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December 2013

Sustainability Innovation Foundry – FY13: Merging Research and Operations

Jerry McNeish, Jack Mizner, Howard Passell, Elizabeth Kistin-Keller, Kristina Sullivan, Margaret Gordon

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Abstract

Sustainability is a critical national security issue for the U.S. and other nations. Sandia National Laboratories (SNL) is already a global leader in sustainability science and technology (SS&T) as documented in this report. This report documents the ongoing work conducted this year as part of the Sustainability Innovation Foundry (SIF). The efforts of the SIF support Sandia's national and international security missions related to sustainability and resilience revolving around energy use, water use, and materials, both on site at Sandia and externally. The SIF leverages existing Sandia research and development (R&D) in sustainability science and technology to support new solutions to complex problems. The SIF also builds on existing Sandia initiatives to support transformation of Sandia into a fully sustainable entity in terms of materials, energy, and water use. In the long term, the SIF will demonstrate the efficacy of sustainability technology developed at Sandia through prototyping and test bed approaches and will provide a common platform for support of solutions to the complex problems surrounding sustainability.

Highlights from this year include the Sustainability Idea Challenge, improvements in facilities energy use, lectures and presentations from relevant experts in sustainability [Dr. Barry Hughes, University of Denver], and significant development of the Institutional Transformation (IX) modeling tools to support evaluation of proposed modifications to the SNL infrastructure to realize energy savings.

ACKNOWLEDGMENTS

The taskforce responsible for this initial planning and concept paper was catalyzed by seed funding from SNL Division 6000 and built on collaborations forged over a number of years between SNL Divisions 6000 and 4000. The taskforce acquired additional members from Divisions 4000, 6000, and 8000 to further develop the ideas and to move forward with the vision of making Sandia National Laboratories a foundry for sustainability innovation.

Additional funding to support the activities of the SIF was provided from facilities energy savings.

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NOMENCLATURE

DOE	Department of Energy
SIF	Sustainability Innovation Foundry
SNL	Sandia National Laboratories

1. INTRODUCTION

Sustainability is a critical national security issue for the U.S. and other nations. SNL is already a global leader in sustainability science and technology as documented in this report. This report documents the ongoing work conducted this year as part of the Sustainability Innovation Foundry (SIF). The efforts of the SIF support Sandia's national and international security missions related to sustainability and resilience revolving around energy use, water use, and materials, both on site at Sandia and externally. The SIF leverages existing Sandia research and development (R&D) in sustainability science and technology (SS&T) to support new solutions to complex problems. The SIF will also build on existing Sandia initiatives to transform Sandia into a sustainable entity in terms of materials, energy, and water use. The SIF will demonstrate the efficacy of sustainability technology developed at Sandia through prototyping and test bed approaches and will provide a common platform for support of solutions to the complex problems surrounding sustainability.

The Sustainability Innovation Foundry (SIF) completed an active year in FY13. This document provides a high level summary of the main activities and accomplishments of the SIF, with an emboldened look toward the future. The major activities by quarter are listed in Table 1.

Table 1. Major SIF Activities in FY13

Quarter	Activity	Key Outcome
1st	Idea Challenge Proposals received and awarded	Several innovative proposals were developed. 2 were awarded funding to further develop the concept. 1 is being actively worked as part of the SCIF renovation/repurposing effort.
	Institutional Transformation project initiated	Significant progress has been made in developing the model of energy use for SNL buildings. Tool will be used to evaluate future energy/water use modifications.
	Albuquerque Sustainability Roundtable Meeting	-Connections made to greater ABQ and NM sustainability community. -Tour of PNM solar facility. -Initiated Winrock Sustainability project.
2nd	Tour of PNM solar facility	Additional connections made at facility which should lead to future collaboration. Educational component for tour attendees was high.
	Energy Futures Seminar (Dr. Barry Hughes)	2 sessions were conducted, one at Sandia, and one at UNM.

Quarter	Activity	Key Outcome
		Total of over 100 guests heard very inspiring presentation concerning his modeling tool and analysis.
	CA Energy Commission Grants awarded to solar startups (Sun Synchrony and Cool Earth)	Sandia is providing support to these startup organizations as they attempt to commercialize their technology.
3rd	Development of SS&T summary information	Broadly defines the level of effort that Sandia is conducting in sustainability science and technology research.
	California Prop 39 proposal developed	Points out the importance of conducting a risk informed analysis of the expenditure of the Prop 39 funds for energy conservation projects.
4th	Transformational Directions for Water in the West - Roundtable	Connect forward thinking sustainability professionals toward problem solving of the resource issues in the west.
	Strategic Plan development	Further refinement of the SIF strategic plan toward increased visibility and impact on Sandia projects.
	Energy behavioral change study initiated	Develop RFP for study of behavioral change in energy consumption habits at Sandia.
	Continued development of Sustainability Science and Technology (SS&T) concept	Discussions continuing.

2. SUSTAINABILITY IDEA CHALLENGE

The Sustainability Innovation Foundry formulated a competition for new sustainability research ideas within Sandia. The competition was open to all staff, and called for development of a one page abstract of the idea. The ideas were requested to describe the benefit to sustainability at Sandia. The best ideas were selected to receive up to $5,000 for further development of the idea into a proposal or white paper. A total of $30,000 was allocated to the competition.

The competition was held in the first quarter of FY13. A total of seven idea abstracts were submitted. The ideas covered topic related to energy use, and toxic materials disposition. They are summarized in Table 2. The ideas selected for funding are highlighted in the table. These were further developed and submitted early in the second quarter of FY13 [Appendix A]. The proposals have been distributed to appropriate departments within Sandia for potential utilization. For example, the SCIF space optimization idea has been forwarded to the facilities and relevant analysis departments for consideration as they renovate or seek to utilize existing space more efficiently. Also, the water treatment using waste heat concept has been further developed and >$520, 000 additional external funding has been awarded to the idea developers.
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Table 2. Idea Challenge Topics

Proposal description	Proposal developers	Awarded Funding
HSB Footprint: Space planning for SCIF areas	Amber Romero, 5600	Yes
Ecological Solvent Recycling for Automated Chromatography Systems: A Green Chemistry Innovation - Solvent recycling approach for chem labs	Greg O'Bryan [8223]/Mitch Anstey [8125]	
Sandia National Laboratory partners with the US Air Force to site, procure, and license the first Small Modular Reactor (SMR) in the desert southwest- Facilitate development of small modular nuclear reactors.	David Wheeler	
Sequestration and separation of carbon nanostructures from flue gas exhaust- Air discharge purification technology development.	K. Hattar (01111), T. Beecheem (01114), P. Feng (08131), and C. Tomlin (04822)	Yes
Adaptive HVAC Operation for Improved Energy Sustainability at Sandia- Application of information technology to improve efficiency of energy delivery systems.	Kevin Hulin [8136]	
Water treatment using membrane distillation and waste heat- Use waste heat to treat/purify water.	Brian Dwyer [6912], Phillip Pohl [6112], and Charlie Morrow [6223]	Yes

Proposal description	Proposal developers	Awarded Funding
Oracle Equipment Tracking and Reporting Database- Improved tracking of equipment for reutilization.	Mark Smith [1930], Dorean Chleunphonh [10618	
RE-Cycling – Reclaiming the critical rare earth elements from fluorescent lights, a national need- Recycling of scarce materials	Tim Boyle [1815] et al	

3. INSTITUTIONAL TRANSFORMATION (IX) PROGRESS

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Reducing the energy consumption of large institutions with hundreds of existing buildings (national labs, city/state federal governments, school districts, military bases, industrial complexes, and others) while maintaining and improving existing infrastructure is a critical economic and environmental challenge in the US and around the world. The Institutional Transformation (IX) model integrates energy conservation strategies and collaborative decision support modeling approaches to help facilities managers at large institutions simulate different future energy reduction strategies leading to a more sustainable, optimal, resilient, secure, and low-resource-consumption future.

The IX prototype described in this document was built to allow that kind of analysis at Sandia National Laboratories in a unique collaboration between Sandia's research and development staff and its facilities staff.

