New Brunswick Strategic Planning Proposal

Proposal Title: Rutgers Alternative-fueled-Vehicle EcoSystem (RAVE)

Proposal Initiator: Dunbar P. Birnie, III

Primary Contact Name and Phone Number:
Dunbar P. Birnie, III; Professor, Materials Science and Engineering; (848) 445-5605

Primary Contact Email Address:
dunbar.birnie@rutgers.edu

Primary Strategic Priority/Foundational Element/Integrating Theme Addressed (Select one)

_X_ Envision Tomorrow's University
__ Build Faculty Excellence
__ Transform the Student Experience
__ Enhance Our Public Prominence
__ Strong Core of Sciences and Humanities
__ Inclusive, Diverse, and Cohesive Culture
__ Effective and Efficient Infrastructure and Staff
__ Financial Resources Sufficient to Fund Our Aspirations
__ Robust Shared Governance, Academic Freedom, and Effective Communication
__ Cultures, Diversity, and Inequality—Local and Global
__ Improving the Health and Wellness of Individuals and Populations
__ Creating a Sustainable World through Innovation, Engineering, and Technology
__ Educating Involved Citizens and Effective Leaders for a Dynamic World
__ Creative Expression and the Human Experience
__ Measuring Progress and Defining Success

Proposal Abstract:

Rutgers University should take measures that establish us as the central focus of a regional ecosystem promoting green transportation. We have the opportunity to be first in the nation at expressing and demonstrating a vision for changing our fuel-use habits for commuter transit, fleet usage, and impacting public transportation and public health. Making this a visible program would provide a platform for new technology development, social and policy studies, business development, lowering environmental pollution and influencing the citizens of our highly congested state. Recent studies examining fuel efficiencies and carbon loads for electric transportation show that dramatic improvements can be made – though the way to get there has not been mapped out. A number of recommendations are made that can inexpensively assist in helping to shift our regional fuel usage patterns and help make Rutgers a highly-visible leader in the design, operation, and strategic implementation of such systems. These recommendations are extremely low cost compared to their value in demonstrating our environmental stewardship. In addition, there would be many additional associated opportunities to accentuate the Living Learning Laboratory that Rutgers aspires to create more broadly. The team members listed below come from many fields within the university and are committed to participating in this transformation, and developing the cross-disciplinary collaborations that can result and grow in influence with time.

Full Proposal Description

Introduction

Many discussions about the possible pros and cons of electric transportation fall back on gut instincts and worries about the carbon footprint of the electric generation side of the picture. The electricity needed must *certainly* be generated somewhere and with some kind of fuel. Using US Department of Energy data on the energy usage for the entire country in 2012 (**Figure 1**) we can see that coal, natural gas, and nuclear are the most significant contributing sources of energy for electricity generation, but each is known to have significantly different carbon-footprint contributions. Further, it comes as no surprise that there is significant regional variation in the fuel-mix used for electricity generation – and that would then influence the net carbon-footprint for electric transportation on a regional comparison basis. The Union of Concerned Scientists has done a close analysis of the regional variations in electricity generation mix and applied that to electric vehicle transit efficiency[2]. **Figure 2** shows their quantification, where darker regions have higher carbon-footprint electricity generation and lighter regions have more renewable generation. Even in the highest footprint regions (dark blue) the EVs are better than a substantial majority of gasoline powered vehicles currently on the market. In the light blue regions EVs are *substantially* better than their conventional cousins. For New Jersey specifically, a gasoline vehicle would have to get 64 MPG to be equivalent to typical EV travel! So, in round numbers for our region, EV transportation provides perhaps a ~50% reduction in carbon-footprint, depending on which gasoline vehicles are replaced (and for many cases results in a much better reduction than that).

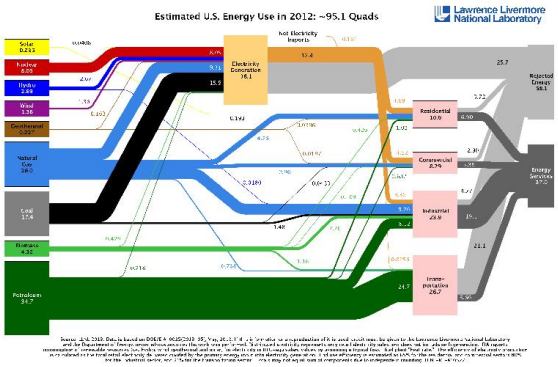

Figure 1: Energy use flow chart for the US in 2012[1]. Energy sources are shown at left; consumption is at the right. Transportation used about 26.7 quadrillion BTUs (about 25% of the US energy consumption), most of this derived from petroleum. Electricity generation is both consumer and supplier in the energy flow diagram.

