Lecture-33

Energy Conservation in agriculture

India is currently following a development path which aims to remove income and energy poverty of millions of households. As a result, energy requirements of the country are expected to rise. While India's energy intensity is on a decline due to structural changes in the economy and improvement in energy efficiency, overall energy requirements would grow due to growth in economic activity. For the power sector alone, the generation capacity should reach 8,00,000 MW by 2031-32, nearly a five-fold rise from the current levels (GOI, 2006). The Indian power sector offers a lot of scope to improve on existing efficiencies in generation, distribution and utilization of electricity. The resultant savings in fossil fuel consumption would translate to a large potential for reductions in associated carbon emissions. The per capita electricity consumption in India is recorded to be 704.2 kWh in 2007-08. This is quite low as compared to the that recorded in 2006 for China (2041), high income OECD countries (9774), high income countries (9675) and the world average (2751) (World Bank, 2009). A large proportion of the Indian population continues to face income as well as energy poverty. In the future, electricity consumption per capita is likely to rise to meet the basis needs of those not served with electricity. Furthermore, increasing economic activity would place a greater demand for energy resources. In the past, investment in capacity expansion, extension of the distribution network and end-use appliances was based on least cost. This was often at the expense of energy efficiency. This approach was partly influenced by a lack of financial resources, but also by a lack of institutional capacity and absence of incentives in electricity pricing. Although significant progress is being made to introduce efficient technology and to improve operational
performance in the power sector, efforts are limited due to financial scarcity as well as institutional constraints (Singh, 2009). The pricing anomalies in the power sector have been addressed in general by the SERCs to a varying degree. However, political compulsions continue to shield subsidized tariff for agricultural consumers across the country.

Energy scarcity, along with the local and global environmental impacts of energy use emphasise the need to speedily address inefficiencies in the power sector. However, numerous barriers including financial, technical as well as institutional exist and which impede the achievement of this objective. Singh (2009) discusses opportunities for efficiency improvements in the power sector and identifies the following three climate cobenefit policies; (i) adoption of efficient agricultural pump sets. (ii) modernization of the low tension (LT) distribution network to High Voltage Distribution System (HVDS) and (iii) adoption of clean and efficient coal-based generation technology. In spite of the known benefits of such policies, the progress thereof is rather limited, suggesting that the above mentioned barriers are hampering policy implementation. This paper attempts to identify the challenges in implementing a policy for nationwide programme to adopt efficient agricultural pump sets. Due to the presence of technical as well economic efficiencies associated with the policy, this exercise would offer a wider perspective amongst the three policies. India adopted a National Action Plan for Climate Change (NAPCC) last year. It proposed eight national missions with

climate related benefits including a National Mission on Enhanced Energy Efficiency (NME3) which has recently been approved (in-principle) by
the Indian Prime Minister. Apart from this, the Bureau of Energy Efficiency (BEE) has initiated large pilot projects under the Agricultural Demand Side Management (AgDSM) programme. This aims to reduce electricity consumption for irrigation by enhancing the efficiency of pump sets. This is discussed further in the next section. The main objective of this paper is to assess stakeholders' perspectives, through a survey,
on implementing a nation-wide policy for adoption of efficient agriculture pumps. This Further, the policy related to adoption of efficient agricultural pump sets also entails HVDS investment as a prerequisite. This is discussed further in the next section.

