Direct Delivery of POWER SUBSIDY TO AGRICULTURE in India

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About SE4All

Sustainable Energy for All (SE4All) is a multi-stakeholder partnership working with business, civil society, governments and international institutions to promote public private partnerships to induce significant changes in the way energy services are produced and accessed to reach three global goals by 2030: (i) ensure universal access to modern energy services, (ii) doubling the share of renewable energy in the global energy mix and (iii) doubling the rate of improvement in energy efficiency worldwide. Launched by the UN Secretary-General in September 2011, the initiative is catalyzing major new actions and investments aimed at achieving the three main goals to speed the transformation of the world's energy systems, pursue the elimination of energy poverty, address climate change and enhance prosperity.

About ESMAP

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance program administered by the World Bank Group (WBG). It provides analytical and advisory services to low and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. This includes country-level activities to address specific national energy challenges, which are designed to inform country policy development and reforms, as well as follow-on investments by the WBG, its development partners, and national governments. ESMAP is funded by Australia, Austria, Denmark, Finland, France, Germany, Iceland, Lithuania, the Netherlands, Norway, Sweden, the United Kingdom, and the World Bank Group.

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The World Bank study team was led by Mohinder Gulati (Advisor- Energy) and Sanjay Pahuja (Lead Water Resources Specialist) and included Sudeshna Ghosh Banerji (Senior Enegy Economist), Mani Khurana (Energy Specialist), Anjali Garg (Energy Specialist), Paul Sidhu (Senior Agriculture Specialist), Rajinder Singh (Telecom Regulation Specialist), C. Subramanian (Power Engineer, contributed Annex D) and Srivatsa Krishna (Consultant). We are grateful to the consultant team who worked hard and came up with innovative ideas and suggestions. IWMI team led by Aditi Mukherji (Senior Researcher), included Tushaar Shah (Senior Advisor), R.P.S.Malik (Agricultural Economist), Shilp Verma, Upali Amarsinghe (Statistician) and Nitya Chanana (Researcher). Infosys team was led by Vivek (Partner) and included Mitul Thapliyal, and Sachin Sinha (Consultants). Extensive consultations were held with the Planning Commission, Ministries and Departments of Government of India; power, finance, agriculture and groundwater departments of the three participating state governments and their power companies; farmers for survey and focus group discussions; Columbia Water Centre, Columbia University; Punjabi University; State Electricity Regulatory Commissions; Administrative Staff College of India; USAID; and Cellular Operators (both the GSM and the CDMA Associations). Hundreds of people contributed with their time and provided valuable insights and advice. We are most grateful to them for generously sharing their insights and time.

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Electricity Distribution Company; K.D. Chaudhary (Chairman), and A.K. Verma (Director) Punjab State Power Company; Vijay Modi, Earth Centre, Columbia University, and Nandan Nilekani (Chairman) UID.

The study was peer reviewed by R. Vasudevan, former Secretary (Power), Government of India; N. Sreekumar, Prayas; Prof Christopher Scott, University of Arizona; Sunil Khosla, Lead Energy Specialist, World Bank; Rohit Khanna, Program Manager and Sameer Shukla, Senior Energy Specialist, ESMAP; Pedro Antmann, Lead Energy Specialist, World Bank. The editorial help of Paul Yillia (Water-Energy nexus expert) and Jinsun Lim (Junior Professional Officer) Sustainable Energy for All, their patience, and ability to deliver under tight deadlines to make up for our inertia, made it possible to finally publish this book.

The financial and technical support by the Energy Sector Management Assistance Program (ESMAP) is gratefully acknowledged. ESMAP – a global knowledge and technical assistance program administered by the World Bank – assists low- and middle-income countries to increase their know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth. ESMAP is funded by Australia, Austria, Denmark, Finland, France, Germany, Iceland, Lithuania, the Netherlands, Norway, Sweden, the United Kingdom, and the World Bank Group.

Foreword

Kandeh K. Yumkella

Special Representative of the UN Secretary-General & Chief Executive Officer, Sustainable Energy for All (SE4All)

This report is a significant contribution to the global debate on the vital links between water, energy and food. The authors have made an attempt to examine the negative consequences of formulating policies in isolation for three related sectors in India. There is no doubt that groundwater-based irrigation is the engine of the agriculture sector and economic productivity in rural India, with major multiplier effects for rural agri-businesses, produce and service markets, employment generation in rural areas and improved livelihoods. However, a combination of outdated energy policy and the absence of an appropriate policy for efficient groundwater management have contributed to a persistent culture of inefficient power supply and suboptimal agricultural productivity. Hence, farmers are suffering from poor quality of electricity delivery to pump groundwater for irrigation as we read in the report.

The report illustrates how state governments in India, the power sector and farmers are all locked up in what is described as a persistent downward spiral of distrust and inefficiency. In a candid way, the report shows that even though farmers are supposed to be benefiting from subsidized power supply, the mechanisms of subsidy delivery has broken the links that keep power utilities accountable to agricultural consumers and vice-versa. The report is a significant step forward for anyone seeking new approaches to address and overcome this intractable problem facing the state governments, farmers and power utilities in India for decades.

The authors have suggested a five-stage modular subsidy delivery model though which all stakeholders, including the state governments, power utilities, and farmers can work together to move out of the downward spiral of mistrust and inefficiency. I have no doubt that the proposed approach is clearly a genuine blueprint for an integrated decision making framework. The scheme combines innovative ICT tools and concepts, as well as performance-based incentives and management instruments to deliver energy subsidy to agriculture. It includes options that can be implemented within existing institutional frameworks and public policy choices of power subsidy to agriculture, to create a sound policy environment for sustainable energy and agriculture practices.

Ideally it is crucial to improve energy access to farmers but it is equally important to do so in ways that can ensure that social benefits from increased access are delivered in commercially viable and environmentally sustainable ways. This is a fundamental SE4All narrative on our approach on universal access to energy, and that is partly what this report is about. The authors' recommendations are valuable for decision makers in the region and even beyond. Globally, we are facing an increased demand for essential resources, be it water, energy or food. Our prospects of coping adequately now and in the future will depend largely on our ingenuity to manage and use these resources more efficiency and more sustainably.

Foreword

V.S. Sampath, IAS (Retired)

Chief Election Commissioner of India (Retired)

What India does in the next decade to make its manufacturing competitive and agriculture profitable would define the script of its economic growth and fight against poverty. Both the industrial growth as well as improving agricultural productivity are critical for creating jobs for India's ten million young who would be joining the ranks of unemployed every year. Both require electricity to propel their production.

Subsidized, and sometimes free, power to extract groundwater has stimulated agricultural growth and rural economy in India. However, delivering this subsidy through unmetered power supply has caught both power and agricultural sectors in a vice-like grip. Unmetered power supply renders estimates of electricity consumption by agriculture, and therefore subsidy claimed by the power utility, a disputable claim. It has led to inefficient use of electricity and groundwater, and depletion of groundwater threating aquifers that in turn increases production risk and climate vulnerability of farmers. It has also eroded commercial discipline in power utilities, helped camouflage theft and inefficiency, weakened financial viability of the power utilities. Operationally inefficient and financially distressed power utilities find it difficult to finance the system expansion to meet electricity demand of a growing population and economy. Indian power sector has suffered from stubborn energy and peak-capacity deficit for the last six decades.

Subsidy by the government pays, in varying proportions, for delivering benefit to the farmer, end-use inefficiency, inefficiency of the power utility, and theft of power by non-agricultural consumers. The public policy choice of free or highly subsidized power has been quite wrongly translated into "unmetered" power. Current system of power subsidy to farmers is delivering much less than intended benefit to them, is making power utilities financially unviable and unable to finance investments, and putting a fiscal burden on the state. High trust-deficit between farmers, power utility, and the government has so far eluded a mutually acceptable solution.

The proposed approach of offering a choice to the farmers to opt for direct delivery of power subsidy, use of information and communication technology, financial incentives for the farmers to use energy and groundwater efficiently, and offering results-based incentives for the employees holds enormous potential to address a problem that has eluded India for more than four decades. A modular program, it should be piloted in a few states in India to field-test the concepts, learn by doing, overcome the mistrust of the farmers and the power utility employees and refine it before it is rolled out through the state.

Having worked with a state and the central government in the fields of agriculture, energy and finance, I realize the enormous complexity of the challenge but also the huge benefits that can be realized if this intractable problem can be solved. The scheme proposed in this report offers a potential solution. I fervently hope the governments and the farmers would collaborate and make efforts to implement it.

During his career with IAS, Mr Sampath has also served as Secretary (Power), Government of India, and with Government of Andhra Pradesh as Principal Secretarty (Finance), Principal Secretary (Energy), Commissioner (Agriculture).

Preface

India is at the cusp of accelerating its economic growth. Quoting former Chief Election Commissioner of India, Mr. Sampath " What India does in the next decade to make its manufacturing competitive and agriculture profitable would define the script of its economic growth and fight against poverty. Industrial growth and improvements in agriculture productivity are critical for creating jobs and both would require electricity to propel production." Can Indian states rise to the challenge of improving their power sector to meet rising demand for electricity.This report offers solutions to one of the most intractable problems of Indian power sector.

Since 1970s, state governments in India adopted a policy of providing free or subsidized power to farmers to increase agricultural productivity. As the number of tube wells started increasing exponentially in the 1970s, the utilities removed meters and introduced flat tariffs for agricultural electricity supply to save the transaction costs. However, the dynamics of electoral politics led to populist policies to increase subsidies and many states shifted to free and "unmetered supply" to agriculture which has undermined energy accounting and internal accountability in power utilities. Lack of verifiable energy accounting helps hide inefficiency and theft of electricity by non-agricultural consumers that gets classified as agricultural consumption which in turn leads to disagreements between the government and the power utilities on claims for subsidy payment. Weak financial performance of the power utilities has hindered infrastructure maintenance and ability to finance the required investments. Cheap or free power erodes farmers' incentive to use energy and groundwater efficiently and groundwater overexploitation has reached near-crisis level in several states dominated. As a result, the distorted incentives for all stakeholders have trapped farmers, power utilities, consumers and governments in an inefficient low-level equilibrium.

Most proposals that have been put forth in the past to address the "energy-groundwater nexus" involve withdrawing power subsidies and reintroducing pricing for agricultural power. However, under the present political economy and state of agriculture, a solution to address the energy-groundwater nexus cannot be considered realistic if it is based on a withdrawal of subsidies from farmers. At the same time, it is also clear that the current system of electricity provision to agriculture is unsustainable, from energy, groundwater, and also fiscal perspectives.