The IX modeling allows users to simulate the application of different combinations of energy conservation measures (ECMs) to different buildings over different time frames while integrating projected changes to energy prices over time. For example, a user may wish to know how much total energy could be produced and at what cost by installing rooftop photovoltaic collectors on all rooftop space that meet certain characteristics, replacing windows in one set of buildings, and replacing HVAC systems in another set. The model allows users to simulate the staging of all these efforts over time, since the renovations described above applied across many buildings could take many years. The model tracks the energy savings and costs for multiple long term facilities development strategies, allowing the user to identify a preferred one. The modeling is useful for evaluating cost and benefit tradeoffs associated with competing strategies and making them clear to decision makers and other stakeholders. A schematic of the model is shown in Figure 1.

In general, this approach helps:

1. institutions identify and set energy savings goals and develop roadmaps for achieving them
2. reduce the uncertainty associated with long range facilities planning aimed at lower energy consumption, and
3. quantitatively illustrate strengths and weaknesses of competing plans.

The modeling platform integrates eQUEST (http://doe2.com/equest/) within a Visual Basic for Applications (VBA) wrapper. The IX model will allow coarse grained analysis of broad applications of energy conservation measures over 20-30 years, or fine grained analysis of ECMs applied to a single building over the course of a year, or combinations in between. The IX technology, being funded through SNL's Sustainability Innovation Foundry, is currently being applied to development strategies at Sandia National Labs.

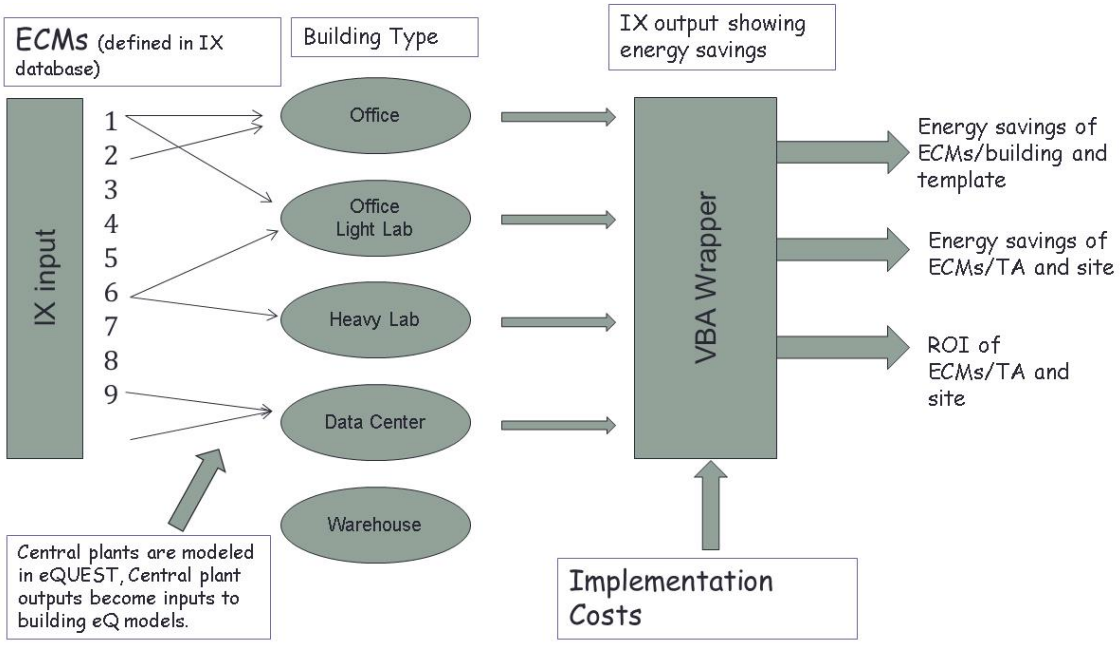

Figure 1. Schematic of IX Model

The Sandia IX model focuses on all buildings at Sandia's New Mexico and California sites with areas greater than 10,000 sq. ft. This includes 93 buildings in New Mexico and 21 in California and accounts for approximately 5.7 million square feet of building space and more than 90% of the building area at SNL. The effort breaks those building down into the following categories: Office, Office/Light Lab, Heavy Lab, Warehouse, and Semi-Conductor Fabrication Facility, Office/Data Center, Office/High Security, and Office/Warehouse, Educational Building, Cafeteria, Auditorium, and Medical.

Energy conservation measures (ECMs) include solar photovoltaics, cool roofs, wall treatments, interior and exterior window treatments, weatherproofing, occupancy and daylighting sensor, lighting, heating, ventilation and air conditions (HVAC), building automation systems, low energy appliances and office equipment, and central utility buildings.

Each of the buildings is modeled in eQUEST. The VBA wrapper allows the user to implement ECMs for different buildings in different years, and then integrates the effects of ECMs across buildings and across years.

4. ALBUQUERQUE SUSTAINABILITY ROUNDTABLE

The ABQ Sustainability Roundtable was organized by the SIF in response to considerable community interest in the accomplishments and capabilities outlined in the poster on SNL Sustainable Site Development and Operations displayed at the 2012 Sandia Research and Technology Showcase (http://www.sstp.org/showcase/posters/posters2012).

The ABQ Sustainability Roundtable brought together leaders from local businesses, universities, public utilities, local government agencies and non-profits engaged in sustainability issues in central New Mexico with the goal of increasing awareness about existing challenges and resources to help facilitate partnerships and referrals between organizations.

Roundtable participants met three times in FY13. The first two meetings, in October 2012 and January 2013, were held in the Sandia Science & Technology Park and facilitated by the SIF (agenda and notes below). These discussions enabled participants to share information about their own organizational objectives and discuss possibilities for information sharing and collaboration. The third meeting, in April 2013, included a visit coordinated jointly by the SIF and PNM to PNM's Power Operations Control Center and Prosperity Energy Project.

The ABQ Sustainability Roundtable led to follow-up conversations and information sharing between the SIF and the City of Albuquerque and Central New Mexico Community College. It also generated discussion around the conceptualization of a collaborative Windrock Sustainability Project.

Efforts are currently underway to determine and develop appropriate Roundtable gatherings for FY14.

Sandia Sustainability Innovation Foundry * Roundtable with Community Leaders
October 29, 2012
In attendance: Margaret Ochs (SNL), Howard Passell (SNL), John Soladay (CABQ), Jim Hinde (CABQ), Jon Hawkins (PNM), Diane Burke (CNM), Allan Oliver (Green Chamber), Deirdre Firth (CABQ), Jack Mizner (SNL), Jack Scherer (CABQ), Ralph Cipriani (SNL), Amy Miller (PNM), Gary Goodman (Goodman Realty), Elizabeth Kistin Keller (SNL), Tim Nisly (RGCDC)
Agenda:
3:00 Welcome and Introductions
3:15 Overview of Sandia's Sustainability Innovation Foundry
3:30 Group Discussion: Linking Sandia's capabilities with company, organization and community needs
4:00 Next Steps and Action Items
Notes:
Topic/Issue Areas:

- Resource Management
    - Energy Efficiency
    - Energy Storage
    - Smart Grid Technology
    - Demand Management
    - Energy Independence

    - Water
- Transportation/Aviation
- Facilities Management
    - City Buildings
    - CNM Buildings
    - Operations & Maintenance for Large Scale Solar

Strategies/Mechanisms:

- Information Sharing
    - Roundtables
    - TEDx-type forum
    - Site Visits
- Joint Funding Applications
    - Internal (SNL)
    - Government (city, state, federal)
    - Private
    - Non-profit
- Joint Advocacy/Policy Development
- Education/Marketing
    - Branding
    - Recruiting
- Transactional
    - Consulting
    - Technology Transfer

Other Partners:

- UNM
- LANL
- Intel
- Industry (MIOX, EMCORE)

Tasks/Responsibilities: Please review the notes and submit additional (or more detailed) ideas on the topics/issue areas this group might connect around as well as the strategies, mechanisms and partners we might employ and engage to address these issues. Please send your ideas to Elizabeth (ejkisti@sandia.gov) who will compile the submissions and share them with the group before the next meeting.

