ENERGY PRESENTATION, PART 1, APRIL 2007

Energy is now on everyone's mind. It has become clear that energy is a problem for several interconnected reasons. In the long term, deriving energy from fossil fuels is not sustainable because they will eventually be exhausted. In the short term, the cleaner-burning fossil fuels, natural gas and oil, are expected to become more scarce. Increasing scarcity will be followed by price increases. These will be exacerbated by the growing energy demands of developing countries, particularly India and China. In the absence of alternatives, this means more of our energy will come from coal, which is still abundant. But switching to coal will result in more greenhouse gas emissions, and the buildup of greenhouse gases is causing climate changes whose ultimate effect is unknown but likely to be bad for a great number of people.

Although our Federal government has been slow to recognize the energy problem, many state and local governments have begun to take steps to reduce energy use or switch from fossil fuels to other energy sources. New Mexico has been very active in this effort. Recently, Governor Richardson and four other western-state governors signed an agreement to develop a joint strategy to track, manage, and reduce greenhouse gas emissions within the region. This agreement will include a market-based greenhouse gas emissions registry and reduction program.

A number of steps have been taken in the past two years to help New Mexico achieve the goal of reducing emissions. Overall, these efforts are aligned with international programs such as the Kyoto treaty; and private initiatives at the national level such as the Chicago Climate Exchange, which has set up a voluntary cap and trade system for carbon emissions; and the US Green Building Council, which has set up the LEED standards to promote energy-efficient building design and practices. LEED is an acronym for Leadership in Energy and Environmental Design.

State activities include some by the governor, some by the legislature, and some by the New Mexico Public Regulation Commission (PRC). I will review them briefly, and **Handout 1** covers them in more detail.

The governor has issued a series of executive orders since 2004 designed to increase energy efficiency and reduce greenhouse gas emissions, and has set up a Climate Change Action Team to report to him on progress toward these goals. A few examples from the list will illustrate the sort of actions being taken.

The executive order on transportation requires that all cabinet agencies and public schools, including state colleges and universities, must use renewable fuels for 15% of their total transportation requirements by 2010, and requires that 75% of new vehicles must be able to run on alternative fuels or be hybrids.

The executive order on new construction requires all state agencies, including the Higher Education Department, to achieve LEED Silver ratings in new construction over 15,000 sq. ft., and smaller buildings and renovations must achieve similar standards.

The state Construction Industries Commission and Division have been ordered to update building codes to promote energy efficiency in private new construction, and to provide green building training and technical assistance to consumers.

The legislature has made some of the governor's executive orders law, and during this session has introduced bills covering a range of energy-related initiatives. Please refer to **Handout 2** for details.

The Public Regulation Commission, or PRC, has been an important source of renewable energy initiatives. In 2002, the PRC approved a rule requiring that electric utilities must generate 10% of their electricity from renewable sources by 2011. Partly because the PRC's authority to adopt a mandatory renewable standard was challenged, the state legislature passed the Renewable Energy Act in 2004, which required that investor-owned utilities like PNM (but not co-ops, at that time) must include a percentage of renewable energy in their retail sales to New Mexico customers. The percentage started at 5% in 2006, to increase to 10% in 2011. The accounting is done with Renewable Energy Credits (RECs), which the PRC regulates. The PRC has ruled that, in calculating credits, solar power gets triple credit, and geothermal and biomass get double credit, compared with wind. In the 2007 regular session, this Act was amended to increase the percentage to 15% in 2015, and to 20% in 2020. Also, the Act now includes Rural Electric Cooperatives, which have a first-time requirement of 5% in 2015 and 10% in 2020; their accounting is also to be done with RECs. In addition, the Act was amended to require a new automated system to track all of the RECs, ensuring that all are recorded, and none is counted more than once.

The PRC also adopted a net metering rule. This rule requires that in homes where photovoltaics are installed and hooked up to the electric grid, the electric utility must purchase any excess energy fed back into the grid when more energy is produced than consumed; when this happens electricity meters actually run backwards. Just recently, the PRC expanded this program to include commercial-level facilities.

Several of the state-level actions just described will affect what local governments can or should do with respect to energy because local governments operate within a framework determined by the state. The focus of our report is how local governments can reduce their use of energy, reduce their greenhouse gas emissions, and help their citizens do the same. Our aim is to develop consensus positions on what actions local governments should take.

