or projects[44].

The 2010 Wind Program review panel consisted of 9 people, split into three groups covering technology acceptance, application and viability.

[44] DOE: 2010 Wind Program Peer Review Report, 2010, p. 13

**Table 3: 2010 Wind Program peer review panel**

| Name | Affiliation | Panel |
|---|---|---|
| Randy Swisher (Chair) | American Wind Energy Association | Technology Acceptance |
| Mark Ahlstrom | WindLogics | Technology Application |
| Mark Lauby | North-American Electric Reliability Corporation | Technology Application |
| Julia Levin | California Energy Commission | Technology Acceptance |
| Amir Mikhail | Clipper Windpower | Technology Viability |
| Dale Osborn | Distributed Generation Systems, Inc | Technology Viability |
| Kyle Roblee | Global Common Biofuels | Technology Application |
| Stu Webster | American Wind & Wildlife Institute | Technology Acceptance |
| Carsten Westergaard | Vestas Technology R&D | Technology Viability |

*Source: 2010 Wind Program Peer Review Report, p. 14*

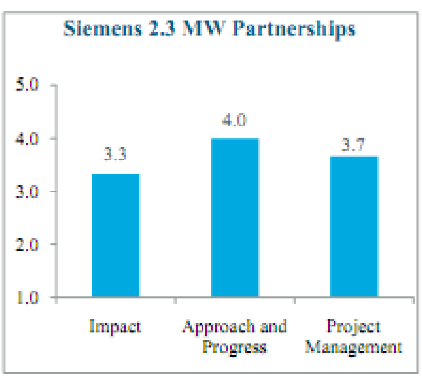
The panel reviews the program as a whole on

1. Relevance
2. Quality, productivity and accomplishments
3. Management

For each project presented, the panel scores on three aspects:

1. Impact
2. Approach and progress
3. Project management

**Figure 16: Score on three aspects**




Scoring is given using a 5 point scale at both program and project level.

As an example, also the Siemens CRADA is reviewed – "Siemens 2.3 MW Utility-scale Turbine Partnerships". A summarizing chart is provided, showing the scores on each of the three aspects (see below).

Annex 7 provides the full report review of the project.

**Other monitoring mechanisms**

Concretely, given the unique position of NREL within the renewable energy landscape, multiple organizations provide evaluation and oversight, both passively and actively. NREL's position as a National Laboratory centrally focuses them on DOE and other federal agencies and Congress. However, the unique structure of NREL management, through the joint partnership of MRI and Battelle under the Alliance, provides reciprocal information and technology flows through other prominent RE organizations at both a national and international level as well as with public and private bodies alike. NREL's contacts and ties to universities and independent laboratories through subcontracted work or information transfer provide and informal academic and professional oversight of NREL objectives.

While many appropriations decisions can be political, as seen in the 2011 Congressional budget debates, NREL's effective execution of the mission is critical to retaining funding. The Alliance's retention of the contract to run the National Laboratory is also a key indicator of success and confidence. NREL administrators are clearly aware that their performance and effectiveness impact their funding and they strive through a variety of communications channels to ensure their stakeholders understand their value add and that congressional members also understand. To this end, NREL hosts thousands of visitors from around the world each year, maintains a Washington, DC office and speaks and publishes extensively. NREL also publishes lots of reports, scientific articles, etc., but that is essentially just outputs.

That said, measuring actual impact is difficult, since the impact in this way mostly is indirect. Attempts to monitor the movement towards the outcomes in the US market are made: All though it is close to impossible to isolate NREL's influence specifically, subjective judgments are made. An example could be solar, where the impact measure is e.g. more GW installed and the NREL performance measure is to get the cost of solar down so it is closer to coal – that will have an impact on the amount of PV installed.

More directly, NREL also has a fan of energy efficiency and renewable energy technologies that are available for licensing to both small and large businesses – from start-ups to Fortune 500 companies. A marketing summary is provided of each technology with a description including benefits, applications and industries as well as development stage[45].