Next Meeting: Tuesday, January 3, 10-11:30

Sandia Sustainability Innovation Foundry * Roundtable with Community Leaders
January 3, 2013

In attendance: Margaret Ochs (SNL), Howard Passell (SNL), Jon Hawkins (PNM), Diane Burke (CNM), Allan Oliver (Green Chamber), Jack Mizner (SNL), Amy Miller (PNM), Elizabeth Kistin Keller (SNL), Tim Nisly (RGCDC), Jessica Rowland (UNM), Mike Hightower (SNL), Mayling Armijo (BernCo), Dan Beaman (BernCo), Ann Simon (MRCOG)

Agenda:
10:00 Welcome and Introductions
10:15 Discussion of Objectives, Expectations, Challenges and Resources
11:00 Next Steps and Action Items

Notes:

Organizational Objectives:

- Use R&D to increase sustainability within Sandia and become recognized as a leading institution in sustainability science through applications with community partners (HP)
- Identify partner institutions that enable joint grant applications and projects (MO)
- Decrease energy and resource use by 25% by 2017 (JM)
- Develop an comprehensive economic development strategy around sustainability, water and energy (DD)
- Utilize the unique R&D capabilities and location of NM to develop and operationalize resource security strategies (MH)
- Improve campus management to decrease costs while serving as living labs (DB)
- Leverage local resources and expertise to improve training for diverse set of sustainability-related customers (DB)
- Develop the partnerships, plans and actions to obtain and utilize key grant opportunities (DoL, NSF) (DB)
- Revamp and implement sustainability policy that links environmental concerns with economic development through new renewable and efficiency products, water conservation methodologies and clear and effective metrics (AM)
- Finding a way to move from ideas embodied in core values and sustainability policies to action and results through awareness, education and implementation (JR)
- Creating local sustainable economies and advance the green energy economy through policy platforms, conferences and studies/guides (AO)
- Take advantage of the new technologies and research to get new ideas and solutions for New Mexico (TN)
- Contribute to regional economic development the Ag collaborative, transportation planning, clean energy and health initiatives
- Enable the linkages and partnerships needed to utilize resources efficiently and address these issues at scale (EJKK)

Expectations for this Group:

- Identify new partners and generate joint applications and projects (SNL)
- Apply technologies developed in NM to local issues; Pull innovations into the community
- Leverage local research capabilities for strategic economic development
- Identify opportunities for connecting students with community partners (UNM)
- Serve as a resource on grants, planning and infrastructure (BernCo)
- Strengthen information sharing and the network of referrals for private companies (Green Chamber)

Priorities and Actions:

- Policy and Planning Mandate
    - Review existing memorials (http://www.nmlegis.gov/Sessions/09%20Regular/memorials/senate/SM044COS.pdf)
    - Consider drafting and supporting a Legislative Memorial mandating an economic development plan centered on resource sustainability and then participating in the study/plan

- Facilitate Information Sharing
    - Submit organization worksheets
    - Circulate existing plans and policies
    - Hold brownbag discussions/tours at different organizations

- Clarify Vision and End Goal

- Articulate the links between sustainability and economic development/jobs

- Identify Opportunities for Collaboration
  - Jointly develop criteria for grant screening from MRCOG
  - Provide more info on how research/capabilities might apply to small businesses (leverage NMSBA)
  - Utilize partners to advocate for the increased role of sustainability studies at UNM
  - Assist on existing grants/applications (i.e. CNM's NSF Sustainability Grant and DoL application) with a specific focus on forecasting, self-assessments and partnerships/action
  - Pool resources for qualified grant writers and reviewers

Tasks/Responsibilities:

- Please complete the organization worksheet and submit it to Elizabeth at ejkisti@sandia.gov. Feel free to include reports, policies etc. developed or utilized by your organization that you would like to share with the group. A compiled set of resources will be shared with the group.
- Determine whether your organization might be interested in hosting a tour or info-sharing session for the group and let us know what dates/times might be convenient for you.

Next Meeting: TBD

Sandia Sustainability Innovation Foundry * PNM Tour
April 26, 2013

In Attendance: Lisa Aldon (CNM), Dan Beaman (BernCo), Diane Burke (CNM) Ralph Cipriani (SNL), Cliff Ho (SNL), Elizabeth Kistin Keller (SNL), Carol Meincke (SNL), Jack Mizner (SNL), Tim Nisly (RGCDC) Howard Passell (SNL), Jesse Roach (SNL), Jessica Rowland (UNM), Darin Sand (Goodman Realty), Andrea Sisneros-Wichman (CNM), La Tonya Walker (SNL), Katie Zemlick (SNL)

Agenda
10-10:50 TOUR - PNM Power Operations Control Center – Get a high level overview of how highly trained grid operators dispatch and manage energy resources, including renewable energy, on the state's power grid.
10:50-11 Travel to PNM Prosperity Energy Project
11-11:30 TOUR – PNM Prosperity Energy Project – Visit the nation's first solar storage facility integrated into a utility power grid.
11:30 Lunch & Discussion at the Mesa del Sol Café

Notes
The Operations Control Center visit provided a high level overview of how highly trained grid operators dispatch and manage energy resources including renewable energy on the NM state power grid. The Prosperity Energy Project provided a view of the nation's first solar storage facility that is integrated into a utility power grid.

From the ABQ Journal, "Public Service Company of New Mexico built the facility, dubbed the Prosperity Energy Storage Project, to show how batteries can smooth out the ups and downs of utility-scale solar photovoltaic plants. That's key to making PV generation a reliable and consistent source of electricity for the grid, even when the sun is low in the sky, or when clouds are blocking solar rays.

The project, which includes a 500-kilowatt solar PV system and a 250-kilowatt battery storage system, came online in September 2011. Now, nearly 17 months later, PNM managers say it has performed beyond expectations."

5. SUSTAINABLE FUTURES LECTURE SERIES [DR. BARRY HUGHES]

Dr. Barry Hughes, Director of the Center for International Futures at the University of Denver was invited by the SIF to speak in ABQ at Sandia and also the University of New Mexico. He provided a provocative insightful presentation, "Alternative Futures for Energy Production and Consumption in the US and the World". His SNL presentation can be viewed at the following link: http://digitalmedia.sandia.gov/Mediasite/Play/ed9070925f2f429d83cc1273b58266121d.

Dr. Hughes earned a B.S. in Mathematics from Stanford in 1967 (with distinction) and his Ph.D. in Political Science from the University of Minnesota in 1970. His principal interests are in (1) global change, (2) computer simulation models for economic, energy, food, population, environmental, and socio-political forecasting, and (3) policy analysis. The fundamental concerns that synthesize these interests are (1) developing effective response to long-term global change and (2) improving the long-term human condition. He has developed International Futures (IFs), the widely-used computer simulation for study of long-term national, regional, and global issues (see http://www.ifs.du.edu/). He has supported the U.S. National Intelligence Council's reports to the President on *Mapping the Global Futures 2020* and *Global Trends 2025*, and *Global Trends 2030*, and worked on long-term global forecasting for many other national and international institutions.

The International Futures System and Project - International Futures (IFs) is a large-scale, long-term, integrated global modeling system. It represents demographic, economic, energy, agricultural, socio-political, and environmental subsystems for 183 countries interacting in the global system. The central purpose of IFs is to facilitate exploration of global futures through alternative scenarios. The model is integrated with a large database containing values for its many foundational data series since 1960. IFs is freely available to users both on-line (www.ifs.du.edu) and in downloadable form. IFs is used widely. It is central to the African Futures Project in collaboration with the Institute for Security Studies in Africa, and it was a core component of a project exploring the New Economy sponsored by the European Commission. Forecasts from IFs have supported Global Trends 2020, 2025, and 2030 of the National Intelligence Council. IF's was used to provide driver forecasts for the fourth Global Environment Outlook of the United Nations Environment Program.

Dr. Hughes presented and discussed the results of simulations on alternative energy futures composed in collaboration with Sandia National Labs Sustainability Innovation Foundry. The simulations assess 1) the potential globally-scaled environmental and economic consequences of future extraction and combustion of projected reserves of fossil fuels including shale gas and oil, and 2) the impact renewables might have on altering those alternative energy futures and their consequences. Dr. Hughes also used the model to explore alternate scenarios suggested by members of the audience.