Policy for Adoption of Efficient Agricultural Pump Sets

The policy recommendation is to implement a joint programme for replacement of inefficient agricultural pump sets (including motor/engine and pump assemblies, piping, foot valves etc.) along with mandatory electronic metering of their electrical connections. Such a program should be supplemented with feeder metering and system modernization of the low tension (LT) distribution network with a High Voltage Distribution System
(HVDS). The distribution companies (discoms) should also undertake separation of rural feeders with partial support from Restructured Accelerated Power Development and Reforms Programme (R-APDRP). Irrigation pumps used in the agriculture sector account for about 25% of electricity consumption in India. This share is reported to be 48.89% in Gujarat, 43.39% in Haryana and 42.27 % in Karnataka. Due to subsidised tariffs, agricultural consumers contribute only a little to the revenue of utilities. Farmers, who pay HP-based flat rates irrespective of their electricity use, perceive zero marginal cost for electricity use and, hence, disregard efficiency in consumption. This is reflected in purchase preference for cheap but inefficient pumps. Various pilot studies have revealed the poor level of energy efficiency of these pumps. An energy audit of electrical pump sets at four field study locations in Haryana average pump set efficiency was found to be only 21-24% (World Bank, 2001). The study also found that only 2% of the pumps surveyed had efficiency levels above 40%. Phadke et al. (2005) find that a DSM program for replacing ineffieicnt agricultural pumps in Maharashtra would be cost effective by lowering the short-run cost of electricity generation in the state. More recently, an energy audit of a sample of pump sets at Doddaballapur Taluk of Bangalore Rural District in Karnataka was conducted under the Water and Energy Nexus (WENEXA) Project of the USAID. The study revealed that 91 per cent pumps were operating at the efficiency of less than 30 per cent (Oza, 2007). Subsidised tariffs for agriculture and domestic consumers are supported partly by budget subsidies from respective state governments. In 2007-08, this was estimated to be Rs. 141.6 billion (GOI, 2008). Apart from this, the SERCs continue to rely on cross subsidisation of tariffs by charging higher tariffs from industrial and commercial consumers to support lower tariffs for agriculture and domestic consumers. Flat pricing of electricity and unmetered supply continues to shield inefficiency in consumption and obscures operational efficiency of utilities. A policy to enhance efficiency of pump sets, to meter such consumption and to price electricity efficiently would have wider implications for the sector and beyond. A reduction in subsidy

requirement for the power sector would allow state governments to channel the funds to other social sectors including education, primary health and rural infrastructure. In this context, Singh (2009) proposed a national programme for adoption of efficient pumps for agricultural use to moderate the impact of above mentioned institutional inefficiencies.

INTERNATIONAL SUPPORT FOR DOMESTIC ACTION

We constructed alternate policy scenarios for varying degree of adoption of efficient pump sets by farmers. It is assumed that number of agricultural pump sets would grow to 20 million by 2011-12. In efficient scenarios, all new pump sets are expected to be efficient and hence require less number of hours of operation, and have 10% lower rated output. Similar is the case for all pump set replacements. The transmission and distribution (T &D) losses are expected to fall from 32.25% in 2007-08 to 25% by 2011-12. In a conservative scenario with little penetration of efficient pumps, it was estimated that about 5% reduction in carbon emissions can be achieved. In the case of an aggressive pump replacement scenario, a reduction in carbon emissions of up to 30% can be achieved.

There are multiple benefits for the power sector utilities as well. A lower demand for power from the agriculture sector would improve consumption profile towards better paying customers and, hence, would improve revenue realization per unit of electricity. Agricultural loads are rather spread out and hence incur higher technical losses. A change in consumption pattern away from agriculture could lower overall technical losses for the distribution utilities. It is often argued that due to the absence of metering, part of T & D losses are often camouflaged as consumption in the agriculture sector. Better metering and energy accounting would certainly help in bringing more transparency in the system. These are expected to improve operational as well as financial performance of distribution utilities. In the long-run, these changes would provide a conducive environment for efficiently pricing the electricity in a manner which provides incentive for energy conservation. A lower demand for electricity would necessitate lower investment for generation capacity addition in the sector in the long-run.