[45] US DOE: http://techportal.eere.energy.gov/lab/NREL

# 8 A Chinese REC

## 8.1 The Chinese context

The development of a Chinese renewable energy industry has become a political project for the Chinese government over the past few years. Only in 2006 the first version of the Chinese renewable energy law saw the light of day, but it has been revised twice and in its latest version specifically sets the priority to ensure the Chinese renewable energy industry a global market position. The recently adopted 12th 5-year plan has now formally confirmed this as an overriding industrial priority which will in all likelihood put the Chinese RE industry on the global map over the coming 5 years.

The most essential instrument in the first stages of implementing this strategy has been to ensure the Chinese suppliers a thriving domestic market. 6 large wind bases each with capacities of 10 GW have been reserved for domestic suppliers while the Chinese suppliers are rapidly increasing their local market shares.

The Chinese wind suppliers have beaten their foreign competitors in the domestic market through a combination of fierce price wars and government protection, the former of which has been achieved through economies of scale in production as well as challenging the production and product standards introduced by foreign suppliers. But fearing that the local manufacturers have taken this one step too far, the government has emphasized the need to ensure sufficient quality in production to attract the interest of foreign market buyers. A global position will eventually require a global presence at international quality standards.

In other technologies, particularly solar PV, China has been successful in establishing itself as a global supplier, while not necessarily being a leading high-tech application supplier. In contrast to the wind energy sector the Chinese position here has been established on the basis of foreign market demand, while the domestic market has been lagging behind.

These are the two most notable examples of renewable energy technologies and their platforms in China and they equally reveal the probable key drivers for the establishment of a Renewable Energy Centre.

Whilst NREL was sparked by the US government, just as the Chinese focus on RE is sparked by government, the technology context is of key difference.

When NREL started in the 1970s, the maturity of RE technologies had not yet reached a stage of broad commercialization - a stark contrast to today. A key task for NREL at first was thus also to spread information about RE, as very few people, including the policy level, knew much about RE. The project of setting up NREL was filled with excitement and thrill from the newness of entering the unknown and once NREL was established it was largely driven by staff spurred on by a personal commitment to advancing RE.

RE is today, also in China, big business and whilst NREL has had the years to mature with the RE sector, indeed foster the sector in which it finds itself in today, a Chinese REC will need an almost opposite approach of finding its place in an already established sector.

### 8.2 Objectives, activities and policy impact

Looking at the establishment of a Chinese REC in such a context, the question remains what we can learn from NREL in becoming a successful player in the RE field. This section will look at what a Chinese REC can learn from NREL when establishing objectives, deciding on activities and how that can lead to policy impact.

.

*A. Aligning REC objectives with wider range of government agencies*

NREL aligns it goals with those of DOE and ensures their objectives and activities to be on par with those of the DOE. However, ensuring wider government backing at both federal and local levels has been important to NREL to ensure not only continued funding but also to leverage potential policy impact by being the preferred choice of consultation when it comes to a professional analysis and opinions on RE.

Aligning objectives with not only the NEA, but other key agencies could help further a successful REC. Ideally, a Chinese REC wants several Chinese government agencies investing, taking a stake in and using the services of the centre.

NREL has continued community outreach activities and joins conferences, gives statements etc. leaving footprints throughout the RE market.

A new REC needs to build the momentum still: Fostering a relationship to selected government agencies throughout the REC lifetime is important and particularly involving these key agencies in defining overall objectives could prove fruitful later down the road.