Solutions to this intractable problem had so far eluded the Indian power sector. A search for solutions through multi-stakeholder consultation, review of global experience, and use of most recent developments in metering, information and communication technology was launched in December 2010 at the request of the Planning Commission of India (now transformed into National Institution for Transforming India- NITI Ayog). Three Indian States- Andhra Pradesh, Karnataka, and Punjab volunteered to participate in the study. Several consultations were held with the Planning Commission, Ministries and Departments of Government of India, State Governments and their Departments of Energy, Finance, Agriculture, Groundwater and the power companies. Farmer surveys and focus group discussions were held with farmers at select locations in Karnataka and Punjab.

In this report, we offer a politically feasible and effective approach to solving a problem that has dogged the Indian agricultural, groundwater and power sector for more than four decades. We propose a transparent, efficient and politically feasible scheme for delivering power subsidies, which offers farmers improved service delivery, as well as incentives to use electricity and groundwater efficiently *despite receiving free power*. A modular implementation plan is presented which takes into account different political, agricultural, and institutional capacity contexts of different states in India. We are convinced our proposals will improve operational and financial performance of power utilities and create enabling conditions to improve rural power supply without increasing the states' fiscal burden.

We hope that this report would help policy makers, farmers, power utilities and regulators to formulate mutually acceptable solutions that increase agricultural production and rural livelihood and in addition improve the operations of the power sector in its quest to become an engine of economic growth in India.

Mohinder Gulati
Sustainable Energy for All

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Abbreviation & Acronyms

AEL	Annual Energy Limit
AISP	Agricultural Input Subsidy Program
AMI	Automated Metering Infrastructure
AMR	Automated Meter Reading
APSPDL	Andhra Pradesh Southern Power Distribution Company
ARRs	Annual Revenue Reports
BEE	Bureau of Energy Efficiency
BESCOM	Bangalore Electricity Supply Company Limited
BHOOMI	Karnataka Land Record Digitization
BIS	Bureau of Indian Standards
CCAP	The Center for Clean Air Policy
CEA	Central Electricity Authority
CMRI	Common Meter Reading Instrument
CSOs	Civil Society Organizations
CWC	Columbia Water Center
DRUM	Distribution Reform Upgrade and Management
ESMAP	Energy Sector Management Assistance Program
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HVDS	High Voltage Distribution System
IAS	Indian Administrative Service
ICT	Information and Communication Technologies
IDMS	Integrated Database Management System
ISGTF	India Smart Grid Task Force

IWMI	The International Water Management Institute
KVCTP	Kerio Valley Cash Transfer Project
LAN	Local Area Network
M&E	Monitoring and Evaluation
MDMS	Meter Data Management System
MES	Minimum Energy Support
MGVCL	Madhya Gujarat Vij Company Ltd
MoP	Ministry of Power, Government of India
MSEDCL	Maharashtra State Electricity Distribution Company Ltd
NABARD	National Bank for Agriculture and Rural Development
NASA	National Aeronautics and Space Administration
NDPL	North Delhi Power Ltd
NGO	Non-Governmental Organization
NREGS	National Rural Employment Guarantee Scheme
PDA	Personal Digital Assistant
PFC	Power Finance Corporation
PLCC	Power Line Carrier Communication
PPP	Public Private Partnership
PSC	Project Steering Committee
PSERC	Punjab State Electricity Regulatory Commission
PSPCL	Punjab State Power Corporation Limited
R-APDRP	Restructured-Accelerated Power Development and Reforms Programme
SE4All	Sustainable Energy for All
SMEs	Small and Medium-sized Enterprises
T&D	Transmission and Distribution
TERI	The Energy and Resources Institute
ToD	Time of day
ToU	Time of use
TPDDL	TATA Power Delhi Distribution Ltd
WBSEDCL	West Bengal Power Distribution Company Ltd

Table of Contents

FIGURES

TABLES

BOXES

ANNEXES

Executive Summary

While electric-powered groundwater irrigation is quite prevalent in the world, a specific confluence of historical, policy and political factors has trapped many Indian states in a vicious spiral of declining groundwater levels, stagnant or declining agricultural productivity, deteriorating power service delivery, and bankrupt electricity utilities. The large scale and the specific modality of providing subsidized unmetered power for groundwater irrigation has introduced severe distortions in the power and water sectors, and its use as a tool in electoral politics has become so entrenched that the problem, referred to as the "energy-groundwater nexus", seems almost intractable.

Until the early 1970s, the state electricity utilities in India levied water charges on electric tube well owners based on metered consumption. As the number of tube wells started increasing exponentially in the 1970s, the utilities removed the meters, stopped recording consumption, and introduced flat tariffs for agricultural electricity supply. The objective was to save the transaction costs and to gradually increase the flat tariff in line with electricity generation and supply costs. However, the dynamics of electoral politics made it difficult to increase tariffs; instead, the political parties adopted competitive populist policies to increase subsidies and many states shifted to free and unmetered supply. As a result, farmers today have come to expect free or highly subsidized power as a given; and there is a perception that undertaking the highly unpopular measures of reducing or withdrawing the power subsidies would be equivalent to political suicide for state-level policymakers.

As a result, the groundwater-electricity nexus has trapped farmers, power utilities, consumers and governments in an inefficient low-level equilibrium. Providing unmetered supply to agriculture has undermined energy accounting in power utilities and impaired their internal accountability systems. In addition, lack of verifiable energy accounting helps hide inefficiency and widespread theft of electricity by non-agricultural consumers that gets classified as agricultural consumption. The average technical and commercial loss in the electricity sector in the country is now as high as 40%, and more than 75% of the total technical loss and almost 100% of commercial losses occur during distribution. While the total electricity consumption in India increased 12-fold from 1971-2000, the estimated agricultural electricity consumption has grown 25-fold during the same period. In addition to damaging financial performance, electricity subsidies have eroded skills development among utility staff, hindered infrastructure maintenance, and undermined the utilities' ability to finance the investments required to meet the increasing demands for electricity. Since power is cheap or free, farmers have no incentive to use energy and groundwater efficiently. Groundwater overexploitation has reached near-crisis level in the states dominated by electric tube-wells and cheap or free power – the nine states of Punjab, Andhra Pradesh, Karnataka, Haryana, Gujarat, Rajasthan, Madhya Pradesh, Maharashtra and Tamil Nadu together account for 85% of India's groundwater blocks that are in critical condition. If current trends of declining groundwater tables continue, 60% of all aquifers in India will be in critical condition by 2025. While the farmers are ostensibly the beneficiaries of subsidized electricity, they suffer from a *de facto* 'de-electrification' – rationing and poor quality of electricity delivery – which results from the lack of accountability of the power utilities to the farm-sector users. Farmers suffer power rationing and poor supply quality such as voltage fluctuations, frequency, low voltage, frequent interruptions, and phase imbalances that have hit rural areas with substantial economic costs. Poor quality of power supply imposes significant coping costs on farmers, lowers the quality of life in rural areas, and hampers the growth of local industries and commercial enterprises. Therefore, the current system of delivering subsidized electricity to farmers actually imposes substantial economic costs on the farm-sector as well.

Most of the proposals that have been put forth to address the "energy-groundwater nexus" involve withdrawing power subsidies and reintroducing pricing for agricultural power. Conceptually, these approaches are the clearest, but the experience from the attempts made in this direction indicates that they are likely to fail. This is because any viable approach to change the status quo needs to acknowledge and work with three realities. First, it ought to be understood that farmers are reluctant to relinquish access to subsidized power, even when utilities promise supply-quality improvements. Second, political decision makers will always avoid implementing a rational price regime for power supply to the agricultural sector because it is hugely unpopular. Finally, rural prosperity is largely driven by the irrigation economy in which groundwater plays an increasingly important role both through the provision of direct benefits to farmers and through multiplier effects via local markets. Therefore, under the present circumstances, a solution to address the energy-groundwater nexus cannot be considered realistic if it is based on a withdrawal of subsidies from farmers. At the same time, it is also clear that the current system of electricity provision to agriculture is unsustainable, from energy, groundwater, and also fiscal perspectives. While a systemic solution based on rational pricing of electricity is definitely needed, further delays in addressing the groundwater-electricity nexus will compound the damage already done to government budgets, utilities, farmers, groundwater resources, and the overall environment.

This study report proposes a transparent, efficient and politically feasible scheme for delivering power subsidies, which offers farmers improved service delivery as well as incentives to use electricity and groundwater efficiently *despite receiving free power;* can improve operational and financial performance of power utilities; and can create enabling conditions to improve rural power supply without increasing the states' fiscal burden. The proposal is based on recent technological advances, but with ample field-level evidence of technical and financial feasibility.

THE PROPOSED ALTERNATIVE: DIRECT DELIVERY OF POWER SUBSIDIES

The proposed approach does not question the public policy choice of providing free or subsidized power. Instead, it focuses primarily on improving the efficiency, equity and cost–effectiveness of delivering power subsidies to farmers. Under the proposed scheme, farmers would have a choice-either to continue with the current system of limited hours of free/subsidized power supply, or to adopt the new system of longer, more convenient, hours of supply-still free/subsidized but the subsidy would be denominated in quantity of electricity instead of hours of supply. Coordinating direct delivery with ongoing complementary schemes for groundwater and agriculture improvements has significant potential to enhance the impact and effectiveness of the proposed scheme.

There are four key elements of the proposed scheme:

(i) *Segregated feeders:* Segregated electricity feeders would provide rapid power supply improvements for rural residential and commercial consumers; provide villagers with quality-of-life benefits such as household lighting, education, entertainment, and small appliance use; generate opportunities for micro enterprises to invest in off-farm and non-farm income-generating activities; and help realize the potential of 'smart' rationing and synchronizing farm power supply with the needs of agricultural operations. The Government of India has recognized the benefits in a flagship program to support rural feeder segregation in its XIIth Five-Year Plan.

(ii) *Minimum energy support (MES):* The MES would provide an annual electricity allocation to each farmer for agricultural use. The MES could be defined either in number of hours of supply or in quantity of electricity (kWhs), and amount of subsidy can be estimated either on the basis of connected load or the size of land holding. If subsidy is determined on the basis of land holding, the quantum would depend on land categories, which could be assigned in each state according to the agro-climatic-groundwater zones. Electricity requirement estimates for existing agricultural operations would be prepared and finalized through farmer consultations and participation of agricultural experts. Building broad-based support for the land-holding-linked power subsidy allocation would require considerable consultation with farmers but because the new subsidy scheme is optional at the feeder level, the task would be lightened. To gain farmers' trust, the allocation should be embedded in power sector policy and regulations, and offer the freedom at feeder level to opt out after a defined period of perhaps two years after scheme implementation. Electricity saved by the farmer through efficient use or conservation could be either added to the MES for the following year or encashed at the regulated tariff level at the option of the farmer. This would completely shift the farmer incentives toward more efficient energy and groundwater use even while continuing to receive free power because efficiency gains can be retained or monetized. A kWh-based subsidy would also allay framers' apprehensions about tariff increase. Since at the feeder level, the farmers would have an option to continue with the existing system or choose the new system of direct delivery of subsidy, it is unlikely to face political resistance. On the contrary, the state-level decision-makers would reap political benefits from efficient subsidy distribution and improved power supply to villages.

