To:
U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability

From:
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Subject:
Response to Request for Information titled *"Addressing Policy and Logistical Challenges to Smart Grid Implementation"*

Overview:

We support the Department's interest to "seek to assure smart grid deployments benefit consumers, the economy and the environment." Current smart grid initiatives are occurring in a largely uncoordinated fashion and tend to increase near-term energy costs. Meanwhile, Renewable Portfolio Standards are also expected to increase near-term costs. The lack of a comprehensive energy and climate policy reduces the likelihood of a significant reduction in greenhouse gas emissions or energy imports. In the midst of these trends, our findings suggest that properly coordinated smart grid investments can allow renewable resources to be dynamically matched with a new class of flexible loads while using existing generation to meet current load, without compromising any of the three critical metrics: energy security, affordability or sustainability.

The Utility Dilemma:

The electrical sector has, for more than sixty years, provided secure and low cost electricity to power the nation's industrial and economic growth. However, utilities today face many challenges as they attempt to reconcile the task of providing their customers with the economical and reliable electric power to which they are accustomed, with new demands for improving sustainability and decreasing carbon emissions.

Wholesale grid parity, which we define as price parity with natural gas generation when measured at the terminals of the power plant, has been achieved for wind generation in resource rich areas. Retail price parity is imminent for solar energy in resource rich areas. However, both technologies suffer from strong spatial and temporal variability and poor correlation with the time and location of demand. If utilities have to meet RPS mandates and maintain current reliability levels, they will have to build higher cost renewable plants close to load centers, substantial new back-up generation, energy storage or new power delivery infrastructure. Nuclear energy offers a proven form of carbon-free energy, but its capital cost is significantly more expensive than alternative forms of generation. The net result is that the ongoing RPS and nuclear initiatives will likely increase cost of electricity in the near term, and as a result, may not be widely supported by consumers. Yet, without such initiatives, there seems to be no path towards lower carbon emissions and improved sustainability.

Another major game changer that utilities are viewing with some interest and concern are electric vehicles. If electric vehicle (EV) adoption dramatically increases, an event which the utilities do not control, the utilities will have to significantly upgrade generation and distribution infrastructure. Further, the broad adoption of EVs in the market is not assured as it may be limited by the success of biofuels - a competing technology for secure and carbon neutral transportation. With such uncertainty, it is difficult for utilities and public service commissions to commit to the large scale infrastructure upgrade investments needed to support broad EV deployment.

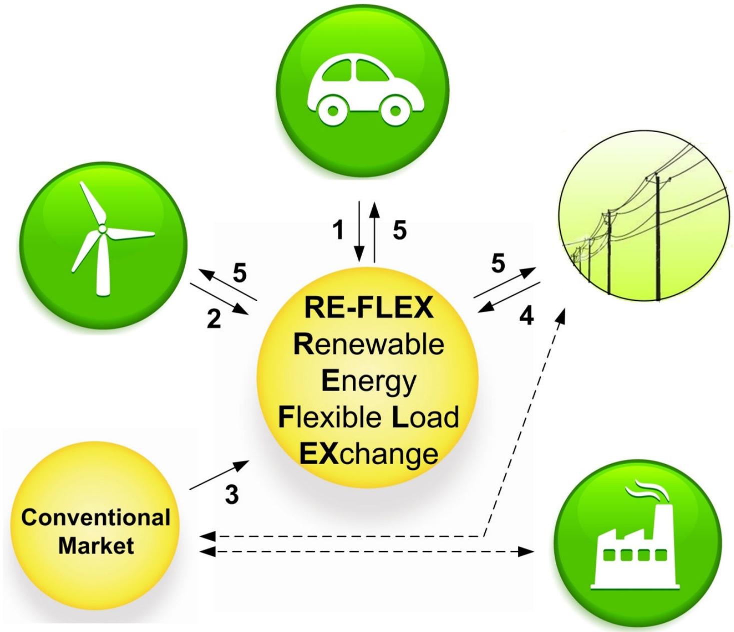
The Energy Consumer Has Spoken:

Energy consumers from Baltimore to Boulder to Bakersfield have resisted up-front cost increases to support smart grid deployments which do not show certain and significant future cost savings. The majority of consumers seem to generally support sustainability and lower carbon emissions, but not when it conflicts with personal prosperity and economic growth. In a democratic country such as the US, with strong commercial and lobbying interests, it has proved very difficult to implement policies that move towards sustainable energy and lower carbon emissions, or require dramatic changes in life style. This is the conundrum that we have been facing for the last decade.