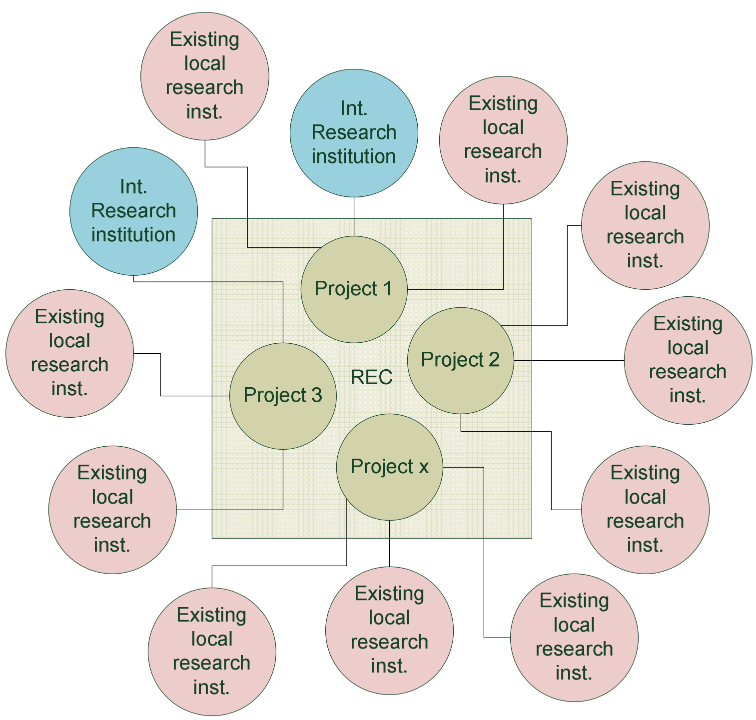
*B. Couple industry needs with an integrated science approach*

A key characteristic of NREL's success seems to be its continued ability to adapt itself to fit the RE sector as the technologies have matured, as policies have changed and the RE industry has expanded. Working with the industry to define which way R&D should go and even partnering with the industry to conduct R&D is a product of this approach that recognizes the industry as a key player and driver in the RE sector today, as opposed to back in 1977.

Working with industry to understand what technical solutions may have the greatest impact on furthering the use of RE is today one of the cornerstones of NREL's strategy in R&D, leading to a distinct focus on applied science. It also leads to a focus on an integrated solutions approach, thinking of not one RE technology but also the technology's storage options and interaction between electricity and transmission. The same goes for more analysis oriented activities. This tight integration ensures NREL's research activities are directed at the specific barriers RE technologies face in the US marketplace – which in turn accelerates the deployment of RE.

With the Chinese REC starting up in an already expansive RE research field, a Chinese REC may not necessarily need to have a research capacity of their own, but could be the driver of project based research that capitalizes on the integration that NREL achieves. The difference would be a focus on bringing together experts from already existing organizations and laboratories rather than centrally housing expertise at the REC. In fact, several interviewees stressed the importance of *not* trying to have all resources in one place, but partnering with other laboratories, institutions, and organizations – also across country borders – as creating the most innovative results. The integration is in this sense not only across technologies, disciplines, and stages in the innovation cycle,