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6. SUSTAINABILITY WATER ROUNDTABLE PLANNING AND DEVELOPMENT

The SIF participated in the planning of a workshop, ***Transformational Solutions for Water in the West,*** convened in September. This workshop, hosted by the Atlantic Council, Sandia National Laboratories, and the New Mexico Water Resources Research Institute, explored transformational ideas for mitigating water scarcity in the Western US. These concepts included technical, policy level, or both together. Current evidence suggests that incremental improvements in water sustainability being applied now around the West, such as municipal conservation, irrigation technology improvements, desalination, and water trading are not on track to close the future gap between increasing freshwater demand and decreasing freshwater availability. The urgency of this threat is increasingly evident in the steady and long term decline of important aquifers and their projected inability to provide water for future agricultural irrigation, projected declines in states' abilities to meet legal water delivery obligations between states, degradation of aquatic ecosystems and ecosystem services, and projected shortages of water for energy production. We also had the distinct pleasure to welcome Senator Tom Udall to participate in the discussion and moderate one of the sessions. This workshop explored transformational solutions to the projected future gap between supply and demand in the western US. These are solutions that will return large-scale, non-linear changes to the supply-demand equation. These solutions may come from technology, or policy, or both.

The workshop objectives were to answer the following key questions:

- What are the transformational technical and policy solutions to freshwater sustainability for agriculture, energy production, urban and rural residential consumption, industry, and the environment?
- Which transformational solutions are already being implemented? Can they be scaled up?
- Are there examples of transformational solutions being implemented with other resources? Can they be transferred to water?
- What attributes have made existing technical and policy solutions successful? What are their risks, and how can they be better managed? What are the obstacles to their implementation?
- What roles should science, industry, government, and citizens play?

We solicited abstracts for presentation and posters from the broader community of water and regulatory professionals. We looked for the respondents to spend as few words as possible framing the problem, and the remainder describing with great specificity proposed actions, solutions and results.

The results of the workshop will be documented in a joint Sandia/Atlantic Council document. Speaker presentations as well as Senator Udall's remarks and other informational materials are now available on the Atlantic Council website: http://www.atlanticcouncil.org/events/past-events/transformational-solutions-for-water-in-the-west.

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7. BEHAVIORAL CHANGE AROUND SUSTAINABILITY

Sandia set an energy reduction goal of 25% by the end of 2017 from a 2011 baseline. Technological approaches to date (e.g., occupancy sensors, HVAC modifications, metering) have already achieved reductions of 7% to date. However, to maximize energy savings potential, the approach must also address the behavior of building occupants and operators. Previous outreach efforts, consisting of typical approaches like posters, fact sheets, display kiosks, giveaways, lectures, green teams, and contests, have been largely information-based and have not achieved lasting changes in behavior. Sandia realizes that lasting change in behavior must be approached in a more reasoned, logical manner. As a result, Sandia is planning to engage an external consultant to implement a proven, systematic, approach to foster sustainable behavior across a broad spectrum of domains to reduce energy use in buildings, and process loads. Transportation energy use reduction will be a secondary goal of the project.

The project is expected to be a multi-phase, multi-year effort to support Sandia's energy and greenhouse reduction goals through 2017. Sandia envisions five steps for this project:

1. Select and prioritize the behaviors contributing to energy use.
2. Identify the barriers and benefits to each of the selected behaviors
3. Develop strategies that reduce the barriers to the selected behaviors while simultaneously increasing the behavior's perceived benefits
4. Pilot the strategies
5. Implement the strategies on a broad-scale and evaluate the success of the strategies in modifying the selected behaviors to determine the effect on energy use.

The target energy efficiency to be gained from this project is still under evaluation. However, early results from IX modeling and other facilities investigations indicate the savings can be substantial.

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8. SUSTAINABILITY SCIENCE AND TECHNOLOGY WITHIN SANDIA

Another activity of the SIF this FY has been to further develop and socialize the concept around integrating sustainability science and technology (SS&T) at Sandia toward a broader, stronger purpose. There are a number of threats to national security, including weapons proliferation, terrorism and sustainability. Sandia is currently structured to solve problems in the first 2 categories, but requires a broader vision and investment to adequately address the sustainability threat. Sandia's expertise provides unique capabilities, opportunities and responsibility to address the sustainability issues.

We define sustainability as *"the condition in which there are sufficient energy, water, and food resources, and ecosystem services to maintain peaceful and secure social, economic, political and ecological systems, without eroding natural capital. "*

Sustainability science and technology is really just science and technology focused on development of long term solutions to and strategies around the supply, demand and distribution of energy, resources, water, agriculture, human population growth, and ecosystems. Regional and global perturbations to these systems can create unrest, instability, and conflict, and ultimately national security threats. Properly applied SS&T prevents and mitigates threats to our national security.

Sandia already conducts research in many areas related to SS&T (Table 3).

Table 3. Sandia's SS&T Research

General Topic	Detail	Sandia has a role already
Energy	Fossil fuels – exploration/production	X
	Fossil Fuels - conservation	X
	Transportation	X
	Electricity generation and transmission	X
	Smart- and micro-grids	X
	Renewables	X
	Batteries	X
Infrastructure	Build infrastructure	X
Water	Treatment/reuse	X
	Conservation	X
	Management	X
Biology	Biodiversity	X
	Ecosystems	X
	Soils	X
	Disease epidemics/biosurveillance	X
Food	GMOs	
	Fisheries	

Conducting SS&T in an integrated, forward looking manner can help Sandia work toward resolving solutions for many national security issues. The following are just a few such issues:

- Reduce our dependence on foreign oil
- Increase deployment of low-carbon stationary power generation
- Understand risks and enable mitigation of climate change impacts
- Provide the foundation for a future global climate treaty
- Increase security and resiliency of the electrical grid and energy infrastructure
- Assure energy security for critical installations
- Strengthen the nation's science & technology (S&T) base in energy, climate, and infrastructure

The SS&T fits nicely with the Sandia strategic plan, which calls for

- amplifying our national security impact,
- leading the Complex as a model 21st century government-owned contractor-operated national laboratory,
- excelling in the practice of engineering, and
- committing to a learning, inclusive, and engaging environment for our people.

One approach for this new SS&T core capability is to enable it as one of the corelike competencies in the basic activities of the laboratory (Figure 2, right side).

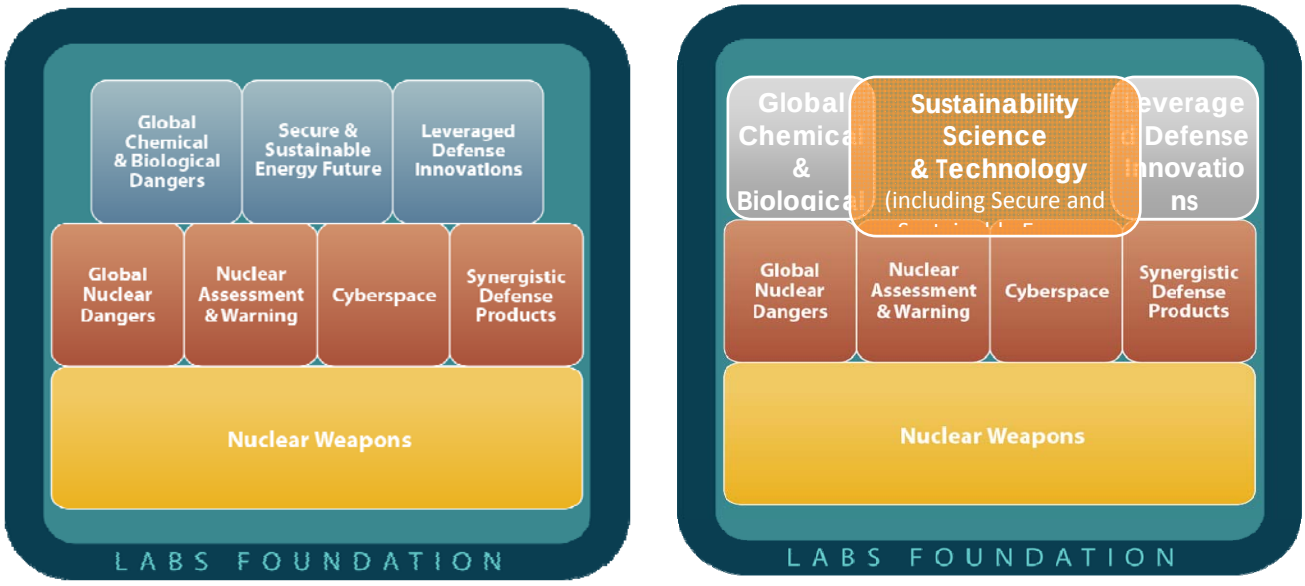

Figure 2. Core Capabilities of Sandia.