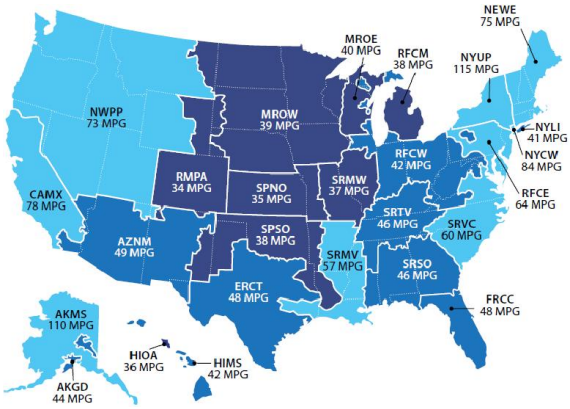

Figure 2: Equivalent gasoline mileage (miles per gallon) required to match typical EV travel environmental impact on a per-mile carbon footprint basis [2].

A further and important aspect of the future electric transportation effects relate to societal aspirations that our electricity generation move toward increasing fractions of renewable generation as we move forward. Again referring to the Union of Concerned Scientists analysis [2] (based on 2012 regulations) we find that many regions have set regulatory goals for the generation mix. **Figure 3** (next page) shows these regional goals, which together will be making electric transportation more environmental with time, even for vehicles that are put into service now!

To summarize this section, electricity can be generated in many ways, but it provides one of the few energy forms than *can have nearly zero carbon footprint*. And, while the change will likely be gradual, the direction of change is clear. Electricity has the added advantage of versatile usage – including for transportation, and the improvements in battery and vehicle technology seem poised

to provide the marketplace with increasing choice as every major car manufacturer has options in the realm already.

What is Being Proposed

To facilitate an intensive, forward-looking, and busy local EV user community – and the studies, education and outreach on this topic – a number of specific recommendations are being made. Some of these are dependent on modest investments in our infrastructure beyond our current practice. Others depend on choices and fund raising beyond the scope of our current spending. In a broad overview we recommend:

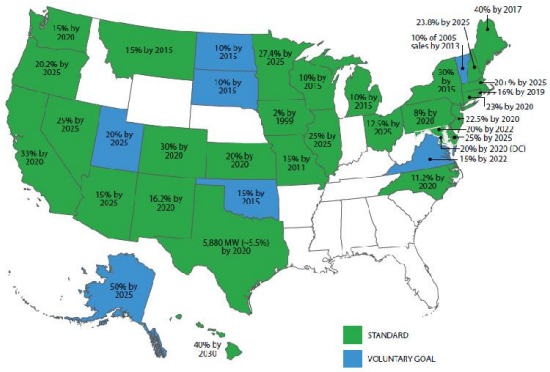

Figure 3: Renewable electricity milestones by region, highlighting the future continuing reduction of the carbon footprint ascribed to electricity generation [2].

1) Assertively install EV charging infrastructure and encourage its utilization by the Rutgers community of faculty, staff, and students,
2) Engage in research that builds on the high accessibility of charging infrastructure and expertise,
3) Coordinate education and outreach related to energy usage, planning, and its implementation, and
4) Participate in local economic development allied with innovation in these areas.

As noted above, these are all interconnected in a multitude of ways, and are limited only by the imagination. Within these areas, though, some specific recommendations are given below that may provide guidance in ways to ensure the highest impact for the smallest investment.

<u>Installation Strategies</u>

5) Work to provide plentiful access points for plug-in charging. Install more than what the present usage would require. Concentrate on active construction projects and plans*,
6) Provide electricity at no charge to users within the Rutgers community. The electricity value is *very* small compared to the value of promoting a large community of users, the environmental savings, and the visibility and outreach that this develops.
7) High rate DC charging is not necessary. Basic, sturdy units will be sufficient; authentication of users is preferred as usage data are valuable for education and research purposes.
8) Installation locations should facilitate multi-user sharing/swapping. This can be done in parking situations like the Livingston array, but where opposite rows of parking pull in nose-to-nose.
9) Installation locations can incentivize EV users to otherwise less appealing spots easing the parking density pressure often felt in congested parking lots.
10) Encourage additional usage for Rutgers fleet/facilities vehicles.
11) Coordinate EV charging with close access to campus bus routes, bicycle sharing, bike racks, and bike storage to encourage a synergistic usage of EVs and bicycles.
12) Actively seek project-based co-funding to expand the EV charging infrastructure.