Drivers and Key Stakeholders: Agricultural Pump Set Replacement

Identification of drivers a policy implementation empowers the policy makers as well as the implementing agencies to commit resources. The importance of key drivers for implementing a nation-wide policy for pump set replacement would also assist in identifying benefits to various stakeholders and thus seek their cooperation and commitment. It is often noted that a lack of institutional capacity has resulted in failure of various public programmes both within and outside the energy sector. The most important drivers that support implementation of the suggested policy are identified as:

- Energy savings
- Reduced pressure on groundwater reservoirs
- Ability to manage tariff subsidy
- Enhanced transparency and accounting of energy consumption

- Facilitation of appropriate tariff design

It is important to note that benefits of the policy go beyond the power sector and has other environmentally benign outcomes, like by easing pressure on groundwater reservoirs. Due to lack of consumer metering and energy accounting, system losses have been camouflaged as high consumption in the agricultural sector (Singh, 2006). Improved transparency and energy accounting would not only plug revenue leakages, but may also reduce the tariff subsidies from state governments. The respondents to the survey identify the respective state governments as the most important actors for the implementation of this policy. This was followed by the distribution companies, central government and regulatory institutions. Furthermore, the respondents also identified a role for associated ESCOs / implementing agencies, who would undertake projects for replacement of inefficient pump sets. Given the crucial role to be played by stale level entities, a clear recommendation would be to strengthen institutional capacity with state-level agencies to successfully implement such a programme.

USDA's Cooperative State Research, Education, Extension and Service (CSREES)

leverages the nationwide expertise housed at land grant universities. CSREES provides funding for about 60 projects that include an energy-related objective. The goals of these projects include:

• Reducing costs associated with the conversion of biomass to energy and industrial products,
• Increasing biobased product inventories to replace petroleum based products,
• Developing technologies for effectively converting agricultural (including forestry) residuals into energy and products,
• Developing cost effective biocatalysts capable of converting lignocellulosic materials economically, effectively and with low environmental impact, and
• Identifying unique biomass feedstocks for the sustainable production of bioenergy and industrial products.

USDA's Farm Service Agency (FSA) administers the Conservation Reserve Program (CRP) and the CCC Bio-Energy Program. The CRP was established by the Food Security Act of 1985 to assist owners and operators in conserving and improving soil, water, and wildlife resources on their farms and ranches by converting highly erodible and other environmentally sensitive cropland and marginal pasture to long-term resource conserving covers. Participants enrol cropland in the CRP for a period from 10 to 15 years in exchange for annual rental payments and cost-share assistance for installing certain conservation practices. Enrollment of up to 39.2 million acres is authorized, and there are currently about 36 million acres under contract.

CRP lands sequester significant amounts of carbon dioxide in soils and vegetative cover and many CRP lands have the potential to be used for the production of bioenergy crops, such as

switchgrass, willows, and poplars. A 2003 analysis, for example, estimated that 13 million acres of cropland enrolled in the CRP could produce an average of about 4 tons of biomass per acre (dry matter) or over 50 million tons of biomass annually. The 2002 Farm Bill specifies the conditions under which CRP enrolled acreage can be utilized for biomass production. First, harvesting must be consistent with conservation of soil, water quality, and wildlife habitat, and second, payments must be reduced commensurate with the economic value of the biomass produced. Under CRP's Biomass Pilot Program established in 2000, USDA approved the use of CRP land in 4 projects located in 4 States. The programs approved include one each in Minnesota (hybrid poplars), New York (willows), Iowa (switchgrass), and Pennsylvania (switchgrass). Projects were also approved in Oklahoma and Illinois.

The CCC Bioenergy Program began on December 1, 2000, and ended on June 30, 2006. Under the program, cash payments were made to bioenergy producers who increase their annual bioenergy production from eligible agricultural commodities. Eligible commodities included barley, corn, grain sorghum, oats, rice, wheat, soybeans, other oilseeds, cellulosic crops, and animal fats and oils. From December 2000 through March 2006, the program reimbursed bioenergy producers $537 million for 2.5 billion gallons of increased ethanol production, 146.4 million gallons of increased biodiesel production, and 26.7 million gallons of base biodiesel production.