The SS&T can give broader mission and rebranding to the Secure and Sustainable Energy Future effort. The SIF effort to demonstrate the value of such an assertion of Sandia as the nation's

leading SS&T laboratory is ongoing. The effort will allow Sandia to be on the cutting edge of future national security problems around sustainability, participate in the booming SS&T business area. It will create an additional corporate identity for Sandia as the nation's leading SS&T laboratory and help to better integrate and leverage this across Sandia organizations.

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9. CALIFORNIA PROP 39

California has recently passed a new mechanism to provide funding for energy efficiency and upgrading of K-12 schools, Proposition 39. The allocation of the funding to deliver the most improvement in energy efficiency requires detailed analysis. The SIF has been developing tools for such an analysis at the SNL campus, and could provide those tools and expertise to CA schools for their evaluation.

The Challenge. Reducing the energy consumption of large institutions with hundreds of existing buildings (city/state federal governments, school districts, national labs, military bases, and others) while maintaining and improving existing infrastructure is a critical economic and environmental challenge. Effective, high impact utilization of the Proposition 39 funding can lead to substantial cost savings for the State of CA through reduced energy use. Sandia National Laboratories' Institutional Transformation (IX) work integrates energy conservation strategies and collaborative decision support modeling approaches to help facilities managers at large institutions simulate different future energy reduction strategies leading to a more sustainable, optimal, resilient, secure, and low-resource-consumption future.

The Benefits. The IX modeling will allow users to simulate the application of different combinations of energy conservation measures (ECMs) to different buildings over different time frames while integrating projected changes to energy prices over time. For example, a user may wish to know how much total energy could be produced and at what cost by installing rooftop photovoltaic collectors on all rooftop space that meet certain characteristics, replacing windows in one set of buildings, and replacing HVAC systems in another set. The model allows users to simulate the staging of all these efforts over time, since the renovations described above applied across many buildings could take many years. The model tracks the energy savings and costs for multiple long term facilities development strategies, allowing the user to select the preferred one. The modeling will be useful for evaluating cost and benefit tradeoffs associated with competing strategies and making them clear to decision makers and other stakeholders. Development of the modeling framework will be a collaborative effort between CA institution staff [e.g., school district facilities] and SNL scientists and engineers.

The Approach. This approach will:

- help CA identify and set energy savings goals and develop roadmaps for achieving them
- help reduce the uncertainty associated with long range facilities planning aimed at lower energy consumption, and
- quantitatively illustrate strengths and weaknesses of competing plans.

The IX Toolkit. The modeling platform integrates eQUEST (http://doe2.com/equest/) within a Powersim (www.powersim.com) wrapper. eQUEST development has actually been supported by State of CA funding. The IX model will allow coarse grained analysis of broad applications of energy conservation measures over 20-30 years, or fine grained analysis of ECMs applied to a single building over the course of a year, or combinations in between. The IX technology, being

funded through SNL's Sustainability Innovation Foundry, is currently being applied to development strategies at Sandia National Labs.

10. SOLAR PROJECTS WITH STARTUP TECHNOLOGY

Sandia can bring to bear significant technology and expertise to support solar projects with startup technology. In particular, this year, Sandia has gained a project grant from the California Energy Commission to work with a startup technology firm, Sun Synchrony, in moving their concentrated photovoltaic (CPV) technology toward commercialization. Sandia is providing a variety of expertise and facilities to the grant, including testing at the Solar Energy Laboratory (SEL) in Albuquerque, FMEA analysis, wind loading analysis, and general project support to the team. The Sun Synchrony team is comprised of a number of companies, creating a solid ecosystem to help bring the new, more efficient technology further toward commercialization.

The project is for 21 months, with a total funded budget of $475,000, and matching funds from the other teammates of $325,000. The project will further develop, prototype, and field test the Sun Synchrony CPV module and its' tracker. Project goals include placement of test modules at the SEL for shortterm testing, as well as placement on a local community college rooftop for testing and educational purposes. Ultimately, there may also be modules placed on the Livermore campus for additional testing. The technology is expected to be significantly more efficient than existing solar flat panels, and have a smaller infrastructure footprint, providing a potential new cost-effective solar energy solution for buildings.

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11. FACILITIES ENERGY REDUCTION OPERATIONS

One of the primary aspects of the SIF is integrating facilities organizations with research organizations within Sandia. As such, there is a synergy around the facilities efforts to reduce the energy utilization at Sandia. The goal is a 25% reduction by 2017, from the FY11 baseline.

For FY13, the effort has produced tremendous improvement. The 3.6% reduction in energy intensity in FY13 produced a savings of 29.8B btus/year. There were a number of activities that led to this savings (Table 4). The biggest savings resulted from the conversion of multiple buildings to full digital controls.

Table 4. FY2013 Facilities Energy Reduction Projects

2013 Projects	Annual Budget	Savings (btu's/yr)
Install lighting/HVAC Occupancy Sensors (6587, 811, 758, 1090, 752, 971)	$240,000	2.8 B
Convert Buildings to full digital control (C907, C941, C914, 897, 890, 891, 886, 856)	$5,154,000	16 B
HVAC and Chiller projects	$471,000	6 B
Energy audits/retro-commissioning –Building Tune-ups	$315,000	5 B
Institutional Transformation (IX) -ECIS Collaboration (Energy Efficiency via Simulation)	$575,000	Best in Class
Sustainable Innovation Foundry (ECIS collaboration to address and integrate sustainability with mission work) – Sustainable Science and Technology: 40-70% of ECIS budget.	$50,000	Investment in the Future
Training and Awareness	$15,000	
TOTAL	$5,820,000	29.8 B

The efforts to achieve the Sandia energy reduction goals are ongoing. FY14 will see additional investments toward many similar activities in other buildings at the institution. The challenges lie in determining creative methods/technologies to reduce the baseload use of approximately 26000 kW/day. Modeling studies utilizing the IX tool have and will continue to support identification of these solutions. Consideration of significant changes to operations and maintenance could produce dramatic reductions. Likewise, support from the research community and modification of their usage behaviors are expected to produce significant gains in the quest for energy reduction and sustainability.

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12. SUMMARY

The aim of the Sustainability Innovation Foundry is to provide a focus for activities at Sandia in the sustainability science and technology area. The SIF has had a number of initiatives toward that end in FY2013. The key activities have been highlighted in this document. One of the short term real impacts is to affect staff and community members and their thinking about sustainability, as well as the plans and ultimate energy use at the institution.

The idea generation challenge produced a number of useful ideas, and, thus far, one has received further funding.

Additionally, several activities are ongoing, and expected to further impact the energy use and sustainability of the institution. The IX modeling project will continue to aid in developing plans for and implementing energy saving modifications at the site. The Prop 39 initiative will take forward some of these tools for utilization in the State of CA. The proposed repackaging of the SS&T research at Sandia is being discussed and debated. The value proposition for that change appears very positive, but requires leadership at a senior level. The facilities directed work to reduce energy on-site is seeing significant savings, and looks to have even more savings in the coming years. FY14 looks to be another positive year for the SIF initiative, as we seek to grow Sandia's role in sustainability and help to meet the nation's security challenge in this area.