* As a regional comparison/baseline, New York City recently adopted a rule that 20% of new parking construction must be readied for EV charging. See one recent web article: http://www.plugincars.com/new-york-requires-lots-and-garages-be-built-ev-ready-129063.html

Research Efforts

1) Provide easy access to data from Rutgers installations and encourage the use of system data as it may apply to technology advancement and research goals.
2) Encourage collaborations with other institutions studying electric transportation, vehicle battery usage (for example "Vehicle-to-Grid" and "Vehicle-to-Building" studies),
3) Encourage local studies of user populations and their interactions with the infrastructure, including changes in commuting habits and energy usage habits.
4) Encourage partnerships with equipment manufacturers (vehicles, inverters, data systems, EV charging equipment, etc).
5) Couple the infrastructure with other modes of transportation and engage in studies related to those synergies.

Education Efforts

1) Encourage curriculum development in advanced energy, environmental, policy, and engineering studies.
2) Encourage student support to study transportation and energy issues of relevance to our local university situation and the region.
3) Let our sustainability vision and behavior serve as a model for other New Jersey large employers who would learn from our efforts and follow suit.
4) Consider extending the free plug-in access to all who come to campus. The cost is not large and the ambassador value might be large.
5) Couple our research and education happening at the university with high-school programs (for example the Governor's School for Engineering and Technology).
6) Couple the education and research efforts to other eco-initiatives: bicycle sharing, employee health efforts, etc.
7) Recognize the diversity of populations served by the Rutgers campus including a wide range of distances travelled to campus, economic means, and widely varying schedules. These populations have different parking and on-campus travel needs. This could ultimately reduce on-campus congestion and transit times, thus benefiting the whole community,
8) Vocally disseminate our experiences with EVs, bicycles, and other transportation to the local communities to help them motivate improvements in their infrastructure.
9) Build a community of users who tie into shared experience through sharing of power and plug-in usage to deliver educational value to others who might be converted to EV transit.

Local Economic Development

1) Promote collaborations with local companies, big and small, especially within New Jersey, where combined effort can assist in speeding new technologies to market.
2) Encourage Rutgers technology commercialization in areas that help develop this sustainable business mission.

Alignment with University Strategic Plan

As noted above, there are many ways that building this ecosystem would have impact and would fit with the many Strategic Plan priority areas. To emphasize this point we "score" the initiatives showing where the above themes would have the best fit: **larger numbers indicate larger impact**.

_**4**_ Envision Tomorrow's University: **We plan to develop strong student involvement in the learning, studying, and applying these ecosystem/transportation principles. This is congruent with**

the vision provided by the Aresty program and other ambitious, student-centered and forward-looking configurations of Rutgers.

_3_ Build Faculty Excellence: **This theme provides interested faculty with numerous avenues for cutting edge research – limited only by their imagination.**

_2_ Transform the Student Experience: **Student involvement is critical in our vision. This becomes one avenue of developing the "Living Learning Laboratory" where students are directly engaged in the cutting-edge research on this broad technology area.**

_3_ Enhance Our Public Prominence: **Rutgers would be the first university *anywhere* to take such a strong stance on alternative fuel transportation. The visibility can enhance our regional visibility and stature.**

_1_ Strong Core of Sciences and Humanities: **The data and case studies that are developed can feed into core science and humanities courses that tackle the environmental issues of modern technology and society.**

___ Inclusive, Diverse, and Cohesive Culture

_3_ Effective and Efficient Infrastructure and Staff: **Our work is aimed at the intersection between electric and transportation infrastructure and its usage on a day-to-day basis – and extrapolating to future societal needs.**

_3_ Financial Resources Sufficient to Fund Our Aspirations: **We are actively seeking external funding to push this initiative forward. In addition, our studies will assist in developing policy for parking, transit, energy, and infrastructure investments by the university – in tandem with the added visibility and prominence that we plan.**