(iii) *Smart metering and subsidy delivery via ICT-based instruments:* Smart metering that can be read online in real time is a well-established and cost-effective technology that could be easily adopted in India where mobile connectivity is widespread. Both CDMA and GSM service providers in India have confirmed that they can support this technology. The experience from implementation of various initiatives and projects in different states of India (implemented by the Columbia Water Centre and WENEXA), as well as the results from farmer surveys commissioned for this study, show that farmers can be persuaded to accept power metering as a part of smart subsidy solutions. Farmers could use their mobile phones to remotely control their pump sets and power use, and also receive power supply, consumption, and billing information, freeing up time for more productive activities. Other benefits include smarter power supply regulation to agriculture, accurate energy accounting, and efficient billing; also, performance-based incentives for the power utility staff could become more transparent, and the ability to differentiate peak from off-peak power consumption will provide incentives to consume during off-peak hours. Farmers would be treated by the power utility as a paying customer rather than a politically imposed burden.

(iv) *Performance-based incentives for power utility employees:* Creating performance-based incentives will be critical to gain utility employees' support for implementing and sustaining the scheme. Incentives will need to be specific, quantifiable, equitable, and transparent. Under this scheme targets could be set at each level: at rural feeder-level, the performance parameters could be reduced technical losses and improved bill collection, for both farm and non-farm power feeders; at the Division/District level, the performance could include additional measures such as maintenance of agreed supply schedule for "opt-in" feeders, and customer satisfaction; at the Corporate level, improved performance could be linked to stock options for all employees, divestment of shares to employees and customers served by the company, and a stock exchange listing for the distribution company.

The current system delivers the power subsidy through rationed and inconveniently rostered supply; suffers from constant disagreements between the government, regulator, and the utility on the estimates of supply to agriculture and losses; and causes inadequate and delayed payments of subsidy to the utilities; resulting in quasi-fiscal deficits accumulating in the balance sheets of the power utilities and leading to a lose-lose proposition for all stakeholders except the beneficiaries of corruption and inefficiency. The proposed alternative approach will denominate the quantum of power subsidy in a transparent manner; provide longer hours of supply and more flexibility of use to the farmers; deliver subsidy directly to the beneficiaries through an ICT-based instrument such as smart card/bar-coded voucher that can be used for paying the bills. The proposed approach would help provide better estimates of agricultural power consumption and of losses, thereby making theft by other customers more difficult; and can potentially reduce the subsidy burden on the government while maintaining or increasing the subsidy benefits to the farmers.

THE STATE OF TECHNOLOGY AND IMPLEMENTATION EXPERIENCE

The individual elements of the proposed scheme are all proven and well established. In combination, these elements leverage the value proposition – an innovative, cost-effective, and efficient delivery system for subsidies. India and many other countries have considerable experience in implementing each of these elements.

- *Feeder segregation:* A recent World Bank evaluation of feeder segregation in some Indian states concluded that each utility/State must develop the most techno-economically feasible approach based on its existing state of infrastructure, loss levels, consumer mix, financial and metering status, and physical and socio-economic conditions. Seven Indian states-Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab and Rajasthan – have undertaken rural feeder segregation. Gujarat pioneered feeder segregation through its Jyotigram scheme and has achieved very good results in improving power supply to villages thereby improving village economies and quality of life while containing subsidies. The High Voltage Distribution System included in feeder segregation in Punjab improved quality of supply to agriculture. Rajasthan and Haryana have achieved mixed results, while other States are in various stages of implementation. Recognizing the benefits, the Government of India has launched a flagship program to support rural feeder segregation in its XIIth Five-Year Plan.
- *Minimum energy support:* There are numerous examples of direct transfer of subsidies. Spain uses a European Union program which pays subsidies of 420Euros/ha to reduce groundwater extraction. Mexico implements a cap on the quantity of subsidized electricity through a formula-based approach, and is now considering direct cash transfer to farmers in lieu of tariff subsidy. Oman subsidizes the electricity tariff for agriculture but meters consumption and plans to implement consumption quotas. Bangladesh provides a direct subsidy for diesel fuel purchase to eligible farmers based on their land-holdings. Block tariffs with concessional rates for lifeline consumption is generally considered to be the simplest form of minimum energy support.
- *Advanced metering infrastructure and use of ICT to deliver subsidy:* India is well positioned to leapfrog the technology frontier by combining Automated Metering Infrastructure (AMI) with cellular communication technology for agricultural consumers. AMI reduces billing

costs and theft, and improves service outage management, load management and customer service. Wireless would be the most appropriate technology for the Indian context, given the country's extensive mobile phone networks and utility power lines. AMI has been successfully deployed in North America, Europe, South America, and East Asia, and is being promoted in India through the India Smart Grid Task Force. A detailed cross-sectoral selection of ICT-enabled systems for direct delivery of subsidy was assessed for appropriateness in the Indian context. The findings conclude that an electronic system (such as bar-coded vouchers or smart cards) would be the most appropriate instrument for implementing subsidy delivery at the user level.

- *Performance-based incentives:* Since traditional merit increases to base pay have been eroded, many corporations have tried performance-based incentives to improve productivity. These programs are aimed at work team, department, and corporate performance or a combination of three. Indian companies started using not only cash incentive but also Employee Stock Options (ESOPs) since the last decade. As of 2008, more than one hundred companies listed on Mumbai Stock Exchange had issued ESOP schemes. Even some state power utilities such as Maharashtra, West Bengal, and Haryana have instituted some or other form of performance-linked incentives.

Ideally, the proposed approach for direct delivery of irrigation power subsidy should include interventions that can create additional incentives for farmers to increase irrigation efficiency and incomes, such as laser leveling, timed irrigation with tensiometer, micro-irrigation technologies such as drip irrigation and sprinklers, delay in paddy transplantation, system of rice intensification and short-duration rice varieties. There are several recent examples across different states of India that show how thoughtfully designed programs to improve water and agriculture productivity can tap the potential of "last-mile" interventions for maximizing positive impacts. While these interventions are not an essential requirement for direct delivery of power subsidy, they can link the improvements in power delivery and groundwater with higher returns from agriculture, and thus integrating them in the implementation plan will contribute to building a farmer constituency of support.

GETTING THERE – ALIGNING THE STAKEHOLDERS' INTERESTS

Currently farmers do not trust commitments made by the government and the power utility to deliver subsidized power supply as promised. Equally, the government and the power utilities think farmers do not use free power in an economic and efficient manner. The government and the regulators do not trust the power utility about its reporting of losses and agricultural consumption. The key challenge in implementing the proposed approach will be to build trust among stakeholders through meaningful consultations and by implementing successful pilots. The scheme for direct delivery of power subsidy should be supported through a policy instrument and changes in electricity regulation. From a political economy perspective, the various stakeholders are expected to support the proposed approach because of the following benefits that will accrue to them:

- Farmers will gain control and flexibility to optimize use of a scarce resource if MES is defined in terms of quantity of supply and hours of supply are gradually increased. Incentive to pump more carefully and availability of technologies and incentives to conserve water may also help improve groundwater availability. Farmers' ability to synchronize irrigation with requirements of crops will reduce their production risk.
- State governments will gain a handle on the fiscal burden and will pay only for the subsidy actually delivered to beneficiaries.
- Power utilities will improve transparency in agricultural consumption and losses and reduce technical and commercial losses, which will increase their creditworthiness and ability to

raise commercial financing and investments in expansion of capacity and network. Their staff will get incentives for performance, opportunities for career development and professionalism, and a share in the financial growth of their company.

- Politicians will gain the support of satisfied farmers and consumers who benefit from improved services.

Direct delivery of power subsidies to farmers will constitute a paradigm shift in the political and commercial relationships between government, the farmer, and the power utility; and implementing it will require overcoming decades of mutual distrust, an abysmal record of deteriorating supply quality to rural areas, and weak public and corporate governance. Key additional constraints to be overcome for implementation of a direct delivery scheme are: technical difficulty in calculating the power quantum, and a transparent and evidence-based mechanism for periodic review of MES acceptable to stakeholders; inadequate experience to date in implementing a large-scale scheme for direct delivery of subsidy; regulatory changes needed to make decision of the majority to "opt-in" mandatory for all consumers connected to a selected feeder; and inadequate technical skills in the power utilities to adopt modern ICT tools. Therefore a gradual and sequenced approach will be needed, which could demonstrate to stakeholders the substantial benefits of new subsidy delivery mechanism. Detailed preparations, resource commitment, empowered implementing agencies, a well-prepared communication and consultation program, and robust monitoring and evaluation arrangements are essential ingredients of a successful implementation plan, which should be designed in a modular manner so that it can be adapted to the different starting conditions for each power utility.

No matter how the modular approach is structured for the specific conditions of each state, two components will be integral: (i) segregation of rural feeders; and (ii) an AMI system installed at the outgoing feeder and at consumer connections. Farmers would have a remote switching option through their mobile phones. The power utility would install a data center for energy accounting and auditing, incentives for the employees, meter management, billing and collection. Two components that could vary across the models are (i) how the MES is calculated – whether based on consumer landholding (in hectares) or consumer connected load (horsepower or kW); and (ii) subsidy denomination – whether in terms of quantity of electricity (kilowatt-hours) or hours of power supply.

PROPOSED IMPLEMENTATION FRAMEWORK

The strategic framework to implement the proposed scheme comprises four phases that could be implemented over three to four years depending on progress in rural feeder segregation.

Phase 1: Conceptualization would comprise consultations with stakeholders and building political and administrative support for the implementation team (about six months).

Phase 2: Planning and detailed design would comprise engineering design, collection and validation of land records and consumer data, and estimation of MES subsidy allocation (about one year, simultaneous with Phase 1).

Phase 3: Pilot-testing, monitoring and assessing scalability would comprise engagement with farmers, proactive communication and quick response to feedback from the field, coordination of the implementation team with agriculture and groundwater departments to ensure that extension services and benefits of other government schemes (water conserving irrigation technologies subsidies) are packaged and delivered simultaneously (1-2 years).