USDA's Office of Energy Policy and New U**se**s administers the Federal Biobased Preferred Products Procurement Program (FB4P), the USDA Certified Biobased Product Labeling Program and Biodiesel Education Program (BEP). All three programs were created by the 2002 Farm Bill. Under the FB4P, Federal agencies will be required to give procurement preference to qualified biobased products if the products are available, meet performance standards, and are available at costs similar to their non-biobased counterparts. Biobased products are defined as commercial or industrial products that are composed, in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or renewable forestry materials. The first in a series of rules to designate items for preferred procurement was published as a final rule in March 2006. Six items were designated for preferred procurement by this rule: mobile equipment hydraulic fluids, biobased roof coatings, water tank coatings, diesel fuel additives, penetrating lubricants and, bedding, bed linens and towels. The 2002 Farm Bill also provides for a voluntary program authorizing producers of qualified biobased products to use a "USDA Certified Biobased Product" label and logo to identify qualified products. The 2002 Farm Bill authorized funding of $1 million per year from FY 2003-07 for education grants under the BEP. Under BEP, two competitive grants were awarded to the National Biodiesel Board and the University of Idaho to educate the public, and government and private entities that operate vehicle fleets on the benefits of using biodiesel. Program funds have been used for organizing national conferences, conducting technical workshops, and distributing educational materials, including manuals on quality control. Many partnerships with other groups and government agencies have been formed to share information, leverage resources, coordinate activities, and avoid program redundancies. In addition to ethanol and biodiesel, biomass and animal wastes can be used to produce renewable energy. Biomass is used to

generate electric power by direct burning, using gasification systems, or mixing biomass with coal in coal-fired electrical generation facilities.

The primary feedstocks include wood waste used by the pulp and paper industry for industrial heat and steam production. In addition, forest residues and municipal solid waste are used to generate electricity. Another potentially large source of renewable energy is animal waste which can be turned into methane gas through anaerobic digestion. Anaerobic digesters are being adopted by commercial livestock operations not only to produce energy, but also to meet new state and Federal regulations for controlling animal waste. Currently, there are over 90 anaerobic digester projects, either in operation or under construction, located throughout the United States. Nearly all the anaerobic digesters are associated with dairy operations, with a few associated with swine or poultry operations. Another emerging approach to reducing U.S. fossil energy use is to replace petroleum based products with products made from biomass. There are many industrial and consumer products that have been traditionally made from biomass, including yarns and fabrics, soaps and detergents, pulp and paper, lubricants and greases, and adhesives and paints. However, agricultural feedstocks can be used to produce non-traditional products such as chemicals, plastics, hydraulic fluids, and pharmaceuticals. There are many agricultural feedstocks that can be used to make bioproducts, including a variety of crops, wood and plant oils, and agricultural and forestry residues. Bioproducts often require less energy to produce than the fossil and inorganic products they replace. With the increasing costs of fossil fuels, U.S. industries have an increased incentive to consider and produce alternative bioproducts. As examples of new biobased technology, corn starch is being used to produce bioplastic products, and soybeans are being used to produce a polymer used to manufacture carpet backings. The chemical industry could potentially offer a large market for numerous high-value biobased chemicals and other materials made from agriculture.

Progress is also being made in developing energy from solar, wind, and geothermal resources although the amount of energy from these sources is relatively small. Small-scale solar applications are already commercially available that provide electricity for lighting, battery charging, water pumping, and electric fences. There also has been an emergence of large-scale solar technology that is being used in homes and in the industrial sector. Small-wind systems are currently being developed to generate electricity in remote areas and utility-size turbines have been increasing in numbers, especially on farms in areas with consistently high wind speeds. More geothermal resources are being tapped to produce electrical or thermal energy in local areas. There are many agricultural applications for geothermal energy, including heating greenhouses, providing warm water for aquaculture operations, and drying produce. Although ethanol growth has been impressive in recent years, ethanol accounts for about 3 percent of total annual gasoline consumption. About 14 percent of the U.S. corn crop was used for ethanol in 2005/06 and USDA projects 20 percent of U.S. corn production will be converted into ethanol in 2006/07. Clearly, the supply of corn is relatively small compared to gasoline demand, so other domestic sources of renewable energy must be developed to replace oil imports if the U.S. is to greatly reduce its dependence on imported oil. Biodiesel can extend the diesel fuel supply, but the supply of oil crops, animal fats, and other