**Figure 17: Bringing together existing resources in an integrated project approach**

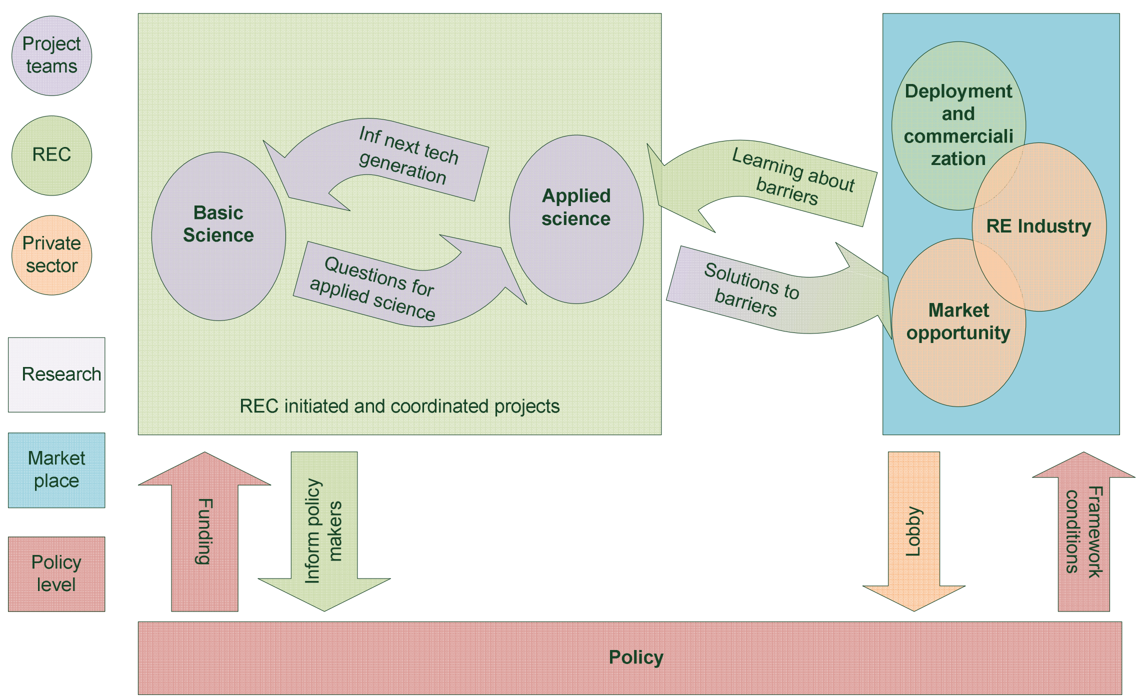



The REC could in this way experiment with the NREL way of thinking in integrated solutions by placing together traditionally separated technological areas, as well as bring together technicians with policy analysts and market players. Organizing this integration with an eye towards market driven and specific goals could increase the productivity of the Chinese innovation system for RE. At the same time, collaboration with international research institutions could bring further expertise and new angles to projects. Similarly, a new paths for collaboration with the international RE industry and expertise could ensure Chinese researchers have a deeper understanding of the needs of overseas markets and could contribute their own innovations to the global industry. Integration implies a two-way street and could be a new platform for Chinese researchers to demonstrate their expertise internationally.

*C. Moving further along the innovation chain*
NREL's focus on industry needs is joined with their ability to work on more than just the traditional research many other national labs limit themselves to. Through years of experience and pioneering the RE field, NREL has the human and technical abilities to conduct both basic and applied research within its own ranks. But NREL goes beyond to address high level integrated analysis of e.g. policies and technology impact, the testing and validation of commercialized products, the demonstration of products and many of the barriers to deployment such as a skilled workforce. This expansive role coupled with their deep understanding of the industry's challenges ensures NREL's solutions see the light of day in the marketplace and are successfully transferred to the private sector.

Understanding where the market is heading may be even more important in a rapidly moving Chinese market place and filling a role as NREL has in closing the gap between research and commercialization could be critical. The Chinese setting where several major players in the RE technology field are in fact also public, could enable a Chinese REC to work with industry and the full value chain all the way into the market place and deeper along the innovation chain than is possible in the US.

**Figure 18: REC as initiator and coordinator of research and pushing solutions to the market**




*D. Facilitate improvements and establish industrial standards*
Another central activities area, which NREL has embraced, is that of bringing world class testing facilities to the market.

Industrial partners gain access to facilities that are seldom feasible to procure on their own, but which are particularly useful in two respects:

i) Testing to facilitate continued improvements to the technology and
ii) Testing to either ensure or establish industrial standards.

Testing facilities to both purposes seems to be a gap a REC could fill in the Chinese RE sector. Besides pushing forward an applied science approach, pushing for industrial standards and credible verification of those into the Chinese RE sector could work as a driver for the Chinese RE industry to expand both domestically and globally. Either as a prerequisite to sell their products in these markets – as would be the case for wind turbines, or to move up the value chain as would be the case for solar PV.

By establishing such research and testing capacities the REC will equally qualify itself to become a credible adviser to the Chinese government.