Phase 4: Rollout through the state would require a strong and scaled-up implementation team, a spatially segmented and sequenced implementation program, and committed political and financial resources. Highly visible successful pilots would be critical to the rollout campaign (2-3 years including some overlap with Phase 3).

The institutional arrangements for implementation would comprise the state government, the power distribution company, and the feeder-level user (farmer) community. The implementation arrangements at each level could be along the following lines:

State Government: The various entities involved in implementation would include:

- *A Project Steering Committee* headed by the Chief Secretary and including representatives of the Departments of Power, Finance, Revenue, Agriculture, and Water Resources; as well as representatives of the power utility and the farmers, could guide and advise the design and implementation of the direct subsidy delivery scheme in the state. This committee will ensure coordinated actions between power utility, groundwater and agriculture department, revenue department (responsible for land records), and providers of extension services; guide and advise on the engagement with the farmers, review subsidy allocation, and carry out mid-course corrections in implementation; and oversee the strategy and implementation of a state-wide communication program.
- *The Finance Department* would be responsible for implementing the mechanism for smart cards or bar-coded vouchers, make advance and replenishment payments of subsidy, and maintain subsidy payment financial accounts and auditing. The power utility could be responsible for integrating software between Finance Department and the power utility for subsidy delivery.
- *The Revenue Department* would establish systems to maintain updated land records and provide online access to the power utility to ensure alignment of electricity connection for farm power, subsidy allocation, and land-records.
- *The Agriculture and Groundwater Departments* could help design the subsidy allocation by providing adequately disaggregated information on agricultural productivity, costs and prices, groundwater resources, the design of groundwater efficiency improvement investments, and in outreach to the farmers. The Groundwater Department could also be responsible for implementing an incentive scheme to improve groundwater use efficiency.

The Power Utility: would be responsible for power-related components, i.e. feeder segregation, AMI, communication infrastructure, metering and billing system, GIS, consumer database and linkage with land-records; communicating with farmers and other stakeholders; and supervising the community organizations hired for political engagement with farmers served by segregated feeders. The power utility could establish a dedicated implementation team that will have the necessary skills in AMIs, ICT, communication and consultation, monitoring and evaluation, power distribution, and metering and billing. The power utility could launch a campaign to: (i) update consumer records and connected loads; (ii) regularize unauthorized and illegal connections; (iii) facilitate easy transfer of connection to the legal heirs/transferees of land titles; and (iv) synchronize consumer records with land records.

The Feeder-level User Community: is the most important element of the design and implementation of the direct subsidy delivery scheme. It is critical that farmers understand the scheme and receive strong assurances that their power subsidy allocation is secure. It is essential to build consensus among farmers supplied by the selected feeder to opt for the new scheme, and provide a mechanism for redressing any grievances during implementation. For these activities, it would be useful to recruit community organizations or individual feeder-level coordinators to engage the farmers. These facilitators would need to work closely with the village Panchayats as well as the water user associations, and will require training in the details of scheme design, implementation plan, stakeholder responsibilities, and a range of communication skills. The facilitators could be compensated for initial engagement, initiating demand for the new scheme, and implementation assistance.

COSTS

The proposed scheme has two main infrastructure cost components: (i) feeder segregation; and (ii) automatic meter readers/subsidy-delivery infrastructure. In addition, the government and the power utility would need to fund cost of communication and outreach to the farmers, capacity-building of the implementing agencies and the community organizations, and technical assistance. Of the infrastructure costs, feeder segregation is estimated to account for about 80 percent and the subsidy delivery model for about 20 percent of the total costs. Feeder segregation costs will vary across states; therefore these are not included in subsidy delivery scheme cost estimates presented in this report. The second component includes the advanced metering infrastructure capable of two-way communication and associated data and information-management software and hardware, costs for establishing subsidy voucher production and delivery for agricultural consumers, and staff training, hardware and software costs at billing centers that process subsidy vouchers. As an example, for a power distribution company serving one million agricultural consumers, the incremental costs of implementing direct delivery model will be about Rs. 12.5 billion (US$250 million) spread over 4-5 years. In addition to capital expenditures, about Rs. 70-80 million would be required during start-up years to build IT systems to identify beneficiaries from existing records at the village Panchayats, land record offices, state utilities and so forth, and integrate them with the proposed subsidy delivery mechanism.

It is essential to run some pilot operations before launching the proposed scheme at a larger scale. The cost of implementing a pilot for 10 feeders in a Discom would be about Rs. 1.1 billion (US$20 million).

CONCLUSIONS AND THE WAY FORWARD

It is clear that at least in the immediate term, any attempts to address the energy-groundwater nexus must assume continuation of the free or subsidized power to agriculture. In this context, the direct delivery of electricity subsidy to farmers offers a pragmatic and politically feasible solution which can enhance rural power supply without increasing the states' fiscal burden, create incentives for efficient use of electricity and groundwater, and also improve utility performance. Since history has locked the farmers, the power utilities, and the state governments in a state of distrust, it is critical that the implementation is supported by adequate financial and managerial resources, and include the following steps: (i) establish a detailed communication and consultation program before implementation; (ii) design the specifics of the program based on the feedback from farmer consultations; (iii) conduct pilot programs and use the results and feedback to improve scheme design before replicating and scaling up; (iv) ensure choice of opt-in or opt-out at a feeder collective level to establish farmer trust of power utilities and government.

The proposed scheme combines mature and proven technologies and management tools. All components of the proposed scheme – feeder segregation; use of AMI/ICT for subsidy delivery; and performance-based incentives for employees – are proven and well established. India has widespread coverage of mobile phone networks, which can provide information on electricity consumption and has the capacity for remote control of irrigation pumping systems so that farmers are no longer held hostage to a power supply schedule and can put this time into higher-value activities.

Individual states can choose their entry point in a five-stage modular subsidy delivery model depending on their starting conditions and opportunities afforded by political economy:

- The states with low agricultural load, low-density rural populations and small villages should choose to improve power sector performance through institutional improvements, and if endowed with a shallow water table and large solar radiation (as in Eastern India) encourage use of solar irrigation pumps instead of extending grid power for agriculture.
- The states with large agricultural loads, supply shortages, relatively dense rural populations and large villages should segregate rural supply

feeders to improve power supply and quality of life in villages. Installing feeder, and possibly distribution transformer, meters and instituting a transparent and auditable energy accounting system should be an integral part of feeder segregation scheme.

- The states with institutional capacity in government and the power utility, and ability to use ICT-based systems, should install AMIs and, with farmer participation, shift from a rationed roster system of supply to longer hours of supply with MES allocated in kilowatt hours.
- The states with progressive agricultural sectors and institutional and financial resources could shift to direct delivery of power subsidies.
- Finally the government can move to a system of cash back for energy savings to tap into potential for end-use efficiency and energy and groundwater conservation.

Groundwater-based farming is the engine of rural India's economic productivity, with very major multipliers in rural agri-businesses, produce and service markets, labor generation, and livelihoods. State governments, utilities, and farmers urgently need to address the groundwater-energy nexus through a set of politically and financially feasible and socially acceptable alternatives centered on the direct delivery of power subsidy to farmers. This report provides clear rationale and evidence for the way forward, and has been reviewed in light of international best practices and broadly vetted through stakeholder consultation. Implementation may begin with a range of different starting points, which will allow all stakeholders concerned at the state level to take important steps towards addressing the energy-groundwater nexus in India.

Chapter 1

Introduction: The Energy-Groundwater Nexus in India

Electricity-powered groundwater irrigation is widely prevalent in the world, and underpins a very significant fraction of agriculture in many countries. The modalities of groundwater use and its regulation, as well as pricing and metering of electricity provided for irrigation vary widely, for instance, across China, Bangladesh, India, Iran, Mexico, Pakistan, Saudi Arabia, Spain, and United States. The case of electric-powered groundwater use in India stands apart from global experience due to a unique confluence of physical, policy and political factors that have trapped many Indian States in a particularly vicious spiral of declining groundwater levels, stagnant or declining agricultural productivity, deteriorating power service delivery, and bankrupt power generation utilities. The large scale and specific modality of providing subsidized power for groundwater irrigation has introduced such severe distortions in the power and water sectors that it is now widely known as the *energy-groundwater nexus*. While some elements of this problem are quite comparable to other parts of the world, the manner of delivery of power subsidy through "unmetered power supply" and its interaction with the electoral politics has created a trap that is quite unique to India, and that has not proved amenable to the various solutions proposed so far for addressing its pernicious consequences.

A. GROUNDWATER USE IN INDIA

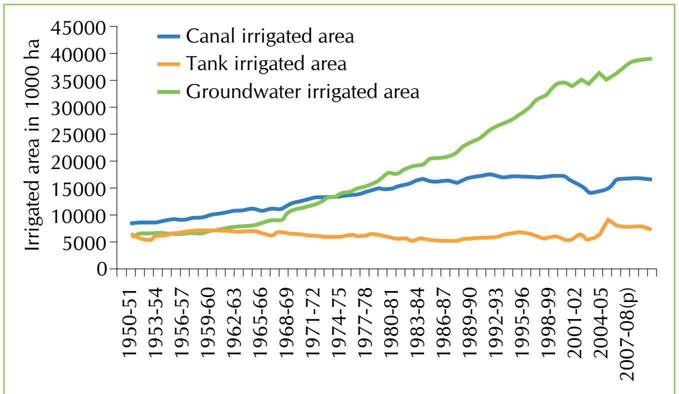
India uses an estimated annual 230 cubic kilometers of groundwater, more than a quarter of the global total, making it the largest groundwater user in the world. More than 60 percent of India's irrigated agriculture depends on groundwater and the crop productivity of groundwater-irrigated farms is almost double that of surface water irrigated farms.[1] For domestic water supplies, some 85 percent of rural water supply schemes in India rely on groundwater sources.

Beginning in the 1960s, the Green Revolution was a turning point in India's agricultural development and productivity expanded rapidly for those who could take advantage of new hybrid seeds, fertilizers, and access to water on demand. Groundwater irrigation development exploded (see Figure 1). Although Government invested heavily in surface irrigation projects to assure access to water supply for more farmers, many farmers remained underserved. Several factors prompted an ever-increasing number of farmers to opt for groundwater irrigation: (a) rural electricity supply expanded; (b) where water-logging and salinity were a growing problem (such as parts of Punjab) groundwater pumping was an effective mechanism to lower the water table and mitigate impacts; and (c) subsidized credit and affordable modular well and pump technologies became widely available. However, a regime of unmetered power supply and power subsidies[2] throughout the Indian States were arguably the most powerful driver for extraordinary growth in groundwater irrigation.

1 Based on Government of India figures from 2005; other estimates are higher. India's National Sample Survey (NSSO 2005) indicated that 69% of kharif and 76% of rabi irrigated areas depended on groundwater.