feedstocks are also relatively small compared to the diesel fuel market. Research may provide technological breakthroughs leading to a significant expansion in ethanol production. In the near future, ethanol's feedstock base could expand significantly with the advancement of technology that could economically convert switch grass and other low-valued biomass into cellulosic ethanol.

USDA's Forest Service (FS) also plays a major role in energy production and conservation. The FS is working to increase production of all energy sources in an environmentally sound manner, capitalizing on the potential of woody biomass as a renewable energy resource, and contributing to the improvement of infrastructure for transmitting energy across the country. Increasing domestic energy supply includes providing energy facility corridors, ensuring that lands are available for energy mineral development and production, developing renewable energy resources such as woody biomass, wind, solar power, and geothermal energy, and relicensing hydropower facilities. Nearly 50 percent of the nation's geothermal energy production comes from Federal lands. There are currently 354 federal geothermal leases, 116 on National Forest lands, covering nearly 360,000 acres. At the present time, there are 5 producing leases on National Forest lands contributing to a 12 mega-watt plant and a 45 mega-watt power plant that, combined, have resulted in more than $12 million in royalties.

The FS actively participates in a government-wide initiative aimed at promoting development and use of biobased products and bioenergy. Programs include research on enhancing opportunities to use forest biomass to produce energy and other value-added products; developing economical, environmentally acceptable woody cropping systems to produce energy and other value-added products; exploring new processes to convert wood into ethanol; and identifying ways to increase energy conservation through changes in manufacturing technologies, harvesting technologies, building construction practices, and designed landscapes.

The focus of the FS Biomass and Bioenergy efforts is woody materials that are not part of the commercial forest product material flows. Woody biomass includes forest vegetation treatment residuals (tree limbs, tops, needles, leaves and other woody parts) that are by-products of forest management and ecosystem restoration. Currently these materials are underutilized, commercial value is low, and markets are small to non-existent.

A recent joint USDA and DOE report, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*, commonly known as the "Billion Ton Report," projects that there are over 1.3 billion dry tons per year of biomass potential, enough to produce biofuels sufficient to meet more than one-third of the nation's current demand for transportation fuels by 2030. About one-quarter of that total, roughly 380 million dry tons of biomass could be produced in a sustainable manner from residues from private, State, Tribal and Federal forest lands and from forest wood wastes.
The Healthy Forest Restoration Act (HRRA) authorized the use of $5 million to help "establish small-scale business enterprises to make use of biomass and small-diameter material." These funds were to be used to: (1) help reduce forest management costs on

National Forest System lands by increasing the value of biomass and other forest products generated from hazardous fuel treatments; (2) create incentives and/or reduce business risk for increased use of biomass from or near national forestlands; (3) institute projects that target and help remove conomic and market barriers to using small-diameter trees and wood biomass.

Effects on Renewable Energy Production and Energy Efficiency

Federal and State governments have helped create markets for renewable energy through tax incentives and mandates. Ethanol production has increased sharply since the late 1990s, to 4 billion gallons in 2005 up from 1.8 billion gallons in 2001. Biodiesel production has grown to over 90 million gallons in 2005, a nine-fold increase from 2001. The EPACT mandates that 7.5 billion gallons of renewable energy be used in motor vehicles by 2012, guaranteeing a future demand for the renewable fuels. In addition to Federal and State programs, high oil prices and the phase out of MTBE have contributed to the growth in renewable fuels production since 2001. While modest in size compared with tax incentives, USDA programs have contributed to this growth. RD grants, loans, and loan guarantee programs supported the planning and construction of new production facilities and energy conservation projects, creating jobs and additional wealth enhancing opportunities in rural America. In total, 650 renewable energy and energy efficiency projects have been funded between FY 2001-05 at a Federal cost of $356 million. In addition, matching and funding by the private sector supporting these projects totaled another $1.3 billion. Included in these programs are 132 ethanol and biodiesel, 130 wind, 20 solar, 4 geothermal, 2 hydrogen, and 11 hybrid projects; 92 anaerobic digesters and 7 landfill gas recover systems; 168 energy efficiency projects; and other projects including solid fuel research.

