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THE ROLE OF RENEWABLE ENERGY IN THE TRANSITION TO A SUSTAINABLE ENERGY FUTURE

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The power industry is a diverse collection of public and private interests, all focused on one objective – delivery of reliable and affordable power of all types to the consumer. The responsibilities in this enterprise are immense, ranging from public policy to private investments, from market regulation to efficiency measures for the end user. And, it is an endeavor in transition, where renewable energy will be playing an increasing role. Assuring that this enterprise serves us well requires the skills of many actors, uniting them in a complex arena where anticipating the future is just as important as delivering the present.

I came to the renewable energy field from an academic career focused on land use conflicts at the urban boundary. Today, I work in a national laboratory filled with scientists, engineers and economists whose mission is to help find the key to this transformation, and make it available and attractive to markets and investors everywhere.

The National Renewable Energy Laboratory, located in Golden, Colorado and managed by Midwest Research Institute and Battelle, is one of the constellations of Department of Energy national laboratories across our nation. NREL is dedicated to advancing the science and application of renewable technologies based on sources like geothermal, biomass, solar, and wind power. As our capabilities and knowledge have grown, we have begun to build a bridge and link other technologies, such as ocean current turbines and run-of-the-river hydro designs, to make them available to the grid operators of the future.

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Today, I ask you to imagine a world dominated by change, a world responding to forces that are unprecedented in human history, a world where traditional analysis and policy making are proving awkward and often unsuited to their primary task. I want to discuss the convergence of energy markets and the regulatory systems that control them today, anticipating the changes that must come in order to efficiently allocate and ultimately price scarce resources. I want you to imagine that in a localized world (Alberta) where energy is relatively cheap and abundant, there is and will be a role for alternatives.

I offer these remarks as a so-called free market economist, who has learned many lessons the hard way, both in trying to create new markets and in the establishment of rules to help guide their behaviour. I should say at the outset, that I relish the idea of competitive open markets. However, I do not believe that all markets are self-regulating, that where public goods are necessary or where change is not delivered by the current market structure, the use of incentives and intervention may be appropriate in order to secure reliable, diverse and affordable energy in the future.

The world of power regulation is no longer a straightforward system where returns to investment, dependable supply of raw materials, and transformation of them into usable energy and distribution to meet demand are automatically assured. We live in a world dominated by geopolitical intersections, constraints in terms of environmental costs and relentless demand for energy to fuel the expansion and intensification of our society. This is all taking place simultaneously, in spite of the boundaries that separate us, but do not diminish our common interests.

Beyond those boundaries, markets are at work, devising ways to maximize returns, to obtain more and better goods and services. Those markets are not the creation of governments or their regulators, but they operate in the context of them, in the context of treaties, compacts, contracts and market sales and unregulated consumer demand. Increasingly, this is measured on regional, continental or even global scale.

Given the growth of developing nations and the location and reserves of our sources of energy in all forms, it would appear to me that the world may one day change its shape, where the energy to supply the developed nations is nowhere close, but in fact is controlled and demanded by countries who need it for their own development interests.

This could be a titanic struggle made more difficult by a fractured, non-coordinated energy regulatory system. Well, that is a sweeping forecast, so let me go back and lay a little groundwork for you with Canada and the United States as my descriptive background.

THE FORCES AT WORK

Energy is not a commodity that exists or is created without demand. We don't want energy for its own sake; we want energy to do work, to enable us to do more work and to drive the engines of commerce and trade. Behind this soliloquy though is a key reason to exploit and develop energy resources. First, we have built a society that cannot exist without energy and second, we have designed our systems so they react to change within a very narrow band. That is, we have very little flexibility in the system we depend so heavily upon.

None of this is static of course. New devices, coupled with continuous pressure from population increases mean we must constantly exploit new stocks or reserves of the fuels that sustain our energy industry. I should pause here and point out that when I use the term "energy" I am describing the potential to do work found in fossil hydrocarbon fuels such as coal, natural gas and petroleum as well as hydrologic resources, nuclear fuels (to create steam) and so-called renewable resources such as wind, solar thermal, photovoltaic panels, biomass for combustion or chemical reduction, geothermal resources and tidal currents.

Population growth in modern society means increased demand for devices, vehicles, heat and cooling systems and food, all within the context of intensifying cities. We traditionally serve that demand by expanding our central station power plants and extending transmission lines to settlements at increasing distance from the power source. In most cases, especially in those developing nations whose national economies are just beginning to surge, demand for energy in aggregate is increasing at a rate in excess of population growth. As people congregate and concentrate their numbers, they begin to resent the co-location of the very energy facilities that will serve them. The dilemma that results means there is a higher hurdle for siting power plants and transmission facilities, and a greater need to control the impacts on the environment in which people live (and consume energy).