2 During the 1970s, India had a cost-recovery consumption-based tariff but during the 1980s the country moved rapidly to concessional flat-rate tariffs and free power.

FIGURE 1: Irrigation Sources in India, 1950-51 to 2009-10



Source: IWMI (based on Agricultural Census, GOI, several years).

B. THE IMPACTS OF UNMETERED AND SUBSIDIZED POWER

Until the early 1970s, State electricity utilities levied electricity charges to tube well owners based on metered consumption. But as the number of tube wells increased exponentially during the 1970s and 1980s, utility companies found that transaction costs for metering were prohibitive compared to revenues generated from the agricultural sector. Consequently, for agricultural electricity supply, most States introduced flat tariffs, removed meters and stopped recording consumption.[3] Initially the idea was to increase the flat tariff over time to align with electricity generation and supply costs. What happened instead was that providing free or highly subsidized power to farmers evolved into a standard promise of electoral politics; today most State politicians know that withdrawing power subsidies would be equivalent to political suicide.[4]

Fiscal impacts. Not only has this subsidy now grown to about Rs. 450 billion per year but also unmetered electricity supply has become a convenient catchall for power utilities' transmission and distribution losses and inefficiencies.[5] During 1971-2009, total electricity consumption in India increased 12-fold (from 44,000 GWh to 554,000 GWh) but increases to estimated agricultural electricity consumption were more than double that-at 25-fold.[6] Estimated losses from subsidized power to State power utilities were Rs.270 billion per year in 2000, equivalent to about 25 percent of India's fiscal deficit, double the annual public spending on health or rural development, and 2.5 times the annual expenditure on irrigation.[7] Distribution companies' financial losses amounted to Rs.526 billion in 2008/9 at current prices.[8] State government subsidy payments filled some of the gap-Rs.296 billion[9] so that net losses (profit after tax) for Discoms amounted to Rs.229 billion. At the State level, accumulated power sector losses were Rs.850 billion in 2008-09,[10] which is 2.0 percent of 2008-09 GDP.

Impacts on utilities. Removing meters on tube wells has undermined energy accounting in power utilities and impaired their internal accountability systems. Many utilities use unmetered agricultural power supply to hide losses that are due to inefficiency, theft and corruption and since power is cheap or free, farmers have no incentive to use energy and groundwater efficiently.[11] Continuing and large financial losses of electricity utilities undermined utilities' ability to finance the investments required to meet the exploding demand for electricity, hindered infrastructure maintenance, and contributed to erosion of skills development among utility staff.

In 2008-09, Andhra Pradesh, Madhya Pradesh, Haryana, Punjab, Rajasthan, Tamil Nadu and

3 Under a flat-tariff system, consumers are charged a fixed amount generally linked to horsepower (or kW) rating of the electricity motor used to operate the water pump for irrigation.

4 Dubash & Rajan 2001.

5 Sant & Dixit, 1996.

6 Government of India Energy Statistics, 2007 and 2010.

7 World Bank, 2002.

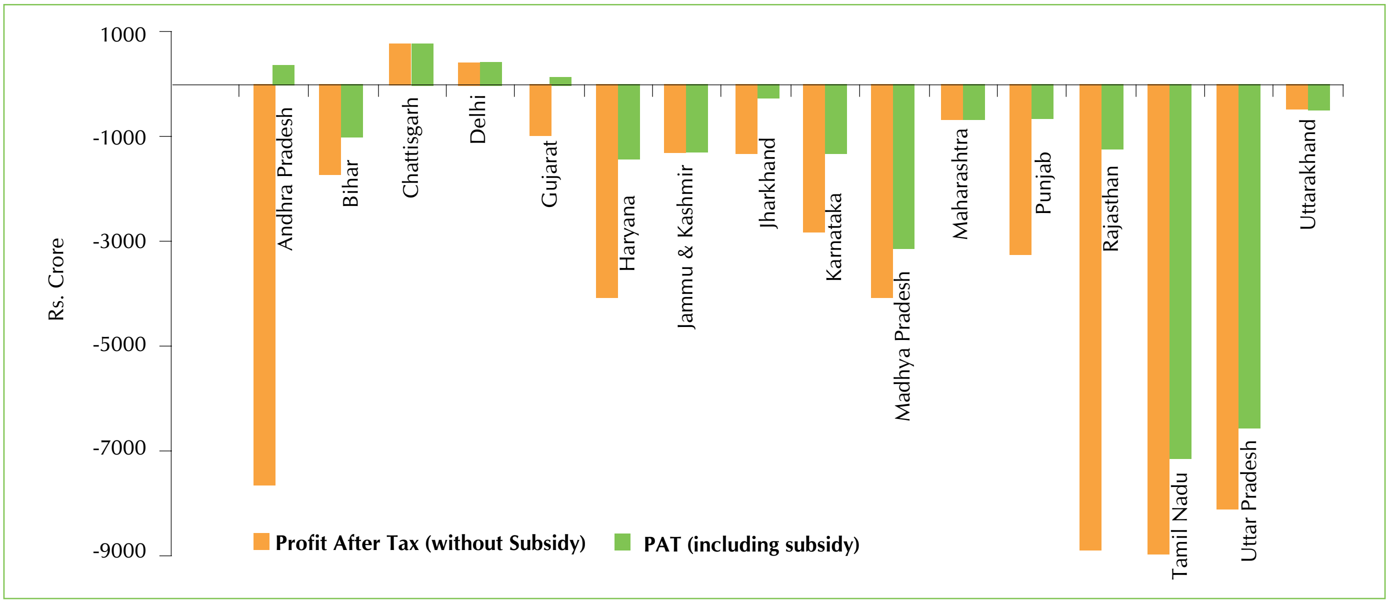
8 Book losses of State utilities selling directly to consumers during 2008-09 (Source: PFC).

9 This is the recorded subsidy("on the books"), frequently less than the amount received by the utility, implying that actual utility losses could be higher.

10 PFC Report: Performance of State Power Utilities for 2006-07 to 2008-09.

11 Thus, in Andhra Pradesh, during 1980-2005, agriculture power consumption rose from 920 GWh to more than 12,000 GWh; the number of tubewells rose from 1.06 million to 1.74 million and consumption per tubewell rose from 870 kWh to more than 7000 kWh and from 820 kWh to 5,000 kWh per hectare of irrigated land.

FIGURE 2: Profitability of Power Sector of Select States-2009



Source: Power Finance Corporation Reports.

Uttar Pradesh account for 75 percent of total accumulated Discom losses and 85 percent of India-wide power sector losses. Financial institutions are no longer willing to extend short-term loans for working capital to the utilities in Haryana, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh, which means utilities may need Government assistance with current losses and over time, with accumulated losses going back to 2001-02. Reports are that Discoms are now resorting to load shedding, even though power is available in the market, because they cannot pay for all the power they need to supply.[12]

Total financial sector exposure to the power sector was 6.53% of 2010-11 GDP or Rs. 4,772 billion (US$106 billion) as of FY2011.[13,14] This includes generation, transmission, distribution, and borrowing from State utilities, central utilities, and private power producers and suppliers, plus private investment in power transmission and distribution.

Impacts on farmers. Low agricultural and rural sector revenues have led State electricity utilities to view agricultural consumers as a liability. As a result some States now see a de facto 'de-electrification' that includes rationing, low-quality electricity delivery, and poor supply quality such as voltage fluctuations, frequency, low voltage, frequent interruptions, and phase imbalances that have hit rural areas with substantial economic costs in both farm and non-farm sectors.[15] Poor quality of electricity delivery means that farmers must bear significant repair costs for motor burnouts, which pushes up the effective tariff by an estimated 25-30 percent. Poor service delivery in the non-farm sector has lowered the quality of life in rural

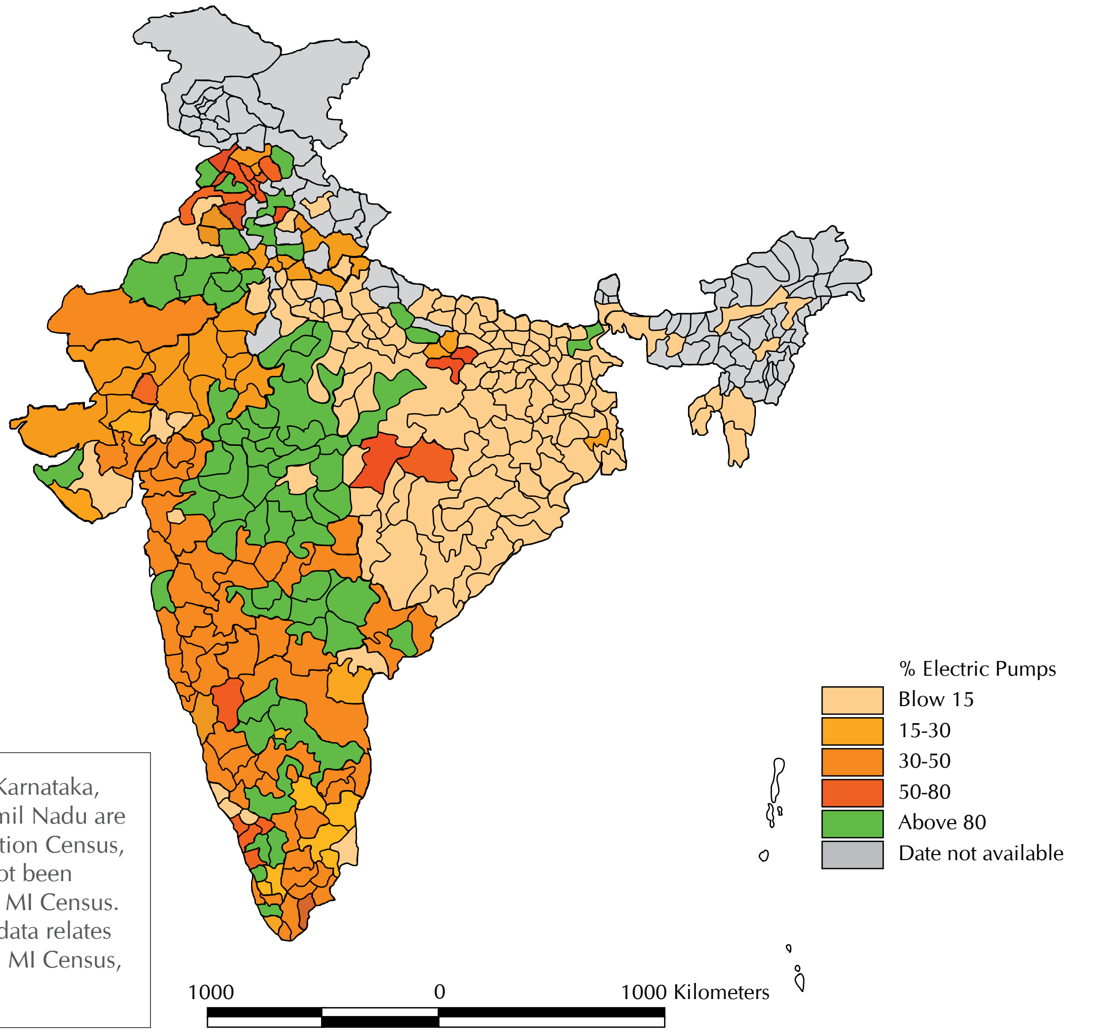
12 Ironically Load Dispatch data show that on specific days more than 10 GW of thermal power stations with variable cost of around 3 cents/unit are shut down due to limited off-take by credit-strapped state utilities, while more than 20 GW of diesel-based captive capacity with running cost of 30 cents/unit continues to be operational in the private sector as a coping strategy.