### 8.3 Organisation

By accentuating policy analysis and deployment & commercialization in the organization after 2008, the integrated approach to solutions delivery was really underlined. All though still funded through a technology focused programme mechanism, NREL has managed to organize and operate according to other criteria.

All though posing al imaginable challenges to introduce an organization along these more untraditional lines in China, it seems that it is exactly the ability to adapt and go down these new roads that continues the “Zeitgeist” from 1977. The most important a Chinese REC organizational set-up can learn from NREL is perhaps the ability to work collaboratively – across universities, research institutions, government agencies and RE industry players.

### 8.4 Budget and resources

From NREL staff interviews as well as former high-level staff, it was clear that NREL is in a strange vacuum in having a reputation as a stable work place and at the same time having dealt with quite severe year on year budget changes.

In a Chinese context, where strong resources are scarce and typically being pulled in many directions, it is important for a Chinese REC to find ways of ensuring dedicated project participants. At NREL, employment security, long term goals and quality of life seems to have been the key drivers of attracting staff, with the option of offering very competitive packages to fill key positions.

The REC would need to be sizable enough in facilities to attract staff and get them excited about the mission. As NREL, a multi-pronged strategy could be adapted, pinching talents at an early stage, working closely with the local community and actively pursuing to keep up their reputation as an organization.

### 8.5 Monitoring and evaluation

Establishing a credible, honest and open feed back mechanism to constantly improve and pave the way for updated objectives and activities in line with the RE market seems to have been of the greatest importance to the continued success of NREL. Close relations and respect for the private players of the market, letting them to an extent dictate the work of tomorrow, has led to an applied technology approach, which enables a publication of tangible goals for the research teams.

The ability to track and "prove" efficiency and effectiveness is often a good way of securing political backing, just as it may facilitate efficiency and effectiveness with the staff when working towards a clear goal within a given timeframe.

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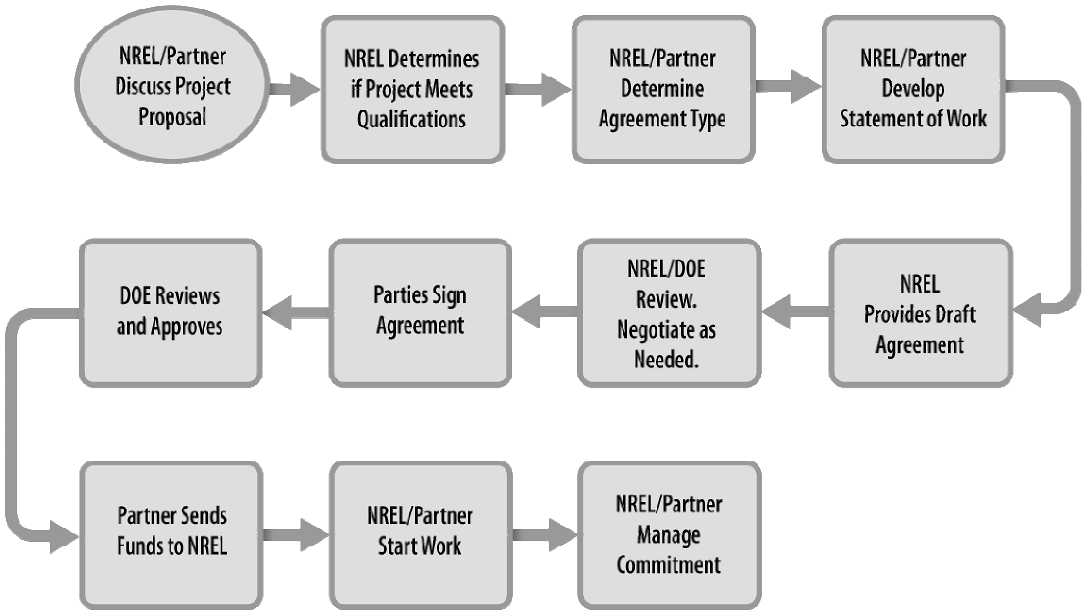
Ron Benioff February 24th, 2011