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13. REFERENCES

1. Tranformational Solutions Workshop materials: http://www.atlanticcouncil.org/events/past-events/transformational-solutions-for-water-in-the-west

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APPENDIX A: IDEA CHALLENGE PROPOSALS

Number	Proposal description	Proposal developers	Awarded Funding
1	RE-cycling – Reclaiming the critical rare earth elements from fluorescent lights, a national need- Recycling of scarce materials	Tim Boyle [1815] et al	
2	Oracle Equipment Tracking and Reporting Database- Improved tracking of equipment for reutilization.	Dorean Chleunphonh [10618], Mark Smith [1930]	
3	Water treatment using membrane distillation and waste heat- Use waste heat to treat/purify water.	Brian Dwyer [6912], Phillip Pohl [6112], and Charlie Morrow [6223]	Yes
4	Sequestration and separation of carbon nanostructures from flue gas exhaust- Air discharge purification technology development.	K. Hattar (01111), T. Beecheem (01114), P. Feng (08131), and C. Tomlin (04822)	Yes
5	Adaptive HVAC Operation for Improved Energy Sustainability at Sandia- Application of information technology to improve efficiency of energy delivery systems.	Kevin Hulin [8136]	
6	Ecological Solvent Recycling for Automated Chromatography Systems: A Green Chemistry Innovation - Solvent recycling approach for chem labs	Greg O'Bryan [8223]/Mitch Anstey [8125]	
7	HSB Footprint: Space planning for SCIF areas	Amber Romero, 5600	Yes
8	Sandia National Laboratory partners with the US Air Force to site, procure, and license the first Small Modular Reactor (SMR) in the desert southwest- Facilitate development of small modular nuclear reactors.	David Wheeler	

RE-cycling - Reclaiming the critical rare earth elements from fluorescent lights, a national need.

Timothy J. Boyle (1815), Ryan Hess (1716), Timothy N. Lambert (6124), Bernadette A. Hernandez-Sanchez (1815), William Sweat (1535), and Samuel McCord (4144)

China is the only commercial source of rare earth (RE) metals/oxides - producing 97% of the RE-oxides – and has recently have placed unwarranted restrictive export policies on these materials. This has led the US Congress to declare the REs as 'national critical materials'. Since the US supply of RE ores is vast, efforts are underway to re-start the mining of RE materials in the US; however, based on the most optimistic estimates, the opening of these RE-mines is a few years away (with 10 yrs being the accepted timeline). Whenever US mining of RE ores does begin, the mines yield RE-oxides and *no* industries are currently available in the US to convert these to the desired purified metals. Therefore, the US is vulnerable and could suffer a critical supply shortage of RE elements. One obvious but overlooked answer to this critical problem is to recycle the RE materials (RE-cycle) that are currently employed in a wide number of applications such as in wind and marine hydrokinetic energy devices, electric vehicles, and computer memories. Currently, only 1% of the RE-containing consumables are recycled worldwide. Recently, several international companies have initiated programs to recover this lost revenue. For instance, Honda (Japan) just announced that key materials for their hybrid automobiles (which include RE oxides) would be recycled. Additionally, Rhodia (France) has begun to reactivate its production plant to recover Tb and other RE elements from magnets. The typical RE-cycle effort employs a modified 'PUREX' processing that uses tributyl phosphate as the main extracting solvent. This is a 'brute-force' method that generates a substantial amount of hazardous waste.

Therefore, we propose to develop an improved RE-cycle process that will avoid this costly and inefficient solvent extraction process currently employed. Due to their widespread used, we will focus on recovering the RE materials used in fluorescent light bulbs. For perspective, over the past two years, Sandia alone has generated 8700 kg of fluorescent lighting waste that totals to a loss of nearly $900,000 worth of RE materials. In addition, SNL pays to dispose of this so-called hazardous waste. Our approach will combine organic chemistry, inorganic coordination chemistry, and laser physics to recycle the RE materials. When successful, we will have developed an environmentally friendly and economically viable method to separate the individual RE elements from fluorescent lamp phosphors that will be applicable to other systems (a.k.a., Nd-Fe-B magnets or batteries).

The success of this effort will RE-move our dependence on China's supply chain, advance the field of RE chemistry, improve speciation of the RE elements, and further the RE-cycling of other RE-containing products at SNL and nationally to a point where commercial industries can employ this process. Locally, we have been in discussion with the head of the New Mexico Recycling Coalition concerned about RE-cycling in NM. She was very enthusiastic about our ideas for separating RE elements and ensured her support in helping us partner with business leaders as our process progresses matures. Nationally, several avenues that would support the fundamental RE-cycle efforts proposed here are preliminarily available. In particular, the Department of Defense, Department of Commerce, the Office of Science and Technology, the Department of Energy, and Department of Interior have demonstrated an interest in addressing the RE risks. Furthermore, the 112th US Congress has presented a bill (S. 1113, sec. 106 RECYCLING AND ALTERNATIVES) that calls for the formation of a program/center on RE-cycling. The RE-cycle science proposed here will establish Sandia and thus the US as a 'green' global leader allowing us to sustain a reliable RE-supply of the economically critical RE materials.

Abstract for the SIF SNL Sustainability Challenge: November 5, 2012

Title: Oracle Equipment Tracking and Reporting Database

Involved SNL staff and departments:

- Mark Smith, Senior Manager, 01830
- Dorean Chaleunphonh, Business Management Professional, 10618
- Lynnwood Dukes III, Senior Manager, 10260
- Diana Goold, Manager, 10264
- Shannon Letourneau, Business Systems Analyst, 10269
- Department 09542

Potential funding source:
??

Problem:
Currently, Oracle tracks property that is above $10K or is considered "attractive." The tool does not yet have a data-entry or a reporting feature that allows individuals to lookup types of equipment, designate the status of equipment, or query the status of a particular item. What if there was a mechanism or feature within Oracle to communicate equipment needs and/or equipment availability across Centers and/or Divisions?

Proposed solution:
After completing a self-assessment on lab space within Center 1800, it became apparent that a tool would be useful in tracking capital equipment (and non-capital equipment). An extension of that tool would be to communicate when a piece of equipment was no longer being used due to a project ending or if a piece of equipment was not going to be used for a period of time (e.g., the next 6 months). This type of information would be useful in sharing equipment across Sandia. We think there is potential in expanding the Oracle Property database to include fields that capture capabilities that equipment supports, better descriptions and titles (or keywords to make for easier searching), and other fields (e.g., type of lasers, microscopes, etc.) that would allow personnel to query what type of equipment is kept at Sandia and to learn about other items/capabilities that can be leveraged between departments, Centers, and Divisions.

This abstract is to propose the use of Center 1800's equipment inventory in the development and testing of the Oracle query database.

Impact:
Improving the Oracle Property database would create a tool that not only tracks equipment but also creates a search and reporting option for individuals to query what equipment is available throughout Sandia and if that equipment is currently being used, stored, available to borrow, or is on its way to reapplication.

If funding is received to improve Oracle's Property database, the outcome would be the development of a reporting mechanism that can be accessed all Sandia personnel (e.g., something similar to the PO or PR Query) to track and view equipment (capital and non-capital). This would impact cost by potentially reducing the purchase of duplicate items, by better leveraging capabilities throughout Sandia, and by improving reporting on capital equipment to monitor recapitalization rates and maintenance of capabilities within Centers.

Title: Water Treatment Using Membrane Distillation and Waste Heat

SNL Staff Involvement: Brian Dwyer, Org. 6912, 845-9894
Phillip Pohl, Org. 6112, 844-2992
Charlie Morrow, Org. 6223, 8450694

Potential Funding Source: Environment and Renewables
Electric Power Research Institute (EPRI)
3420 Hillview Avenue, Palo Alto, CA 94304

SIF Project Description:

A recent joint study (Sandia and NETL) by the proposed Sandia Staff assessed the feasibility of using power plant waste heat to treat impaired water via membrane distillation (MD). The study concluded that two waste heat locations (boiler blow down, and cooling water loop) within a coal fired power plant can provide an ideal energy source for the MD process with the potential to produce 3670 gpm of distillate quality water in a 550 MW coal-fired supercritical steam power plant. [3]

Implementation at SNL:

Proposal Tasks:

1. work with Facilities Engineering to identify the largest waste heat sources within the laboratory building complex and the proximity to a cooling tower,
2. evaluate/model (model already built) potential to use MD coupled with the waste heat source to treat the cooling tower blowdown and/or a side-stream from the cooling tower, and
3. Estimate the cost of implementation at pilot scale.

Proposal Objectives:

1. Increase the Cycles of Concentration for the cooling tower selected,
2. Save water, and
3. Evaluate scale-up potential/issues.

Implementation Beyond SNL:

Continue work with EPRI and NETL on implementation of MD at pilot scale in a power plant. This will include expansion of the model to include full economic estimating capability for equipment.