In 2005, additional conservation practices applied with the assistance of USDA that improved energy efficiency on farms and ranches included:

- Residue management on 4.5 million acres,
- Irrigation water management on 1.2 million acres,
- Nutrient management on 4.1 million acres, and
- Pesticide management on 3.9 million acres.

There is a significant opportunity to realize immediate economic and environmental gains through energy conservation activities. Preliminary estimates of the potential national savings from implementing the following five conservation measures could be greater than $2 billion per year. The measures include:

- Doubling of no-till acreage (from 62 to 124 million acres), saving 217 million gallons of diesel fuel and $500 million each year;
- Switching from high or medium pressure systems to low pressure systems, lowering electricity use, and saving $100 million in pumping irrigation water costs;
- Increasing diesel irrigation pump efficiency by 10-percent, reducing diesel consumption by almost 26 million gallons, and saving farmers and ranchers almost $60 million each year;

- Doubling manure-based nitrogen use to replace fertilizer produced from natural gas valued at $825 million and 100 billion cubic feet of natural gas annually; and
- Using precision agriculture on more acres to reduce application overlap on 250 million acres of cropland, saving up to $825 million in fertilizer and pesticide costs each year.

In addition to ethanol and biodiesel, biomass and animal wastes can be used to produce renewable energy. Biomass is used to generate electric power by direct burning, using gasification systems, or mixing biomass with coal in coal-fired electrical generation facilities. The primary feedstocks include wood waste used by the pulp and paper industry for industrial heat and steam production. In addition, forest residues and municipal solid waste are used to generate electricity. Another potentially large source of renewable energy is animal waste which can be turned into methane gas through anaerobic digestion. Anaerobic digesters are being adopted by commercial livestock operations not only to produce energy, but also to meet new state and Federal regulations for controlling animal waste. Currently, there are over 90 anaerobic digester projects, either in operation or under construction, located throughout the United States. Nearly all the anaerobic digesters are associated with dairy operations, with a few associated with swine or poultry operations. Another emerging approach to reducing U.S. fossil energy use is to replace petroleum based products with products made from biomass. There are many industrial and consumer products that have been traditionally made from biomass, including yarns and fabrics, soaps and detergents, pulp and paper, lubricants and greases, and adhesives and paints. However, agricultural feedstocks can be used to produce non-traditional products such as chemicals, plastics, hydraulic fluids, and pharmaceuticals. There are many agricultural feedstocks that can be used to make bioproducts, including a variety of crops, wood and plant oils, and agricultural and forestry residues.

Meet expected new demands for rural electric generation and transmission.

Demand for new electric power generation capacity is building, after many years of little or no new base load capacity being added. Substantial increases in loan guarantee demands are expected. While USDA loan guarantees typically are for 95-100 percent of the loan, consideration may be given to develop a more traditional loan guarantee program for private lenders and use partial loan guarantees or create a mechanism for lenders to bid for the level of guarantee they would require to provide financing. Loan guarantees and planning grants could be targeted to support the development of distributed generation facilities using biobased fuel, wind, solar, or geothermal resources. Often the distribution grid must be augmented to accommodate the renewable or distributed generation power. Loan guarantee authority to support projects to upgrade the grid would help build renewable energy capacity. High voltage transmission capacity to move renewable energy from its source to demand locations is a serious constraint to renewable power development. Clarifying access rights and pricing for high voltage transmission could also be helpful in facilitating needed transmission development.