## Annex 1: Organisation before October 2008

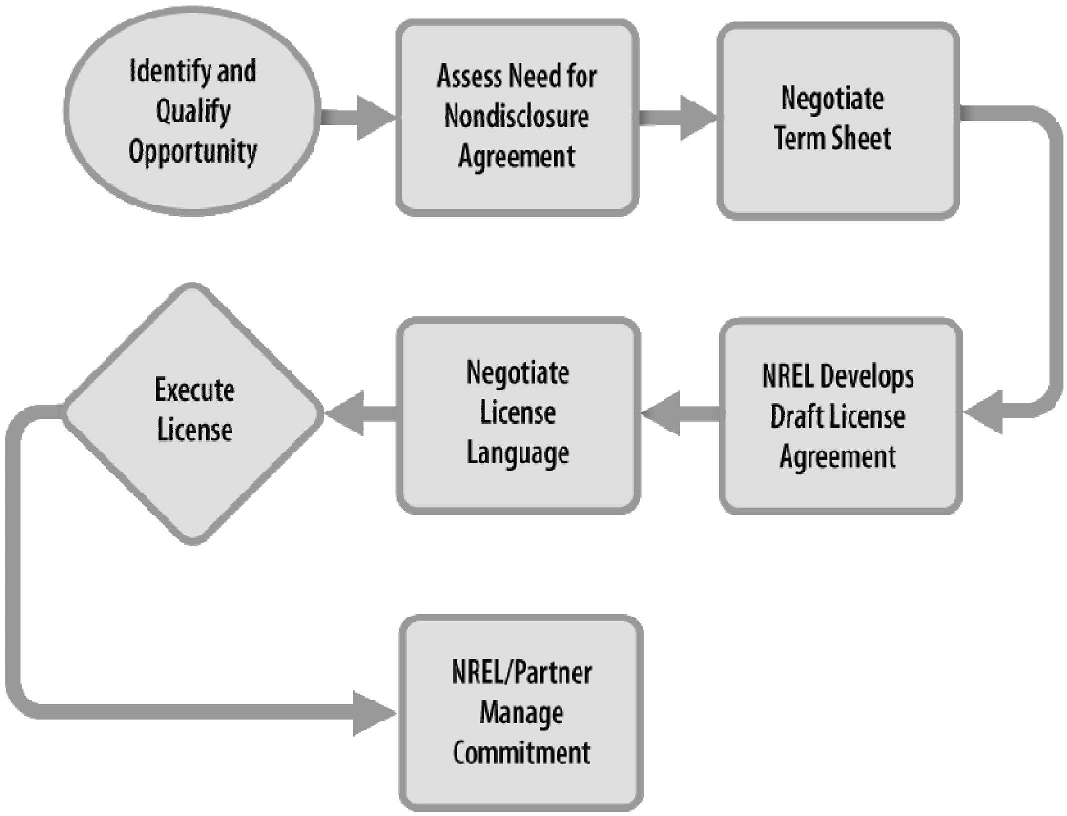
## Annex 2: Organisation after October 2008

## Annex 3: NREL Technology Partnership Agreement Process




*Source: NREL*

## Annex 4: Licensing agreement process




*Source: NREL*

## Annex 5: Program Logic Model for Wind Program

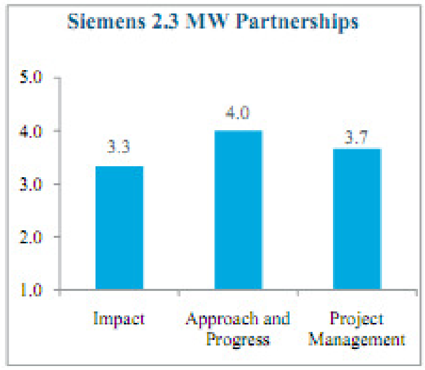
**Table 2. Program Logic Model for Wind Program**