Thermoelectric systems account for almost 90% of all power production in the United States, which consume large quantities of water through cooling tower evaporation and blowdown [2]. Values ranging from 370 to 595 gallons of raw water use per megawatt-hour (MWh) of electricity are estimated depending on the type of fossil power plants [3]. Reduction of raw water usage has become a top priority for the power plants as concerns over water availability, watershed protection, and increased energy demand are increasing

throughout the country. Advanced technical solutions for reducing the raw water use within existing power plants are explored to decrease the water and energy footprint for the power generation cycle.

Membrane distillation (MD) technology is ideally suited to use the latent energy from waste heat to drive this unique membrane separation process capable of treating a wide range of non-traditional water sources (e.g., saline groundwater, boiler blow down, oil and gas production water, municipal/industrial produced water and seawater).

Technology Background:

Membrane distillation is a thermally driven process that involves a vapor stream passing through a hydrophobic membrane. The difference in vapor pressures between the hot feed side and the cold distillate side induces a vapor (permeate) flux across the membrane. Figure A-1 shows the driving force for such cross-flow based on the vapor pressure curve of pure water [1]. The overwhelming advantage of a membrane distillation process over other water treatment methods is its low operating temperature and pressure. Traditional distillation processes require temperatures at or above the boiling point of the feed stream (or 212 °F or higher for water). Membrane distillation units, on the other hand, are constrained to operate below water's boiling point. The potential benefits of MD are the production of high quality water for cooling tower and boiler makeup using relatively low-value heating streams [4].

The major advantage of MD over conventional water treatment technology such as Reverse Osmosis (RO) is that low grade thermal waste heat (available within Sandia and in power plants worldwide) can provide the energy necessary to drive the process; whereas, RO requires additional energy input .In an ideal membrane system no heat would conduct across the membrane, but in reality the ideal membrane is one which acts to insulate or limit the heat transfer from the hot to the cold stream best; thereby, maximizing the difference in temperature of the two streams. Commercially available membranes are so thin that sensible heat transfer becomes unavoidable. In this process, removal of excess heat through conduction is another advantage of MD since the unit acts as both a heat exchanger and a water purifier.

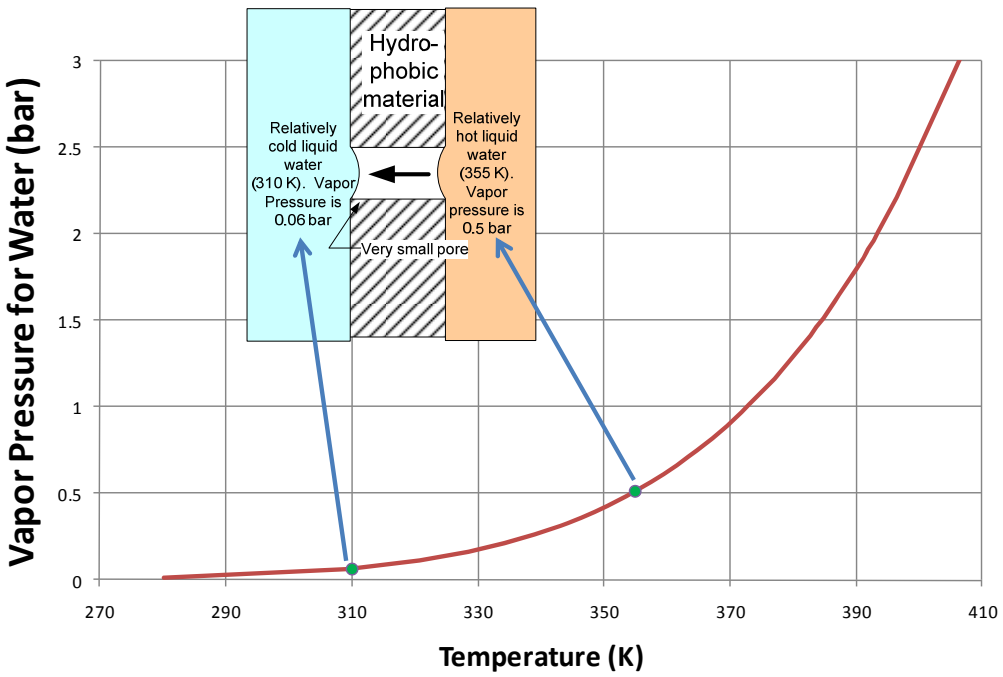

Figure A-1: Schematic of Membrane Distillation Unit Operation

REFERENCES:

1. Morrow, C.W., B.P. Dwyer, S.W. Webb, and S.J. Altman, "Water Recovery Using Waste Heat from Coal Fired Power Plants," Sandia Technical Report SAND2011-0258, 2011.
2. Power Plant Water Usage and Loss Study, Prepared for The United States Department of Energy National Energy Technology Laboratory, August 2005, Revised May 2007.
3. United States Department of Energy National Energy Technology Laboratory. (Revised 2007). Power Plant Water Usage and Loss Study.
4. M. S. El-Bourawi, Z. Ding, R. Ma, M. Khayet; *A framework for Better Understanding Membrane Distillation Separation Process*; Journal of Membrane Science 285 (2006) 4–29

Sequestration and separation of carbon nanostrucutres from flue gas exhaust

K. Hattar (01111), T. Beecheem (01114), P. Feng (08131), and C. Tomlin (04822)

Potential funding: A variety of calls within DOE and DOT.

Proposed Idea and implementation:

We seek to sequester the toxic and cancerous components of flue-gas exhaust while simultaneously isolating high profit carbon nanostructures (e.g., graphene, carbon nanotubes). Specifically, we will target soot, a natural by-product of combustion produced by everything from domestic fireplaces and diesel trucks to power plants. Soot is associated with a variety of adverse health effects including respiratory illness, cancer, and heart attacks. On a molecular level, soot is composed primarily of carbon that forms due to the incomplete combustion of fossil (i.e., hydrocarbon) fuels. Previous effort has identified that within the carbon are highly sought after nanostructures such as nanotubes, buckyballs, and graphene. [1] In high demand due to their attractive properties and the difficulty inherent in their synthesis, we aim to "harvest" these valuable nanocarbons in order to make the filtering of polluting flue-gas a more cost-neutral effort.

To assess viability, a test site at Sandia will be developed to sequester the soot found in common flue-gas exhausts; a mature but often under-utilized technology due to the associated cost. The soot will be introduced into a colutron accelerator to separate the carbon species based on mass and charge using techniques developed during World War II for isotope separation. Verification of the accelerator's filtering capabilities will take place rapidly using Raman spectroscopy, a technique not only capable of determining the types of carbon present but also their quality. As such, the Raman technique will be leveraged in both identification and as a method to assess the relative market value of the carbon structures acquired. If successful, this system will be optimized for other common flue-gas exhausts and implemented at other facilities inside and out of Sandia. Ultimately, success will be based on not only acquiring high value nanocarbons from flue-gas "waste" but also in assessing the potential scalability of the approach through a comparison of the costs of sequestration, separation, and identification to that of the market value of the nanocarbons acquired.

[1] Murr and Soto; "A TEM study of soot, carbon nanotubes, and related fullerene nanopolyhedra in common flue-gas combustion sources"; Material Characterization 55(1) 2005; pg. 50

Sustainability Challenge Abstract

Title: Adaptive HVAC Operation for Improved Energy Sustainability at Sandia

Staff: 8136 – Cyber Physical Systems

Funding Sources: Through this research, we would be eligible to apply for grants through the DOE, NSF, as well as industry. We could also increase our funding eligibility through a partnership with the LoCAL lab at UC Berkley who has published recent research in the realm of cyber-physical systems and their applications toward sustainable energy.

Description: Sandia strives to provide its employees with a comfortable working space while simultaneously being a good steward of the environment and of government resources. To this end, Sandia depends heavily on its Heating, Ventilation, and Air Conditioning (HVAC) systems to provide climate control that meets its business needs without being wasteful. Unfortunately, older HVAC systems are largely unaware of their environment or actual needs and operate by crude heuristics such as timers, schedules, and manual input. In order to promote responsible energy use, these systems must be made able to adapt to the changing environment and operation needs.

The melding of information systems with industry infrastructure is not new and has been the focus of work for example at UC Berkeley and its LoCal lab. However, such efforts suffer from limited experimentation with industry scale environments.