Our suggestions must depend heavily on our assumptions about our energy future. At one end of the spectrum of possible assumptions is the town of Kinsale in Ireland, which has adopted an Energy Descent Action Plan to prepare for a post-carbon world. At the other end of the spectrum, we could assume that some miraculous technological breakthrough will provide a continued supply of cheap energy with no greenhouse gas emissions. The assumptions underlying this study are somewhere in between, and we will begin by making them explicit.

We assume that over the long term energy prices will increase, both because of increasing scarcity, and because concerns about greenhouse gas emissions will result in imposing cleaner, and thus more expensive, standards for production and use of fossil fuels. However, we do not assume that the price increases due to these long-term factors currently constitute a crisis.

We assume that fossil fuel prices will continue to be volatile in the short run, making it difficult for consumers to adapt to them. For example, average U.S. natural gas prices charged to residential customers rose 44% from 1999 to 2001, declined 18% from 2001 to 2002, and then rose 74% from 2002 to 2006, and towards the end of 2006 prices were already beginning to decline again. Gasoline prices were just as volatile in this period. We won't attempt to speculate on how much of this volatility stems from short-term causes such as Hurricane Katrina, how much from industry cycles caused by the time it takes supplies to respond to increases in demand, and how much from longer-term trends such as increasing scarcity, but we assume that fossil fuel energy prices will continue to be volatile.

We assume that due to budgetary constraints, our Federal government will not adopt a large-scale energy research program that will lead quickly to significant technological breakthroughs. However, energy research has begun to receive a good deal of venture capital money, so we assume that technological advances in energy use will continue, although at a slower rate than could be achieved if government support were more generous.

We assume that there will be some governmental moves, either at the Federal or state levels, to reduce carbon emissions, but that the form these will take is still undecided. Possibilities include more stringent regulations on energy producers, taxes based on carbon emissions, or cap and trade programs.

Based on these modest predictions, we assume that our local governments are not faced with an immediate crisis; this gives them some freedom of action. They can choose to emphasize cost over carbon emissions, or vice versa.

Possible actions at the local level are of two sorts; one is encouraging energy conservation and the other is switching to alternative sources of energy. We hope to arrive at consensus positions on both.

Our discussion of alternative energy will be limited to the energy sources available to local governments in New Mexico, that is, wind, solar, wood or other biomass, and geothermal energy. We will not discuss nuclear energy in this report as it is not an option for local governments.

We will discuss wind and solar alternatives at this meeting, and will briefly talk about conservation by private citizens. At our second meeting, to be held this autumn, we will talk about biomass and geothermal alternatives, and discuss what local governments can do to promote energy conservation.

For each of the four alternatives—wind, solar, biomass, and geothermal—we will discuss factors that affect any actions by local governments to increase usage. We need to emphasize that the possibilities change as technology changes, and as costs decline. Costs of alternative energy have tumbled in recent years, and further declines can be expected. This will change the feasibility of actions by local governments.

Cost is an important factor for local governments to consider in making any decision about alternative energy. In order to have some reference point for cost, we need to begin by looking at the cost of the fossil fuels that most of us now use—gas for heating, and electricity for most other energy needs, including heating for some homes. **Handout 3** shows current costs for gas and electricity in this area.

We will begin with wind energy because we already get part of our electricity from wind turbines in eastern New Mexico.

In 2003, PNM interconnected a 204-MW wind generation facility called the New Mexico Wind Energy Center to its system. The facility consists of 136 wind turbine generators, located along the edge of a plateau in eastern New Mexico. It is owned by Florida Power and Light, but PNM has a long-term contract to purchase all of its output. **Handout 4** is a map showing the location of this facility, labeled NMWEC, relative to the rest of the transmission system in New Mexico.

This wind farm was installed shortly before New Mexico passed a law requiring electric utilities to add renewable energy to their generating portfolios, and has thus far enabled PNM to meet its renewable requirements. PNM is allowed to include the cost of producing the required percentage in its electricity rates. Through its Sky Blue program, PNM also offers its retail customers the option of buying even more renewable power on a voluntary basis by paying a premium.[1]

The current cost of producing electricity from wind turbines is between 4 and 6 cents per kilowatt-hour; this is competitive with conventional sources. However, the production cost is not the only cost to a utility of using wind to generate electricity. The problem is that the wind doesn't blow all the time. The ratio of energy actually produced to what would be produced if the wind turbine operated all the time at maximum capacity, which is called the capacity factor, is between 25% and 50%. This means that

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[1] Residential customers may purchase blocks of 100 kWh of renewable energy. The amount purchased may not exceed 90% of minimum monthly electricity use in the past 12 months, which means that the average home customer may purchase up to only three or four blocks. The cost is $1.80 for a 100 kWh block, or 1.8 cents per kWh, which, for those blocks, is added to the average residential electricity cost of between 0.07 and 0.08 cents per kWh.

the total cost of wind power must also include the cost of providing backup power supplies, and the backup generator must be able to come on line almost instantly.