Substitution at this point is not the seamless enterprise that most economists build into their models either. As capital facilities wear out, or as supplies of raw materials grow more costly (witness the price rise for natural gas and petroleum stocks in recent months), we imagine the replacement of them with new technologies or sources such as LNG or CNG. Yet even these transitions are not without problems including the fact that the source countries may not always be friendly (Indonesia for instance in the case of LNG), or issues like aging and inefficient technology, transmission line constraints, storage for natural gas, transportation for "clean" coal not to mention siting resistance from local

areas. In the future we may even face resistance from the countries holding those primary resources as they seek to exploit them locally to underpin their own economic expansion.

We are not at that point yet, but given current rates of energy demand, we soon will be. To me that means we must think systematically about the energy system ranging from acquisition, transformation and transportation to the methods in which we use that energy with an eye to making the entire system as efficient as possible. A key area in all of this will be an increased need to regulate utility provision to allocate resources efficiently, price competitively and prevent market manipulation.

In a word, we need to overhaul our existing, linear and non-cross-cutting regulatory system. The regulatory system of the future must take account of an energy system (dominated by electricity in this case) designed in a different era for different demands and not expected to meet the kind of dynamic forces we are experiencing today.

These forces can be seen most easily in the brief list that follows, which attempts to provide a snapshot, which includes the overlap between issues.

- **DEMAND**

Demand is increasing worldwide for all forms of energy, both primary and derived. Demand can generally be seen as correlating closely with population growth, although not on a one to one basis. A better metric is to imagine an increasing function related to income, thus as income approaches developed country levels, demand in energy growth may increase as a factor of up to 3 annually. Since I have used the term energy broadly, I would reiterate that this includes oil derived energy products which are primarily associated with transportation demands, natural gas demand which is sought for electricity generation and heating and finally electricity demand which is satisfied through generation which may range from nuclear fission through turbine firing to renewable energy sources. In many of the developing nations, a unique phenomena has been emerging when natural gas is used as the fuel of choice, that is represented by a new and significant twin peak of demand; first for summer power generation (for cooling) and second a winter peak for natural gas heating.

Although energy demand is typically not a primary objective for consumers (they use energy to perform work in the main), it is an economic good which can be traded and whose use is responsive to price signals. This is a key point generally ignored in the regulatory arena, where consumer price signals are uncoupled from hourly or daily price changes in energy generation costs and aggregated typically on a monthly

billing. This disconnect makes it difficult to impose behavioural changes that do not originate on the supply side of the equation.

Demands for characteristic changes in the energy system, however, do originate ever more frequently from the consumer sector, for instance a demand for higher reliability standards in the electricity sector and in the case of large manufacturers, access to self generation, co-generation and opportunities to explore direct access with energy generators.

- **WIRE CAPACITY ISSUES**

The transmission system continues to pose a future weak link issue as demand increases. The transmission system in North America was built in its largest share as long as 60 years ago. The system is by definition aging, a condition exacerbated by the fact that metal lines fatigue over time and must either be de-rated or run the risk of sagging lines or possible breaks.

In order to upgrade or expand the system, greater coordination not only in terms of use but also in terms of charges must be developed. This in turn will focus capital investment differentially in the system dependent on location, previous use, age and condition and access. In the special case of extending existing lines or serving new territory, the issues of access rights for new facilities, interconnect standards, wheeling charges and standards for rating (or de-rating) line capacity for dispatch control must be solved at a super-regional level. This will include delicate negotiations for cross-border transmission as well.

- **NATURAL GAS SUPPLIES**

Because of its abundance and production of relatively clean by-products, natural gas is now the fuel of choice for most new power plant development in North America. Increased demand coupled with pipeline constraints and new predictions of declining reserves, however, have contributed to increased prices and speculation that further shortfalls only solved by imports of LNG will sustain the investment based on this type of generation. Expansion of the transportation and storage systems are keys to future price stability in the face of expected declines of reserves.

- **HYDRO ISSUES**

Hydroelectric power has been the backbone of baseload power in North America for over a century. During that period, extensive development of hydropower potential has resulted in capture of most of

the available resource within geographic limits that are reasonably accessible by transmission capacity.

This source of power is locked in a complex relationship with competing demands for recreation, fish and wildlife, flood control and issues of microclimate change. Further, because of the nature of sediment loads carried by river systems, hydroelectric facilities are affected by siltation and capacity decreases over time. Hydropower is a prime source for system operators to use for firming loads due to its rapid dispatch capability, which makes it sensitive to declining levels such as those experienced in the West during times of drought. Hydropower also provides one of the primary storage systems in price sensitive commodity markets through pump storage, allowing timed reuse of flows to compensate for high prices.