We propose implementing a multi-sensor network that provides feedback to a central climate control and building monitoring system. This system would be able to make intelligent decisions about when and to what degree HVAC operations should take place. This system would be made up of multiple sensors as well as network interfaces and would bridge the gap between physical infrastructure and cyber modeling. The sensor network may include, for example:

- Climate sensors to determine the actual temperature and humidity of a room
- Motion detectors to determine whether people are present and to monitor the number of occupants within a space
- Computer monitoring interfaces to identify hardware that is operating at high power usage and may be prone to over-heating
- Internet interfaces to obtain weather forecasts

Melding legacy infrastructure with information age modeling and analysis promises significant cost savings but requires a wide range of fields. With our unique mix of embedded systems, control systems, mechanical, electrical, and computer engineers and expertise in intelligent systems, the cyber-physical systems group is uniquely poised to address these challenges.

By networking sensor systems, enhanced capabilities can be added in software. For example, using the same sensors installed for environmental monitoring, security can be enhanced by monitoring the number of occupants of a room or vault and automatically reminding the last occupant to perform closing procedures.

Ecological Solvent Recycling for Automated Chromatography Systems: A Green Chemistry Innovation

Greg O'Bryan (08223) and Mitch Anstey (08125)

Chemical research and development inevitably requires a form of purification such as distillation crystallization, precipitation, or chromatographic separation. The most applicable method is chromatography due to the versatility, separation resolution, and high recovery yields of the process. Technological advances have made automated chromatography systems affordable and increasingly more common. Such systems provide enhanced throughput and productivity, but these benefits come at the price of high volume solvent usage.

Typical solvents utilized in chromatographic separation include hexanes, ethyl acetate, dichloromethane, chloroform, ethanol, methanol, and acetone; with hexanes and ethyl acetate being the predominant solvents of choice. Following purification, solvent is distilled to concentrate collected fractions and isolate components of interest. The solvent is recovered during this process and as a result large quantities of nearly pure solvent are collected. Ideally this solvent would be re-used for future chromatographic separations, but the azeotropic mixture of hexanes and ethyl acetate recovered from this process does not meet the solvent ratio required for high-resolution separations. Therefore the nearly pure and still potentially useful solvent is sent off for disposal. An article recently published in the journal *ACS Sustainable Chemistry & Engineering* looks at potential substitute solvents to replace the ubiquitous hexanes-ethyl acetate system.[1] The authors found that a heptane-acetone system yielded the best separation results while also being efficiently recycled via fractional distillation. A major advantage of this solvent system is the replacement of hexanes with heptane. Hexane is a volatile solvent categorized as a hazardous airborne pollutant (HAP) in the United States. Workers under repeated exposure to hexanes are subjected to a metabolite that is known to be a harmful nerve toxin. As a replacement solvent heptane has a lower toxicity and volatility, and is considered to be an environmentally friendly alternative.[2] Replacement of ethyl acetate with acetone does not impose any negative restrictions, as both solvents have a low toxicity and do not pose any environmental hazards.

We propose to expand our current auto-chromatography workstation to include a second system that operates solely with heptane and acetone as the eluents. This system will be supplemented with a fractional solvent distillation system to allow efficient solvent recycling. This equipment will have the effect of diminishing chemical purchases, inventory, and disposal costs while mitigating operator exposure and environmental impact. An estimated cost savings on chemical purchases and waste disposal equates to $1k per month (based on an average monthly solvent usage of 12.5 L). Applying the fractional distillation equipment to recycle acetone from rinsing parts and glassware will double the cost savings and further diminish environmental impact. This system will be easily implemented, does not require facilities upgrades, and other than the initial purchase of solvents and equipment does not impose any additional operating costs.

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[1] Drueckhammer, D. G., Gao, S. Q., Liang, X., & Liao, J. (2012). Acetone–Heptane as a Solvent System for Combining Chromatography on Silica Gel with Solvent Recycling. *ACS Sustainable Chemistry & Engineering*, doi:10.1021/sc300044c

[2] Alfonsi, K., Colberg, J., Dunn, P. J., Fevig, T., Jennings, S., Johnson, T. A., Kleine, H. P., et al. (2008). Green chemistry tools to influence a medicinal chemistry and research chemistry based organization. *Green Chemistry*, *10*(1), 31. doi:10.1039/b711717e

All Sandia) Call for sustainability innovation abstracts: Facilities Management and Operations Center Dept. 4800 is soliciting one-page abstracts for ideas and research suggestions to improve energy, water, and materials sustainability at Sandia. More information about Sandia's sustainability efforts is available in this month's Watercooler. Facilities may immediately implement a great idea. Selected abstracts will be awarded $1-$5K to develop full proposals for additional funding. More information about submitting your abstract is available here.

Title: HSB footprint

One of the challenges faced by Facilities in conjunction with the proliferation of iWFO activity is the ever-increasing need for SCIF/HSB space. Buildings MO 324 and MO 325 are a good example of this type of space having been planned, executed, and delivered under extreme schedule pressure, to meet the needs of Center 5600 and others. These types of new facilities increase our overall footprint and increase the overall water, energy, and materials requirements. In some cases Facilities has been able to retrofit existing facilities… but are we, for example, in 5600, doing our part to keep space efficiency at its peak?

We would like to be considered for funding to plan a pilot project in double-bunking and hot swap within our existing SCIF facilities.

> Double-Bunking: reconfiguring a 1 person office into a 2 person office, or a 2 person office into a 3.
>
> Hot Swap: Sharing offices by coordinating specific use times between two or more individuals, like a kiosk but with fixed users. Many of our employees spend a good deal of time in project rooms and labs which makes this something that could be investigated.

It is unclear to us whether the advantages of these techniques will outweigh the disadvantages. The seed money would be used to develop a detailed approach to this, including:

- Feasibility with respect to square footage and furniture and computing space
- Impact to the morale of employees
- Impact to productivity levels
- Timeline and deployment plan
- Office configuration sketches and proposed layouts
- Proposed approaches for managing the space in terms of physical occupancy especially in the case of Hot Swapping

Depending on the impact and value assessment from the proposal, and funding, we would potentially execute these re-configurations, resulting in optimizing the overall footprint of SCIF space.

SNL staff/departments: Center 5600 Space Committee members including members from business team 10656.

Title : Sandia National Laboratory partners with the US Air Force to site, procure, and license the first Small Modular Reactor (SMR) in the desert southwest. (Future Headline)

Small Modular Reactor technologies are rapidly gaining support in the energy sector with a wide variety of commercial companies proceeding with NRC licensing and full lifecycle designs for providing electrical power of quantities less than 500MWe. The various design proposals for SMR's typically range anywhere from 25MWe to 250 MWe depending on the technology and the approach to modularization. Given that many of the commercialized target dates are in the early 2020 timeframe, it is imperative that Sandia Labs take a leading role in engineered support, development, and testing where feasible and also lead the way as a user of the technology to support the long term needs of the Labs, the Department of Defense, and the nation.

Sandia currently has the technical competency across a wide range of disciplines to engage in these new SMR concepts to bring about a functional unit to supply energy needs to this New Mexico lab and the Kirtland Air Force base. Given the vast amount of land available, the ability to competently assess these technologies, and the needs for electricity of future facilities in the Technical Area V area, investing now in siting and constructing an SMR facility onsite will meet the needs of Sandia's mission and demonstrate forward thinking leadership for the community at large.

Currently there are SMR company partnerships occurring with Savannah River Site (SRS) with a DOE grant of $450 Million to support licensing and commercializing these technologies. Sandia should play a similar role for the western portion of the United States and demonstrate the safety, security and sustainability that these technologies will provide for the energy needs into the future.

To engage in this long term project, strong executive level leadership will be required to establish an SMR futures office at SNL to appropriately explore this vision and ensure effective integration of competencies across divisions 1000, 4000, 6000 (at a minimum). Also by engaging early in the SMR design lifecycle, Sandia will be able to engage with the US Air Force and optimize the investment structures to invest in on site SMR's while allowing for better risk management for both the DOE and the DOD with respect to optimizing project costs and long term energy investment return to the site and the community.

Sandia should be a leader in the application and engineering competencies associated with SMR technologies and by formally engaging now, we can provide not only energy sustainability, but long term energy efficiencies by reducing the overall O&M costs associated with energy useage over the next 50 years at Sandia and Kirtland AFB.

Distribution

1	MS0924	Jack Mizner	04853
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