To ease adoption of new policies and technologies, individuals should not have to choose between their family's prosperity and saving the planet. An ideal energy solution reduces energy costs for individual consumers without compromising life style, maintains service reliability, minimizes business disruptions for large influential industry groups, stimulates economic growth, improves national energy security, and reduces carbon emissions to levels recommended by the Intergovernmental Panel on Climate Change (IPCC). The urgency of the IPCC goals requires mobilization of technologies that are at or near price parity with a demonstrated ability to scale to market level. Current initiatives do not simultaneously achieve these objectives, and are thus unlikely to achieve societal goals or to see broad and willing adoption. If a solution akin to the ideal could be identified, public opinion could swing, making it possible to implement appropriate policies to catalyze and guide the market towards such a desirable end goal.

The electric, transportation, and natural gas sectors have been individually optimized over the last 100 years; increasing the difficulty of obtaining significant cost savings within the sectors. It may be more fruitful to look holistically at the problem, using technology and policy solutions that cut across traditional boundaries. For instance, consumers pay $0.50/kWHr for energy at the gas pump, compared with $0.10/kWHr for electricity, yet transportation is primarily powered by liquid fuels – showing the value the market places on storing and delivering energy to mobile loads. This price differential suggests that a low-cost technology to electrify the transportation sector could reap significant cost savings. Further, given that the electric sector is sourced almost exclusively with domestic fuels, electrification of transit would significantly improve energy security. While EV battery costs are decreasing, with manufacturers projecting price parity once 500k – 1 M units have been manufactured, no current technologies show near-term promise of cost effectively electrifying the heavy shipping and aviation sectors. Representing 20% of total petroleum demand, the heavy shipping and aviation sector may be a suitable match for Generation 2 biofuels, given that the domestic production limit of Generation 2 biofuels is roughly 20% of current oil production.

Georgia Tech has identified a framework where targeted smart grid investments are the cornerstone of a future energy system able to supply demand at lower cost than today's energy system with increased energy security and lower cost. Through the use of a Renewable Energy Flexible Load EXchange (RE-FLEX), renewable energy generation is dynamically matched with flexible EV loads in real time, assuring that EVs operate with zero net carbon emissions without employing V2G capability. Operation of RE-FLEX is detailed in Figure 1. The energy is delivered to the flexible loads using the spare T&D capacity that is normally reserved to serve conventional load during contingencies. Sensors spanning the T&D system, down to the level of the distribution transformer, ensure a maximum level of flexible load is served without reducing the lifetime of grid assets. The use of low cost, distributed FACTS devices allows power flow to be routed through grid assets with spare capacity, reducing the need for construction of new grid assets. During contingencies, the flexible load is dropped as necessary, ensuring conventional load is served at current reliability levels.



1) GEVs report current and forecasted plug status and expected energy needs
2) Renewable generators report current and forecasted generation capability
3) Conventional market reports current state and conventional generator dispatch schedule
4) Utility reports current and forecasted state of all assets (transmission lines, distribution transformers, etc)
5) RE-FLEX issues commands to GEVs, renewable generators, and Smart Grid assets; dropping GEV load, curtailing renewable generation, and modifying the state of grid assets as needed to maintain reliability in the conventional market

Figure 1: Overview of RE-FLEX Operation

We have modeled six future energy scenarios, to provide an initial assessment of the impact of the approach. The modeling effort evaluates the incremental cost of building and operating the 2030 energy system over 20 years in comparison to the cost of operating the 2010 system for 20 years. All scenarios use EIA projections for 2030 electric demand. The scenarios are:

Scenario 1 - Business As Usual (BAU 2030): Light automotive transportation is supplied by gasoline, stationary loads by electricity and natural gas. Current generation fleet is utilized at today's level. <u>This is the current trajectory for states with no RPS mandate</u>.

Scenario 2 – BAU 2030 with EVs: Similar to Scenario 1, but with light automotive transportation supplied by electricity using battery powered EVs. Investments and capital costs for establishing a charging infrastructure and battery costs are included.

Scenario 3 – BAU 2030 with RPS Mandates: Similar to Scenario 1, but with RPS of 20% by 2030. Two thirds of renewable energy is wind and one-third solar. Current reliability mandates apply. <u>This is the current trajectory for many states and is a likely scenario for 2030.</u>

Scenario 4 – BAU 2030 with RPS + EVs: Includes RPS mandate of Scenario 3 and 100% EV penetration in light-duty automotive fleet. Battery powered EVs are assumed. Investments and capital costs for establishing a charging infrastructure and battery costs are included.