| Project | Large Wind Turbine Technology | Distributed Wind Technology | Transmission & System Integration | Technology Acceptance |
|---|---|---|---|---|
| Resources | • Appropriations<br>• Industry cost sharing<br>• NWTC facilities<br>• IEA | • Appropriations<br>• Industry cost sharing<br>• NWTC facilities | • Appropriations<br>• State funds<br>• Partners | • Appropriations<br>• State funds (energy offices)<br>• Partners |
| Activities | • Technology development through public-private partnerships.<br>• Supporting research and testing.<br>• Reliability and performance improvement for existing turbine technologies.<br>• Low wind speed technology development.<br>• Offshore wind and resource assessment. | • Technology development through public-private partnerships.<br>• Supporting research and testing. | • Wind generator modeling.<br>• Wind farm data monitoring.<br>• Resource characterization.<br>• Grid operational impact analysis.<br>• Transmission and generation planning.<br>• Grid rules development.<br>• Institution building through utility partnerships. | • Outreach to state-based organizations.<br>• Small wind.<br>• Institution building through utility partnerships.<br>• Support for Native American interest in wind power.<br>• Environmental and siting mitigation.<br>• Emerging applications.<br>• Resource Assessment. |
| Outputs | • New components, concepts and wind systems for land-based applications in Class 4 wind regimes.<br>• Basic research tools to assist industry.<br>• COE 3.6 cents/kWh in Class 4 wind by 2012.<br>• Better understanding of offshore wind energy market and technical challenges.<br>• COE 5 cents/kWh in Class 6 wind in shallow water by 2014. | • By 2015 expand by five-fold the number of distributed wind turbines deployed in the U.S. market from a 2007 baseline.<br>• New components, concepts and wind systems for applications of less than 100 kW.<br>• Development of wind turbines to support mid-sized market applications. | • Ability of wind systems to compete without disadvantage in key areas of market rules, interconnection impacts, operating strategies, and system planning.<br>• Development of new transmission to facilitate wind development. | • 30 states with mature markets that support wind industry growth.<br>• Technical and outreach support widely available.<br>• Fewer barriers to large and small wind integration. |
| Short-term Outcomes 2007–2010 | • The use of wind energy in high and low resource areas accelerates due to their improved cost effectiveness. | • Wind turbines for residential (1-2 kW) use and commercial/ community applications (100 kW and above) enter the marketplace. | • Wind becomes a participant in defining the national needs of emerging grid operation and rulemaking processes.<br>• Announcement of 3 new transmission lines to bring low-cost wind to urban load centers. | • 30 states achieve a level of public awareness and policy environment that fosters a vibrant market for wind energy development. |
| Intermediate Outcomes 2010–2020 | • The use of wind energy as a low-cost electricity source, without financial incentives, becomes widespread as technology matures.<br>• Commercial development of shallow water technologies.<br>• Commercial wind turbine technology for transitional water depths is developed and demonstrated in offshore sites. | • Distributed uses of wind energy at all sizes emerge as a significant opportunity for technology deployment and end-users embrace wind for a growing number of uses. | • Utilities and developers gain clear understanding of barriers to integration and know how to address them.<br>• Increased transmission implemented allowing the expanded use of wind technologies. | • Public acceptance of wind technologies in rural areas, supporting local economic development.<br>• 6-8 regional wind collaborative organizations emerge and function to plan and integrate appropriately large amounts of wind energy into regional operating systems. |
| Long-Term Outcomes and Problem Solutions 2020 and beyond | • The percentage of energy generated from wind exceeds 10%, confirming wind as a major National energy source.<br>• Wind turbine technology for use in deepwater offshore applications is proven economic and becomes a major new electricity source for states bordering coastal zones. | • Wind turbines for emerging applications become available and gain acceptance for specialized uses such as hydrogen production and water supply. | • Wind achieves high grid penetration level and is a nationally accepted part of our energy portfolio.<br>• National transmission infrastructure allows high levels of wind penetration. | • Awareness and acceptance levels are achieved nationally, making further coordination efforts unnecessary. |