___ Robust Shared Governance, Academic Freedom, and Effective Communication

_1_ Cultures, Diversity, and Inequality—Local and Global: **By studying and dealing with the congested region (including many diverse cultures) we have the potential to provide solutions that will be applicable in many corners of our increasingly congested world.**

_2_ Improving the Health and Wellness of Individuals and Populations: **As noted above, the transformation to alternative fuels can dramatically lower carbon footprint as well as more localized smog and pollution that is known to have significant health consequences.**

_3_ Creating a Sustainable World through Innovation, Engineering, and Technology: **Our work is at the crossroads of technology and society. We expect this new insight to assist in bringing new technology, policy, and practices to fruition.**

_4_ Educating Involved Citizens and Effective Leaders for a Dynamic World: **At the core, our involvement of students in these studies will be a major factor in helping them grow in confidence to be leaders as they join the workforce – hopefully continuing to express a positive environmental vision as they mature.**

___ Creative Expression and the Human Experience

___ Measuring Progress and Defining Success

Core Participants

Faculty Participant	Topical Interest and Background
Susan Albin Industrial and Systems Engineering, SOE	She is active in research on quality engineering, process monitoring, data mining and stochastic modeling. Her work has been applied in areas including semiconductor device manufacturing, advanced display technology, and plastics recycling. These data analysis skills will help us attack multi-sensor data logged on energy use, storage, generation and visualizing these complexities.
Glenn Amatucci Materials Science and Engineering, SOE	Director, Energy Storage Research group. Pioneering a number of new battery compositions and configurations. Sponsored by DOE and other agencies. Holder of more than 20 patents on battery technology and

	compositions. Provides key insight on battery development and testing.
Clinton J. Andrews Planning and Public Policy, Bloustein	He studies users of technology with emphasis on energy impacts in smart-grid and smart-building energy systems. His previous experience includes working in the private sector on energy issues, helping to launch an energy policy project at MIT, and helping to found a science policy program at Princeton. Prof. Andrews was also the PI/leader of the 2011 DOE Solar Decathlon (solar house design/build project) in collaboration with NJIT.
Dunbar P. Birnie, III Materials Science and Engineering, SOE	Broadly interested in solar energy generation and the technology involved in electric vehicles. Has published a seminal work on solar electricity for commuter transit[3] and studied the specific scenario of workplace solar charging through the Rutgers Energy Institute sponsored "Solar-2-Vehicle Project[4].
Kevin Lyons Supply Chain Management, RBS	Deep interest in sustainability and business innovation. Working with Tesla to optimize their battery manufacturing as they design their next generation electric vehicles.
Rachael Shwom Human Ecology, SEBS	Actively working on social aspects of technology transformations, with specific interest in efforts to mitigate and adapt to climate change – and our attempts to motivate people to change behaviors and habits as new technologies are introduced.

Desired Outcomes

The present proposal suggests simple measures that could lead to a major transformation in commuting energy usage in the near-to-Rutgers region. We desire that this transformation would also stimulate research and educational initiatives that study and highlight this important change.

Resources Required and Generated

The majority of recommendations offered here are rooted in how we design and operate future installations and infrastructure, though educational and research angles are suggested as well. Since some of the infrastructure requests have real hardware or electricity-value costs, then we request a small funding allocation to support these direct needs. During year 1 we request $25K, growing linearly to $50K, $75, and $100K in years 2, 3, and 4, respectively. Part of this funding would be reserved to hire undergraduate summer interns, or as seed funding for urgent research projects related to the present overall theme. Meanwhile, we will be continuing to seek DOE, industry and other external funding to expand our influence in this broad area. Ultimately we expect the overhead earned from these new grants will be larger than the investment made by Rutgers to launch and emphasize this effort.

References Cited

1) NREL DOE Energy usage map: https://flowcharts.llnl.gov/energy.html
2) 2012 report authored by the Union of Concerned Scientists: "State of Charge: Electric vehicles' global warming emissions and fuel-cost savings across the United States", which can be retrieved here: http://tinyurl.com/UCSglobalwarmingreport
3) Birnie, D.P., Solar-to-vehicle (S2V) systems for powering commuters of the future. Journal of Power Sources, 2009. 186(2): p. 539-542.
4) Birnie, D.P. Solar-2-Vehicle Project.; website: http://www.rci.rutgers.edu/~dbirnie/Solar2Vehicle/, First year annual report: http://tinyurl.com/S2VYear1Report;