Scenario 5 – BAU 2030 with Smart Grid and RE-FLEX: Uses RE-FLEX to dynamically match renewable energy generation and new flexible EV loads in real time, assuring that EVs operate with zero <u>net</u> carbon emissions without employing V2G capability. Specific smart grid functionality is used to minimize grid investments, reduce cost and reduce carbon emissions. Investments and capital costs for establishing a charging infrastructure and battery costs are included.

Scenario 6 – BAU 2030 with IPCC Compliance in 2030: Extends Scenario 5 to include domestic biofuels produced at maximum sustainable scale while domestic oil production is targeted for inorganic feedstocks, eliminating oil imports. Projects a 2% efficiency improvement over 2010 levels of energy use in the electric and natural gas sectors. Scenario 6 is compliant with IPCC recommendations for carbon emissions estimated for 2030.

The white columns in Table 1 compare the six scenarios for total incremental consumer cost (including electricity, transportation, and natural gas sectors), total incremental utility cost, total incremental electric utility energy sales, and net cost to the utility for incremental kWHrs delivered. All costs are incremental above the 2010 cost of operation. As a reference, the BAU 2010 cost for electricity is $0.0989/kWHr. The green columns assess societal metrics, energy security (petroleum imports), cost (societal net incremental cost), and sustainability (carbon emissions). Baseline is BAU 2030 and is set at 100 for each metric. Lower values indicate better performance.

Table 1: Comparison of cost and sales metrics for various scenarios.

	(A) Total Incremental Consumer Energy Spending Over 20 Years (2009$B)	(B) Total Incremental Utility Spending Over 20 Years (2009$B)	(C)Total Incremental Electricity Sales Over 20 Years (TWHr)	(D) Net Cost to Utilities for Incremental kWHr Delivered	Security Metric: Petroleum Imports Relative to BAU 2030	Cost Metric: Incremental Cost Relative to BAU 2030	Sustainability Metric: Carbon Emissions Relative to BAU 2030
Scenario 1 – BAU 2030	$2313	$1804	16,222	$0.111	100%	100%	100%
Scenario 2 – BAU + EV	$2348	$5812	38,963	**$0.149**	38%	102%	91%
Scenario 3 – BAU + RPS	$4169	$3661	16,222	**$0.226**	100%	180%	91%
Scenario 4 – BAU+RPS+EV	$4865	$8329	38,963	**$0.214**	38%	210%	81%
Scenario 5 – RE-FLEX	**$1836**	$4315 - $985*	38,963	$0.111	38%	79%	81%
Scenario 6 – IPCC Compliant	**$1629**	$4088 - $1015*	36,991	$0.111	0%	70%	61%

**Reflects amounts paid by EVs towards generation and delivery infrastructure to support ubiquitous EV charging. This cost is included in the total incremental consumer energy spending amounts.*
(A): Consumer energy cost shows change in total fuel, vehicle and electricity costs over and above BAU2010.
(B): Total incremental cost for utility above BAU 2010. Includes generation, T&D investments, and fuel and O&M costs, and cost of capital. For Scenarios 5 & 6, part of the charging infrastructure investment is covered by EV owners.
(C): Total incremental electricity sales over BAU2010.
(D): Net cost to utilities for incremental load served.

Table 1 shows compelling differences between the various scenarios. Scenarios 2, 3 and 4 all show significantly higher cost of electricity for new loads served. This is unlikely to be acceptable to consumers. Scenarios 5 and 6 show that new electrical loads are served at $0.111/kWHr, the same cost as the incremental cost for the BAU scenario, without compromising utility profitability. Further, the need to build extensive charging infrastructure for EVs is supported directly by the EV loads themselves. Scenarios 5 and 6 validate that the overall cost to consumers is reduced, even while utilities see a 47% increase in total billings with investments per kWHr delivered that are in line with current values.

Impact on Smart Grid Deployment:

The RE-FLEX strategy proposed here achieves several important objectives in terms of cost, security and sustainability of energy. This achievement is contingent upon the deployment of targeted smart grid technologies. An uncoordinated smart grid rollout could result in excessive cost and create public resistance to the additional smart grid investments necessary to realize RE-FLEX. We feel that it is critically important to control near-term costs throughout the smart grid rollout and ensure that consumer costs are not elevated in the pursuit of environmental goals. We have presented a framework deriving the justification for smart grid investments from a cross-cutting analysis intended to meet societal cost, security, and emissions objectives. We encourage the Department to work to identify, vet and promote holistic analyses.