## Annex 7: Example of project level peer review

### Siemens 2.3 MW Utility-Scale Turbine Partnerships

*Lee Jay Fingersh, National Renewable Energy Laboratory*
*FY2010 funding: $1,500K*
*Project initiation: 2007*
*Target completion: 2013*




The purpose of this project is to investigate the accuracy of new methods of wind turbine blade aerodynamic design used to design the Siemens 2.3MW-101 rotor, a 101-meter diameter three-bladed rotor adapted from their widely-deployed 2.3MW-93 93 meter machine. A Siemens 2.3 MW turbine was erected at the NWTC and commissioned in October 2009; instrumentation for power-performance, acoustics, power quality, meteorological and modal testing, and loads instrumentation have been installed on or prepared for the machine. This project will gather detailed blade aerodynamic data, including detailed inflow from a highly instrumented tall tower, to validate the Siemens blade aerodynamics analysis. Testing during the 2010-2011 wind season is expected to include power performance, acoustics, modal, power quality, loads and aerodynamic testing. The collaboration with Siemens will lead to improved understanding of advanced aerodynamic design methodologies that can be used to increase the energy capture of utility-scale wind turbines.

**Criterion 1: Impact**

- Limited impact on the rest of the industry due to the proprietary nature of SIEMEN's turbine.
- Apparently high two-way value and good arguments for dissemination of results through code/tool development.
- It is a vehicle for government and industry collaboration, but not uniquely DOE.
- Aero work and data will be used to advance internal aerodesign codes.
- There seems to be some rather critical information that may not be allowed to be disseminated to the industry. I think that private industry could and maybe is doing this with individual turbine suppliers.

**Figure 11. Siemens 2.3 MW installed at NWTC**

**Criterion 2: Approach and Progress**

- Test has not started, will start sometime in 2010.

- $12-13M contribution by SIEMENS is good support for the NWTC.
- This fits the research charter, and undoubtedly will be useful in creating tools, but I have difficulty in connecting to the commercial turbine and blade supplier industry.

**Criterion 3: Project Management**

- Intellectual Property was not dealt with in-depth up front, so risk management of the project was not in top as seen from the investment side of DOE.
- Project plan seems to be good, and activities thought through, even though there was only a glimpse at meteorological-mast acquisition.
- Not clear how the goals of this program fit in the NWTC charter.
- The team is obviously quite talented, but the protection of IP may limit the project's value.

**Project Strengths**

- Industrial collaboration moves the research closer to industrial impact.
- Can compare the 1 MW solar plant and the DOE 1.5 and Siemens turbines to see the capacity factors of solar and wind.
- The large-scale equipment can be used to confirm some of these design codes used at NREL NWTC.
- Project will likely provide validation of codes that can be used, perhaps, in the public domain. Undetermined in my mind.

**Project Weaknesses**

- The proprietary nature of the machines will limit the generic benefits the industry will be able to obtain.
- Protection of Proprietary Information may be a problem.

**General Comments**

- The project will have a positive effect.
- Add the study component to integrate wind and solar and determine their capacity factors.

**Program Response**

- *DOE and NREL, in partnership with Siemens, have defined a joint project plan and test objectives that meet the research and development needs of both Siemens and the Wind Program. In particular, the project will study the unsteady aerodynamic characteristics of a commercial-scale turbine operating in a turbulent environment and will provide the program and national laboratories with access to critically-needed blade surface pressure data at megawatt-scale to support aerodynamic analysis validation activities. Key test results will be made available to the public, especially those of a more fundamental research and development nature. Some public-domain data may be normalized to protect Siemens-specific intellectual property, but there will still be significant information gleaned from the tests and published to advance wind technology research and development.*