13 Using Rs. 45/$.

14 Mercados, quoting a Goldman Sachs report. This is underestimated because it excludes external commercial borrowing by corporate entities, private equity exposure, insurance, or pension fund investments in the power sector.

15 For example, the number of electric pumps in Bihar stagnated at around 0.18 million from 1976-77 to 1997-98, as did the power consumption in agriculture (Mukherjee, 2008). In states such as Gujarat, Andhra Pradesh, Punjab, Haryana, and Tamil Nadu, where electricity consumption in agriculture has grown over time, hours of electricity supply have declined from 18-20 hours in the 1980s to as low as 6-10 hours in the 2000s.

FIGURE 3: Energy Divide in Groundwater Economy of India



* Figures for Gujarat, Karnataka, Maharashtra and Tamil Nadu are based on Minor Irrigtion Census, 1986 as they have not been included in 1993-94 MI Census. For the other states, data relates to 1993-94 based on MI Census, 1993-94.

Source: IWMI.

areas and hampered the growth of local industries and commercial enterprises.[16]

Impacts on groundwater resources. The implications of subsidized power have been equally severe for India's groundwater resources. The combination of several factors plus the marginal cost of extracting groundwater being close to zero provided strong incentives for over-pumping (Figure 3 & Figure 4). A comparison of these figures shows that groundwater stress has reached near-crisis levels where electric tube wells dominate. Groundwater condition is critical in these nine States – Punjab, Andhra Pradesh, Karnataka, Haryana, Gujarat, Rajasthan, Madhya Pradesh, Maharashtra and Tamil Nadu-which together now account for 85% of India's groundwater blocks that are in critical and semi-critical condition (Planning Commission 2007). If current trends continue, 60% of all aquifers in India will be in critical condition by 2025; this is unsustainable and jeopardizes the livelihoods of millions of poor people, large and rapidly growing segments of the economy, and many of India's most productive regions.

Environmental impacts. Since groundwater is integral to linked hydrological, ecological, and human use systems, a range of environmental services is

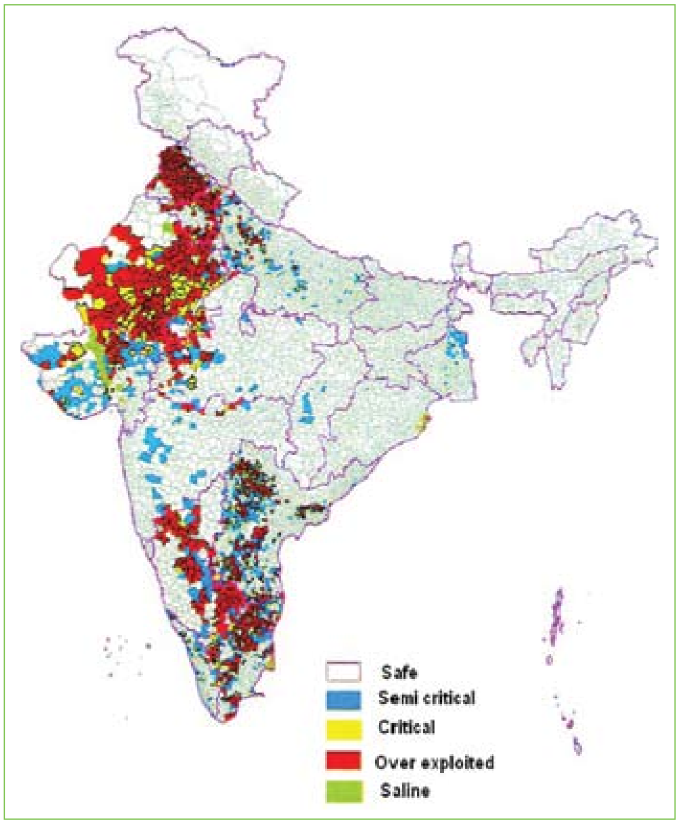
16 Shah & Verma, 2008.

imperiled by groundwater overexploitation and quality degradation. India has a highly variable monsoonal rainfall pattern; in many areas about 50 percent of annual precipitation falls in 15 days. Groundwater is crucial to sustain springs, inland wetlands, and riverine base flows during the dry season. Therefore groundwater contributes critically to flows for fisheries and aquatic ecosystems, and groundwater levels directly influence many vegetation species that are important sources of food, fuel, and timber for dependent communities. Thus repercussions of declining groundwater levels include significant adverse environmental impacts felt across the country.

C. MAJOR CHALLENGES IN ADDRESSING THE ENERGY-GROUNDWATER NEXUS

The energy-groundwater nexus has trapped farmers, power utilities, consumers and governments in an inefficient low-level equilibrium. Despite significant efforts invested at research and policy levels to solve this, most of the solutions proposed in the past suggested removing incentive distortions by withdrawing power subsidies and reintroducing pricing for agricultural power. Conceptually, these approaches are the clearest but they are doomed to fail. Instead, any viable approach to change the status quo needs to acknowledge and work with three realities: first, that farmers are reluctant to relinquish access to subsidized power, even when utilities promise supply-quality improvements; second, that political decision makers face political difficulties in implementing a rational price regime for agricultural power supply because it is hugely unpopular; and third, that rural prosperity is largely driven by the irrigation economy in which groundwater plays an increasingly important role both through the provision of direct benefits to farmers but also to multiplier effects via local markets.[17]

FIGURE 4: Groundwater Stressed Blocks of India



Source: IWMI.

Under these circumstances a solution to the energy-groundwater nexus cannot be considered realistic if it is based on a withdrawal of subsidies from farmers. At the same time, it is clear that the current system of electricity provision to agriculture is unsustainable, both from fiscal and natural resources perspectives.[18] While a systemic solution based on rational pricing of electricity is definitely needed, further delays in addressing the groundwater-electricity nexus will compound the damage already done to government budgets, utilities, farmers, groundwater resources, and the overall environment, as discussed in Section B. In addition, the agricultural sector, already lagging among economic sectors, will continue to decline, eroding the livelihoods of the majority of Indian citizens. Until recently there was no solution in sight,

17 Claims that resistance to reform comes from affluent large farmers who benefit disproportionately from power subsidies are refuted by growing evidence that energy costs to *all* farmers have risen, therefore increasing power tariffs would harm small and marginal farmers (World Bank, 2001; Dossani & Ranganathan, 2004; Dubash, 2007).

18 For example, in the 1970s Saudi Arabia implemented subsidized groundwater-based agriculture to enhance food security and generate employment in rural areas but this policy has now been reversed due to critical depletion of aquifers and falling agricultural yields.

TABLE 1: India: Growing Urban-Rural Inequality

Population (million)		2010*	2015	2020	2025	2030
Urban (40%)		474	504	534	563	593
Rural (60%)		712	756	801	845	890
Total		1,186	1,260	1,335	1,408	1,483
GDP (factor cost at 2004-2005 prices)*	**2010 (Billion Rs.)**	**GDP/per capita (Rs.)**				
Urban (manufacturing plus services)	37,328	78,684	114,080	163,882	234,040	332,984
Rural (agriculture)	7,610	10,694	11,277	11,933	12,666	13,481
Total	44,937	37,890	52,398	72,712	101,215	141,283
Urban/Rural GDP differential		**7**	**10**	**14**	**18**	**25**

*Authors estimates: GDP, population from the economic survey of India 2011. Estimates assume population growth of 2 percent, GDP growth of 8 percent, and structure of the economy and population distribution between rural and urban areas remaining the same over the projection period.

however, technological advances have now opened up several pragmatic alternatives, which are discussed in Chapter II of this report.

India's widening income gap. In India, rationalized power tariffs appear to be strongly justified in the current national context of an underperforming agricultural sector contrasting dramatically with the country's industrial and service sectors, which are thriving. This widening gap is creating two unequal societies in India-citizens who are urban, globalized and increasingly affluent and citizens who are rural, poor, largely agrarian and appear to have been left behind in India's expanding economy (Table 1).

This "lagging" India comprises close to 60 percent of the population, a majority that decision makers ignore at their peril if they want to maintain popular support. Rural-urban inequality is too high and rising too quickly to be politically or socially acceptable.[19] Therefore, rural voters must be convinced that any proposed reforms to solve the energy-groundwater nexus will provide them with the adequate, reliable and affordable power supply that is essential to generate non-farm and off-farm economic activities to improve their livelihoods and quality of life.[20] In parallel, improving power supply to the villages is also critical to encourage investments in micro-enterprises to reduce "agro-dependence" of the rural economy.

Therefore providing free or nominal-cost power for irrigation would provide an immediate and pragmatic solution to the politically charged issue of equitable government support to farmers in canal command areas, who should benefit from free provision of irrigation infrastructure and much-below-cost tariffs for surface irrigation water-and groundwater-dependent farmers outside the commands, who must be encouraged to make their own irrigation investments.

19 Even accounting for the benefits of economic growth transfers to rural areas.

20 In the longer term, policy distortions introduced by unmetered and highly subsidized electricity will need to be corrected to achieve a sustainable solution to the energy-groundwater nexus. However, in purely practical terms any solutions to address the nexus will fail if they require unpopular front-ended price reform.

Chapter 2

Overview of Proposed Scheme

Since India is unique worldwide in providing a significant proportion of electricity free and unmetered it requires a unique and tailor-made solution to release farmers, power utilities, consumers and governments from the inefficiencies of the existing energy-groundwater nexus. The scheme proposed here will offer farmers an improved delivery of electricity service, as well as incentives to use electricity and groundwater efficiently despite receiving free power. The scheme provides an attractive and politically feasible method-transparent and efficient-to deliver power subsidies; it provides incentives for power utility employees to improve operational and financial performance, and creates enabling conditions to improve rural power supply without increasing Government's fiscal burden.