What usually happens is that the conventional generators that are online in the electrical system move up and down more as a result of wind variations, and this is not efficient. Based on studies that have been done on this, the additional cost is in the range of a tenth of a cent to half a cent per kilowatt-hour, which adds between 2% and 9% to the production cost of wind energy. Because there has been some controversy about the actual cost of providing the backup power needed when wind generation is added to the system, PNM has commissioned a study of the problems of wind integration for its system, which should be available before mid-2007.

If either the city or the county should decide to use wind energy to meet a portion of its power needs, cost will not be the only consideration. There will also be regulatory problems, physical system problems, and the problem of transmitting the electricity from wind turbines to Santa Fe.

Let’s deal with the regulatory problems first. The Santa Fe area is served by PNM, which is a regulated monopoly. PNM is required to serve within its territory, and any other utility wanting to serve in that territory could do so only with permission of the Public Regulation Commission. PNM is likely to contest such service if it is significant. There are a couple of grey areas in this picture, however. One of them is whether a company that generates electricity need necessarily be considered a utility. Another grey area is what would be possible if either the city or the county were an owner of a wind facility.

Even if either of these grey areas were used to enable the city or county to buy wind-generated electricity from a non-PNM source, the problem of obtaining back-up service would remain. An agreement with PNM or another power and energy provider would need to be reached to provide back-up service, and because such service would require the provider to have generation capacity available whether it was used or not, this would be likely to increase its cost.

Physical problems stem from the logistics of integrating wind generation with the loads and other generation capacity in the electrical system. The variability of wind energy creates challenges in a utility’s ability to constantly match supply and demand, or as it is called in the electricity industry, to match generation to load.

Reliability is also a problem that must be addressed. The reliability of an electrical grid must be very high because it is critical infrastructure. Adding the wind plant in eastern New Mexico to PNM’s system raised reliability concerns for several reasons. At 204 megawatts, the wind farm is large relative to PNM’s peak load of approximately 1,800 MW. It is located far from most of PNM’s customers and is connected to those customers by a radial line 223 miles long. Voltage on this line is difficult to control due to its length and the fact that it is a radial line, which means one end is connected to PNM’s system and the other end is not. To help control voltage, this generation project was equipped with the ability to contribute to stabilizing the voltage in the area.

Getting electricity from the wind turbines to Santa Fe poses still another problem to be solved. The best wind generation sites in New Mexico are on the eastern plains, and electric transmission capability between that area and Santa Fe is fully utilized. If you will look again at the map in **handout 4a**, you will see a line stretching from the Blackwater station in eastern New Mexico to Albuquerque; this line was designed to carry 1000 megawatts, but in fact reinforcements will be needed as transmission approaches that amount.[2] Under current transmission contracts it is scheduled to carry 651 megawatts.[3] In addition, there is a queue of applications from planned wind generation facilities to use that line to carry an additional 460 megawatts.

Handout 4b shows pending and completed applications to use PNM lines for transmission of wind energy. As you can see in Table 1 of this handout, the only wind farms currently in service are on the eastern plains, but Table 3 shows that applications are pending to hook up wind farms in Torrance County, just south of Santa Fe. Getting electricity from Torrance County to Santa Fe will require transmission through different PNM lines than the Albuquerque-Blackwater line used by existing wind farms.

To sum up, any effort by local governments to use more wind energy must take into account both the cost of integrating wind energy into the electrical system serving the Santa Fe area, and the cost of upgrading the current transmission system.

Transmission capacity can be increased; the big questions are how much it will cost and who will pay for it. Legislation passed in New Mexico this year may provide help with the cost of upgrading transmission systems. House Bill 188 establishes the New Mexico Renewable Energy Transmission Authority, which is charged with increasing the transmission capability available for renewable energy.