- **COAL**

Coal is the most abundant fossil resource in North America, with reserves commonly estimated in the range of hundreds of years. Harder, low-sulphur coal such as that found in the upper mid-west and Alberta provides high heat rate combustion that is especially attractive as natural gas prices increase or hydropower volume falls. The burning of coal produces byproducts of SOx and NOx and CO2 that are subject to regulatory restriction and consequently higher costs. Further, the use of this fuel entails high transportation costs, typically by rail, which increases costs and can further contribute to air quality concerns via the diesel motors of the train systems. The key to widespread use of coal would seem to be linked to future success in sequestering unburned carbon as a combustion byproduct.

- **OIL AND PETROLEUM BY-PRODUCTS (PRINCIPALLY TRANSPORTATION)**

Demand for oil and oil derived products is the primary source of energy use, especially in North America. The United States alone, which produces only 2% of the world supply of oil, uses more than 26% annually. This is attributable not only to the number of vehicles (over 800 per one thousand population) but also the high number of miles traveled per vehicle. Thus, while efficiency gains and diminished air pollution measured on a per vehicle basis have improved, overall demand continues to increase simply as a result of higher vehicle miles per vehicle.

The demand for mobility in developing nations, especially China, is expected to exacerbate this trend over the next twenty years. The effect is likely to be very complex, ranging from competition for oil reserves for fuels and road building to the overall impacts on climatic heat balances and air quality.

- **NUCLEAR FACILITIES**

Originally touted as the answer for future baseload power needs in virtually every nation, nuclear power has foundered on the cross of excessive costs, large scale water cooling demands, terrible public perception, safety violations and predictions of future storage problems. In recent years this list has been expanded to include serious security issues, which will ultimately add to the cost factors, not to mention siting and regulatory hurdles for any new facility developed.

These issues notwithstanding, future nuclear proposals are likely to be examined anew for their contribution to relieve baseload demands for natural gas and ultimately coal and to help generate hydrogen as a core transportation fuel. Given the time that is estimated for siting and development of a greenfield site for these types of facilities (up to 20 years from inception) and the financing implied by that, this technology will likely be most attractive at mid-century as shortages in other fuels appear and as safety and environmental issues are addressed more fully.

- **RENEWABLES**

Renewable energy in the form of wind power, photovoltaic panels, bioenergy, geothermal turbines and landfill gas provide attractive alternatives to the current system. Costs are still generally in excess of those offered by burning fossil fuels (large scale wind projects are the exception) but have seen rapid drops over recent years. In addition to high first costs, renewable sources generally suffer intermittency, which is obvious from their very nature. This lack of reliable performance is anathema to power grid operators and results in reduced capacity factors and a derating of their potential contribution to overall supplies.

However, when combined with fossil generation they can be used successfully to firm power from fossil sources during peak demand periods and to act to offset environmental problems such as air pollution. New markets for trading attributes are emerging and the sale of REC's or Renewable Energy Credits has increased the financial viability of renewable energy sources.

• INFRASTRUCTURE

The energy infrastructure, consisting of base sources, generation and distribution plus storage is the heart of energy use. This infrastructure must be constantly maintained and updated, not to mention expanded to meet increasing demand over time. This is clearly capital intensive and requires tariffs that are adjustable to changing costs, improvements in technology and changes in rules or public processes. For instance, many of the rights-of-way for utility corridors were acquired and developed as long ago as the turn of the century. Expansion cannot always occur within these corridors, many of which share access with other utilities such as telecom or even highways.

As a consequence, tariffs must also anticipate access questions, which are not directly foreseen during utility development. An example emerging from the Los Angeles Basin serves to illustrate this point. Underground utilities such as gas mains, sewer lines, water lines, some telecom and electricity are buried under various adjacent local communities. Utility access to these lines is often dependent on discretionary approval by local government, all responsive to local constituencies. With concerns over public safety or even aesthetics, approval may be delayed or even denied, prompting expensive and inefficient work-arounds or even closure of existing facilities.

Recent evidence of local government denial of siting for LNG facilities illustrates the fragile reliance on substitution of energy sources such as Natural Gas, where critical infrastructure development or replacement must be accomplished before any new system can be designed and built.

• THE LOCAL GOVERNMENT ISSUE

Ultimately, approval of new energy generation, transmission, storage and distribution systems must rely on a system of local government approvals. This level of government is the final integrator of the system design and must be included not only in the planning and development, but redevelopment and access for ongoing maintenance of the system.

Design of settlements and cities dictates traffic patterns. Building standards and densities will ultimately dictate the future of energy demand and load profiles. Since the energy system exists to serve loads, the characteristics of final users and their communities will dictate not only the system design but also the nature and magnitude of the tariffs that will support energy delivery in the future.