Under the proposed scheme, farmers can choose either to continue with the current system of limited hours of free/subsidized power supply, or to adopt the new system of longer, more convenient, hours of supply-still free/subsidized-but the subsidy would be denominated in quantity of electricity instead of hours of supply. The scheme does not impinge on Government public policy choices to provide free or subsidized power nor does it seek to reduce the benefits currently being provided to the farmers. Its focus is on improving efficiency, equity and cost-effectiveness of delivering power subsidy to farmers. If direct delivery of the power subsidy to farmers were coordinated with ongoing complementary schemes for groundwater and agriculture improvements there is potential to significantly enhance the impact and effectiveness of the proposed scheme.

This Chapter presents key elements of the scheme; the State of technology and implementation experience; potential for leveraging with complementary investments in groundwater and agricultural extension; and aligning the interests of multiple stakeholders.

A. KEY ELEMENTS OF THE SCHEME FOR DIRECT DELIVERY OF POWER SUBSIDY

The proposed scheme has four key elements: (i) segregated rural feeders to supply power to farmlands and villages; (ii) minimum energy support (MES) for farmers; (iii) smart metering and subsidy delivery through use of information and communication technologies (ICT); and (iv) transparent and measurable performance-linked incentives for power utility employees. This scheme would be complemented with investments supported by government programs to improve groundwater-use efficiency. These elements are described below and in Fig. 2.1.

(i) **Segregated feeders** would provide rapid power supply improvements for rural residential and commercial consumers; provide villagers with quality-of-life benefits such as household lighting, education, entertainment, small appliance use; generate opportunities for micro enterprises to invest in off-farm and non-farm income-generating activities; and help realize the potential of 'smart' rationing and synchronizing farm power supply with the needs of agricultural operations. Feeder segregation would create consumer choices at feeder level and increase supply hours on feeders that opt for the new scheme. This would also help reduce overloading on feeders and transformers as well as increase load diversity. A review of feeder segregation implemented in some States has revealed that benefits of properly implemented and managed feeder segregation go beyond improving the village-level supply, if feeder segregation is accompanied by metering and energy accounting. The Government of India has recognized this in a flagship program to support rural feeder segregation in their XIIth Five-Year Plan.

(ii) Minimum Energy Support (MES) for farmers. The farmer is assured an annual allocation of electricity. Two dimensions of the MES are the *unit of subsidy* that can be defined *either* in number of hours of supply *or* in quantity of electricity (kWhs); and *amount of subsidy* that can be estimated *either* on the basis of connected load (kW) *or* land holding (Hectares).

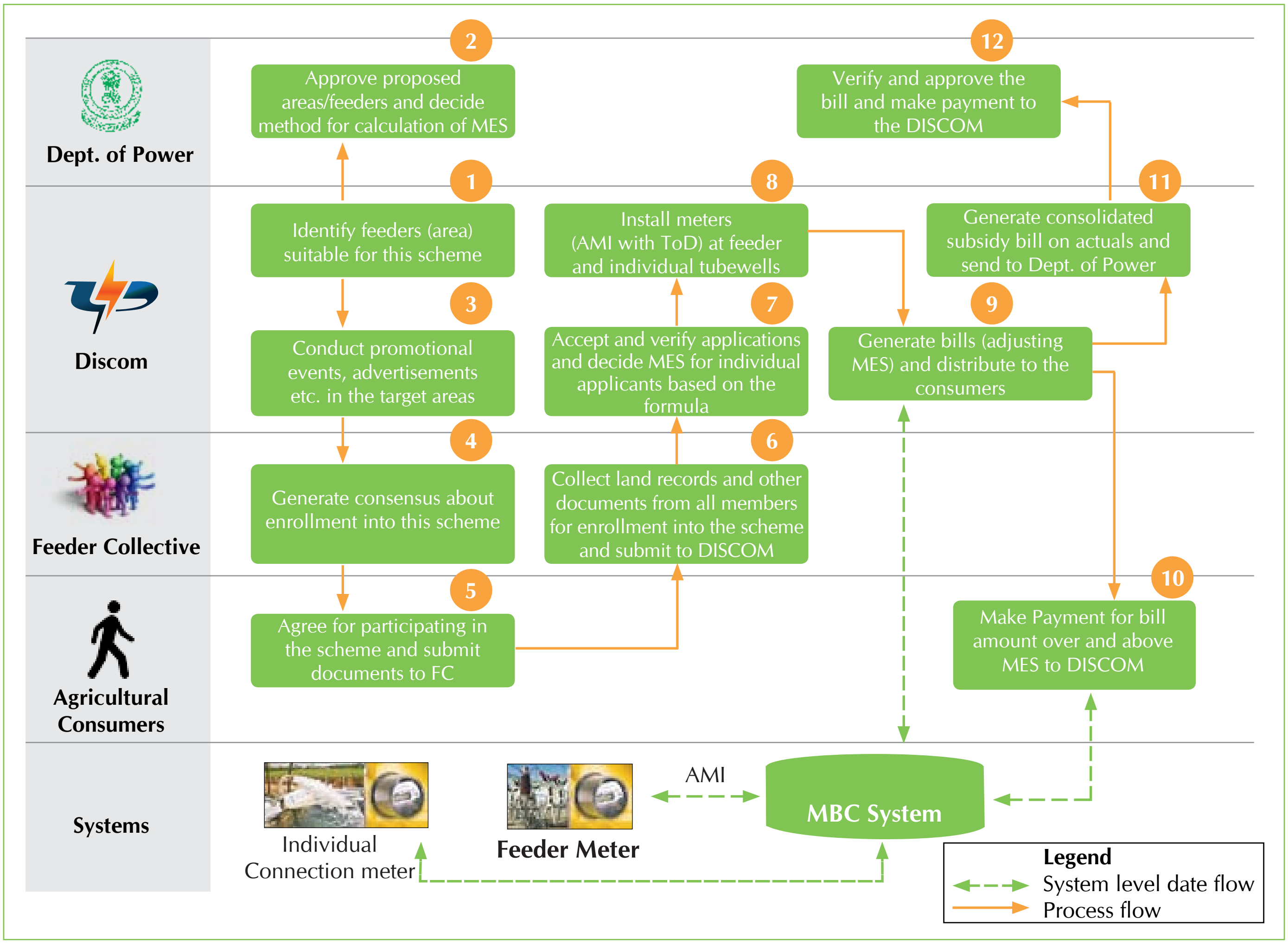
This report argues that allocation based on land-holding and defined in kWhs/year is more transparent, equitable, and easier to administer and monitor. Land-holding, groundwater conditions, access to surface irrigation, cropping patterns, and other agricultural needs are among the important factors that should be taken into account to calculate MES. In each State, land categories could be assigned according to agro-climatic-groundwater zones to establish subsidy allocation. These zones should be as large as practicable, i.e., each State should have no more than two or three zones. Electricity requirement estimates for existing agricultural operations would be prepared and finalized through farmer consultations and participation of agricultural experts. Reference estimates would be based on random sample field measurements to obtain actual consumption, normative estimates prepared by agricultural universities, and cost estimates used by Agricultural Costs and Prices Commission (for crops eligible for support-price mechanisms) that could provide allocation parameters. Building broad-based support for the land-holding-linked power subsidy allocation would require considerable consultation with farmers but because the new subsidy scheme is optional, the task would be lightened. To gain farmers' trust, the allocation should be embedded in power sector policy and regulations, and offer the freedom at feeder level to opt out after a defined period of perhaps two years after scheme implementation.

Electricity saved by the farmer through efficient use or conservation can be either added to farmer allocation for next year or can be encashed at the regulated tariff level at the option of the farmer. This completely shifts farmer incentives toward more efficient energy and groundwater use even while continuing to receive free power because efficiency gains can be retained or monetized.[21] In fact, this is a self-correcting mechanism because if very few farmers are able save or monetize their savings, this signals need for a higher allocation. If farmers become full-tariff paying customers, the utility would not only be willing to supply power to the tube wells for longer hours but also achieve load diversity, thus economizing on generation and network investments. A kWh-based subsidy would also allay framers' apprehensions about tariff increase. Since at the feeder level, the farmers would have an option to continue with the existing system or choose the new system of direct delivery of subsidy, it is unlikely to face political resistance. On the contrary, politicians would reap political benefits from subsidy distribution and improved power supply to villages.

(iii) Smart metering and subsidy delivery using ICT. The use of smart meters that can be read online in real time is a well-established cost-effective technology. Reading meters through telecom networks (or similar technology that transmits data over power lines) is a long-established business practice in many developed and some developing countries. During the last decade, mobile-based technology for meter reading and demand management has become more popular and since mobile connectivity in India is widespread, adopting this technology would be easy. Both CDMA and GSM service providers

21 In fact, it would not be surprising if farmers ask for higher tariffs since they can monetize the savings.

FIGURE 5: Schematic of Subsidy Delivery Scheme



in India have confirmed that they can support this technology in most of India where service would be required. Farmers could use their mobile phones to remotely control their pump sets and power use. Farmers would receive information on the power feeder supply and their power consumption and billing, which would free them to undertake other activities rather than be held hostage to a power supply roster.[22] Other benefits of such meters include: the power utility can read meters online and in real time for smarter power supply regulation to agriculture; energy accounting is more accurate; billing is faster and more efficient; farmers control their own subsidy use and savings; measurement of incentives for the power utility feeder-team staff is more transparent; and ability to differentiate peak from off-peak power consumption provides incentives to consume during off-peak hours. Farmers would be treated by the power utility as a paying customer rather than a politically imposed burden. Targeted beneficiaries could receive Government subsidies directly through technology-enabled systems such as bar-coded vouchers, single/multi-purpose smart cards or transfer through mobile phones, which they

22 Innovative solutions to provide remote switching capability through mobile phones are being successfully marketed to farmers in India indicating the value the farmers place on flexibility and opportunity cost of their time. http://www.nanoganesh.com/

would also use to pay utility bills. This system assures financial integrity and guards against losses or theft while providing Government with advance information about the extent of the fiscal burden so voucher values can be adjusted to provide free power, supplementary payments during extreme weather events such as droughts, or to reimburse for insured crop losses.

(iv) **Performance-based incentives for power utility employees** are critical to gain employee support for implementing and sustaining the scheme. Incentives need to be specific, quantifiable, equitable, and transparent. The scheme would set targets at each level: *Rural feeder-level*: reduced technical losses and improved bill collection; *Division/District level*: reduced technical losses, improved billing and collection, maintenance of agreed supply schedule for "opt-in" feeders, and for customer service; *Corporate level*: improved performance linked to stock options for all employees, divestment of shares to employees and customers served by the company, and a stock exchange listing for the distribution company.