This legislation was intended as much to help export wind energy from New Mexico to the rest of the western grid as it was to bring wind energy to New Mexico's cities. How the Transmission Authority will affect the ability of local governments to get more wind energy from eastern New Mexico remains to be worked out. It is possible that the Transmission Authority can help reduce costs by making it easier both to site new lines and to finance them.

Members of the city and county governing bodies have expressed an interest in getting more energy from renewable sources. This is partly due to the fact that the power needs of both governments will take a big jump when the Buckman Direct Diversion

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[2] PNM is just beginning a study of the line with flows at 900+ MW (email from Abraham Ellis of PNM, March 26, 2007).

[3] 651 MW is the sum of 451 MW of wind energy, and 200 MW of purchased power which is transmitted through the Blackwater Converter.

(BDD) comes on line in 2010. The annual cost increase for each government is projected to be around 20% of its current electricity costs.[4]

The city has taken the first steps towards getting more of the electricity used by city government from wind generation. In December, 2006, the City Council approved a Memorandum of Understanding which obligated the city to purchase 3.7 million kilowatt-hours annually from Patriot Wind, a company which develops and operates wind farms; this represents 10% of the city government's total annual electricity usage. The city may terminate the MOU if transmission service cannot be made available, or if the cost exceeds the city's current average cost of electricity.

The MOU was designed to lead to a power purchase contract (PPA), but in order for a PPA to be signed, Patriot Wind will have to have some way to transmit electricity from its generation site to Santa Fe. This requires an agreement with PNM. Further negotiations between the City and Patriot Wind will depend on the status of this transmission agreement.

Finally, we should compare greenhouse gas emissions from wind energy with emissions from conventional operations. There are no emissions when a wind turbine produces electricity, but the processes of manufacturing wind turbines, setting them up, and servicing them do generate emissions. Researchers have estimated the total birth to death emissions of wind turbines to be 15 metric tonnes[5] of CO_2 per GigaWatt hour (GWh), that is per billion Watt hours of electricity. This compares to 974 metric tonnes of CO_2 per GWh for electricity generated from coal.

We turn next to solar technologies. There are several solar technologies available. These fall into two general categories: non-concentrating and concentrating. For the most part, the non-concentrating technologies are used for individual homes and businesses, and concentrating technologies are used in solar power plants.

In the non-concentrating type, the collector area, which intercepts the sun's radiation, is the same as the area that absorbs it. These systems include both photovoltaics, which use solar cells to convert sunlight into electricity without moving parts, and flat-plate collectors used for space heating where temperatures below about 2000 F are sufficient.

The cost of electricity from photovoltaics has been on a downward path for the past two decades, and is now about 17 to 22 cents per kWh; this is all installation cost, of course, since fuel cost is zero. Ongoing efforts can be expected to bring costs down further. There are several ways to do this. One is to reduce the cost of manufacturing

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[4] Calculated by comparing expected BDD electricity costs in 2010, as calculated in May, 2006, assuming 5,230 AF pumped by the city, and 670 AF by the County, with actual electricity costs of the city and county in FY 04-05.
Expected BDD electricity costs : City, $625,398; County, $89,587.
Actual FY 04-05 electricity costs: City, $2,860,172; County, $456,448.
[5] A metric tonne is 1,000 kilograms, and is equal to 2,205 pounds.

photovoltaic cells. Another is to increase their efficiency, which is now about 10% in actual operation. Another is to reduce installation costs, which are now a large component of the cost of photovoltaics.

Federal and state subsidies offset part of this cost for home owners and businesses. **Handout 6** lists these. In addition, photovoltaic systems can be hooked up to the electric grid, both to provide backup power when the sun isn't shining, and to sell power back to PNM when it is not being used by the owner. New Mexico requires net metering for residential-scale photovoltaic systems, and PNM has gone even further by establishing a program that not only buys the excess at the same price that you pay for electricity, but also pays an additional 13 cents per kilowatt-hour for all electricity generated by photovoltaics hooked up to the grid, whether it is used by the homeowner or fed back to the grid. The 13 cents pays for the renewable energy credits that PNM acquires from these systems.

A local solar energy firm has calculated costs of typical residential and commercial photovoltaic installations after adjustments are made for these subsidies. These are included as **handouts 5a and 5b**. Currently the payback time for a residential installation of 1.95 Kilowatts is about 33 years, but for a commercial installation, due to economies of scale, it is around 12 years.

Solar heating technologies use solar heat for such purposes as providing domestic hot water, pool heating, or space heating. The current cost of solar water heating systems is about eight cents per kWh, which makes them competitive with grid electricity from a cost standpoint. This is, of course, installation cost, as fuel costs are zero. On-going research aims to reduce costs to about 4.5 cents per kWh.

Now we move from residential scale technology to technology suitable for generation plants, that is, concentrating solar collectors.

In concentrating collectors, the area intercepting the solar radiation is greater, sometimes hundreds of times greater, than the absorber area. Most current systems use highly reflective mirrors to heat a working fluid, from which heat is transferred to produce steam. The steam is then used in a turbine coupled to a conventional electricity generator. When coupled with storage, these systems provide firm, non-intermittent electricity generation.

These systems can be configured in a number of ways. One is a parabolic trough, which is a long parabolic mirror with a tube running its length at the focal point which carries the working fluid to the generators. Nine large parabolic trough plants have been operating in California since the 1980's.

In another configuration, the receiver is a tower filled with a molten-salt working fluid. This system uses from hundreds to thousands of flat sun-tracking mirrors called heliostats to reflect and concentrate the sun's energy onto the receiver tower. The hot salt can be stored to allow power production even when the sun is not shining. Plant size can range from 30 to 200 MW. Power towers must be large to be economical. Though power towers are in the early stages of development, a small test facility in California provided enough information to scale up to a 15 megawatt commercial plant in Spain.

Still another configuration is a dish-shaped reflector which concentrates solar heat on a photovoltaic module mounted at the focus of the dish. A number of prototypes are currently operating in the western United States and in Spain.

The advantage of concentrating sunlight is that it allows the use of more efficient photovoltaic cells. A company called Spectrolab has announced that it has developed a photovoltaic cell that is 40% efficient when using concentrated sunlight. For comparison, photovoltaics used in non-concentrating installations currently have efficiency in actual use of about 10%.

There are no local examples of concentrating solar technology. However, PNM's 2007 Electric Resource Plan states that the company has tentative plans to add 25 to 50 MW of concentrating solar power around 2010 or 2011. Plans are still unformed; neither a site for the facility nor its technology—for example, whether or not it will include storage—has been decided.

As yet the cost of electricity from photovoltaics is not competitive enough to warrant installations in public buildings unless concerns about greenhouse gas emissions greatly outweigh cost considerations. New Mexico does not have any subsidies for installation of solar energy devices in public buildings, with the exception of two programs to promote energy efficiency and solar energy in schools. Furthermore, the tax credits that apply to residential and commercial systems do not apply to public buildings, and the economies of scale are not sufficient to offset this lack.

While solar electricity from photovoltaics is currently more costly than electricity from fossil fuels by a factor of at least 5, experts agree that solar energy has enormous promise as an economical source of electricity. There is confidence that costs will continue to fall as production of photovoltaics increases, and there is reason to believe that ongoing basic research in materials will provide the kind of breakthrough that will lower costs even more rapidly. The challenge for local governments is to decide, as new facilities are built, what sort of investment to make in possible future use of photovoltaics.

Our discussion of solar energy is a good lead in to the final part of this presentation, which deals with how we as individuals can participate in making the world "greener".

Actually, we can do a lot without turning to alternative energy at all. We can participate through improvements in our homes, and in the ways we use our vehicles. **Handout 7** presents several strategies, ranging from relatively cheap to relatively expensive, which are available to most of us. All of these focus on conservation:

reducing energy waste. You can get Federal and State subsidies for both alternative energy and energy conservation upgrades.

Although about 50% of all our energy is used in buildings, more than one local business selling home solar systems advises consumers not to install such systems before taking some simple steps to conserve energy. As an example, an acquaintance of one committee member was about to replace her furnace because “it came on too often.” What was needed was not a new furnace, but simple weatherization of her home to keep the heat from escaping. We hope you will find at least one or two new ideas in our handout.

This concludes our first energy presentation. In our second presentation, this October, we will take up biomass energy, geothermal energy, and conservation, and we will present consensus positions for discussion. The Santa Fe Community College has scheduled installation of a biomass boiler to provide heat to its campus by this autumn, so our study of biomass energy will be quite timely. In the meantime, for those who want to read more about alternative energy, **Handout 8** lists a number of informative web sites that we have run across in the course of our study.