B. STATE OF TECHNOLOGY AND IMPLEMENTATION EXPERIENCE

India's unique challenge of large unmetered power sales to agriculture means that there is no readily adaptable or replicable solution available because no other country has this model of supplying farm power subsidies. The proposed scheme combines mature and proven technologies and management tools. A smart combination of these elements increases their value proposition and offers an innovative and cost-effective way of efficiently delivering subsidies to beneficiaries. India and many other countries have vast experience in implementing each of these as described in the following sections.

(i) **Feeder segregation:** An evaluation study of rural load segregation that looked at potential for scaling up in other States in India concluded that the primary objectives of increasing quality and quantity of power supply for non-agricultural consumption in rural areas seem to have been met.[23] However the scheme's financial impact had mixed results. Gujarat had managed to control the subsidy and financial losses but in Rajasthan, overall financial losses and subsidy continue to increase. The study emphasized that no one-size-fits-all approach exists. Each utility/State must develop the most techno-economically feasible approach based on the existing state of infrastructure, loss levels, consumer mix, financial and metering status, and physical and socio-economic conditions. The study also pointed out that its benefits are maximized if load segregation is accompanied by institutional and governance reforms at the power utility. Load segregation provides hardware for a system that can deliver differentiated service to farmers and non-agricultural rural consumers, along with management decision-making tools for effective monitoring. However the overall outcome of better supply quality and sustainable operations can be achieved only through simultaneous and integrated organizational changes, accountability systems, and use of information technology.[24]

(ii) **Minimum Energy Support:** Spain uses a European Union program, "Income Compensation Program", which pays subsidies of Euro 420/ha to reduce groundwater extraction. Mexico tried monitoring groundwater extraction but abandoned it as impractical before shifting to a cap on the quantity of subsidized electricity (Annual Energy Limit- AEL[25]) through a formula-

23 Lighting Rural India: Experience of Rural Load Segregation Schemes in States, World Bank, February 2012.

24 In 2008 Karnataka carried out a pilot project for feeder segregation in Malur Taluk, which showed improvement in supply quality and loss reduction. Similar results were also obtained in Punjab (Box 2).

25 Scott & Shah. 2004. Groundwater overdraft reduction through agricultural energy policy: Insights from India and Mexico, Water Resources Development, Vol. 20, No. 2, 149–164, June 2004.

26 CGWB website http://cgwb.gov.in/gwprofiles/st Punjab.htm

TABLE 2: Results of Feeder Segregation in Malur Taluk in Karnataka (2008)

Sr. No.	Details	Before segregation	After segregation
1	Improvement in voltage (Single phase)	150 V	218 V
2	Reduction in DTC failure rate	1.37%	0.8%
3	Reduction is technical losses	20.7%	17.3%
4	Increase in demand and billed energy (kWh)	91,180	100,342
5	Reduction in number of interruptions	85	22
6	Reduction in interruption period (hours/year)	213.7	6.45

based approach that provides for lighting and an additional component based on standard motor-pump efficiency, and groundwater depth. However, determining the amount of concessional volume and depth of groundwater for each farmer is effort- and resource-intensive.

Mexico is now considering direct cash transfer to farmers in lieu of tariff subsidy, plus removing price distortions by charging cost-recovery tariffs. Oman subsidizes electricity tariff for agriculture but meters consumption and plans to implement consumption quotas.

BOX 1: Punjab - Success in Power Sector but Looming Crisis in Groundwater

Punjab provides free and unmetered power to farmers but an unmetered power supply makes it difficult to estimate agricultural power consumption or how much government subsidy is due. Lack of metering also makes energy accounting opaque and tariff-setting complex but imprecise.

As a result, PSERC experimented with methods of estimating agricultural consumption: (i) under the residual method, agricultural consumption equals the balance after deducting sales to non-agricultural customers plus losses; (ii) norms based on a small sample of metered tube wells and technical studies carried out by Punjab Agricultural University and TERI; and (iii) large sample-based norms with independent third-party verification. Punjab State Electricity Regulatory Commission (PSERC) installed sample meters on 10 percent of agricultural consumers to account for consumption, hired an independent third party to read meters, and established a protocol to monitor consumption. Further, PSERC approved the power utility's investments in feeder segregation, HVDS, Aerial Bunched Cables in theft-prone areas, and installation of AMRs on feeders.

Punjab State Power Corporation Limited (PSPCL) also implemented several measures: (a) installing HVDS, LT capacitors on 11 KV feeders and all tube wells; (b) augmenting overloaded feeders and distribution transformers; (c) IT implementation by introducing GIS mapping; (d) AMRs at all substations and agricultural feeders that download data once per minute; and (e) centralized energy accounting and auditing. As a result, agricultural consumption was adjusted to 1650 kWh/kW from a previous 1930/kWh/kW per year and transmission and distribution losses fell to 17 percent in 2012 from 24 percent in 2007.

Though feeder segregation is improving supply to the villages and HVDS is improving supply quality to agriculture, a groundwater crisis is looming large in Punjab. Some 103 of 138 blocks in the State are considered overexploited and groundwater extraction has reached 145 percent of annual groundwater availability. In addition, intensive use of chemical fertilizers and pesticides has created water quality hazards, salinity, and fluorides exceeding permitted levels.[26] Shifting the date of annual paddy transplantation to after June 10 has yielded some groundwater savings but at the cost of increasing peak electricity demand due to paddy transplantation bunching, and farmers' needs to adjust to different seed varieties.

The next challenge for Punjab is shifting the cropping pattern away from water-intensive paddy but this requires agricultural policy changes. "Bringing Green Revolution to Eastern India", launched by Government would exert competitive pressure on paddy production in Punjab. Punjab is formulating a new agricultural policy to help farmers shift to a less irrigation-intensive, sustainable agriculture that also protects their incomes. If direct delivery of power subsidy is included in the new agricultural policy, farmers could evaluate trade-offs in crop choices.

(iii) **Advanced Metering Infrastructure and ICT-based subsidy delivery:** In the last decade, metering technology has advanced to automatic metering infrastructure (AMIs or so-called "smart" meters), which are used most extensively to meter electricity, and to a lesser degree gas and water. Remote meter reading possible with AMIs reduces costs and theft, and improves service outage management, demand response through time-of-use and pricing, load management and customer service. AMIs can use multiple technologies for two-way communication for remote meter reading and switching power on and off but the two most popular are wireless due to the extensive mobile phone networks and utility power lines. AMIs have been successfully deployed in North America, Europe, South America, and East Asia, and are being promoted in India through India Smart Grid Task Force. To ensure better coordination and interface between metering and communication infrastructure, a turn-key approach in implementation of AMIs is a preferred approach. In 2011, global dispatch of new AMIs exceeded 17 million meters.

The Government of India has approved US$50 million for a smart grid project across the country by 2017 to implement smart grid systems in all State capitals and large cities. Use of ICT, being promoted through R-APDRP, would provide a foundation for future large-scale rollout of AMIs. Both the CDMA and GSM mobile operators in India have extensive network coverage to provide communication services for using AMI in rural areas.

Two components of AMI are: (a) metering systems comprising meters, communication equipment, management reading system, and meter control center; and (b) a meter data management system (MDMS). AMI functional considerations include interoperability, reliability, scalability, flexibility, modularity, bi-directional communication, and data security.[27]

27 Functional Specifications of AMI, ESMAP-funded report prepared by Mr. Rafael Cueto.

Four communication technologies-manual common meter reading instrument (CMRI), cellular, power line carrier communication (PLCC), and radio frequency (RF) were evaluated for Indian conditions and are briefly described in Annex A.

Recent advances in information and communication technology (ICT) offer several tools to automate subsidy delivery and make the process more transparent, efficient, cost-effective, and less vulnerable to leakages. The ICT tools with potential for subsidy delivery include the following: (a) mobile devices such as laptops, personal digital assistants (PDAs) and smartphones can collect data from the field; (b) biometric systems can accurately identify users thus reducing leakages through identity theft; (c) satellite communication provides network connectivity even in remote areas and can transmit data; (d) smart cards and ATMs can provide financial inclusion in remote areas that lack a bank branch office. Although less efficient than smart cards, bar-coded vouchers to deliver subsidy benefits provide a powerful and visible communication tool to establish a relationship between Government and beneficiaries, as distinct from the commercial relationship between consumers and the power utility.

International experience in use of ICT for subsidy delivery was reviewed in a background paper prepared by Infosys. A summary is presented in Annex B. In India too, several programs use one form or another of ICT in delivering benefits or services. A few programs reviewed for the study include: (i) Karnataka Land Record Digitization (BHOOMI) that computerized and created a database of land records and biometric identification of operators at BHOOMI centers to ensure system integrity; (ii) Targeted Public Distribution System in Chattisgarh that has computerized the whole supply chain including a Unified Ration Card database, and dissemination of information of movement of food grains to public through voluntarily registered mobile phones; (iii) Andhra Pradesh using web-based MIS for Indira Awas Yojana and Rajiv Awas Yojana.

(iv) **Performance-based incentives:** Since traditional merit increases to base pay have been eroded, many corporations have tried performance-based incentives to improve productivity. These programs are aimed at work team, department, and corporate performance or a combination of all three. Indian companies started using not only cash incentives but also employee stock options (ESOPs) since the last decade. As of 2008, more than 100 companies on Mumbai Stock Exchange had issued ESOP schemes.[28] Even some State power utilities such as Maharashtra, West Bengal, and Haryana have instituted performance-linked incentives. A successful performance-linked incentive scheme must develop clear expectations, create a clear link between reward and employee-controlled performance, empower employees, set goals that are achievable, establish a credible measurement system, make rewards meaningful, and make payouts immediate.[29] For implementation of new subsidy delivery scheme, incentives for staff should be established at three levels: (i) feeder team for maintaining quality of supply and service, reduction in losses, and bill collection for excess consumption; (ii) division team for maintaining promised supply schedule on the "opt-in" feeders, accurate energy accounting and auditing, and support to the feeder team for quick response time to replace faulty meters and transformers; and (iii) corporate level incentives for implementation of the new scheme and performance of the company.

Potential barriers to implementation in India: Using AMIs for agricultural consumers, availability of communication technology, and a cross-sectoral selection of ICT-enabled systems of direct delivery of subsidy was assessed for appropriateness in the Indian context. Technical parameters recommended in the study take into account several that are relevant for ground realities in India. Nevertheless, the national socio-political realities pose some unique problems that might hamper successful implementation of any ICT-based subsidy delivery model. These include the following:

(a) Resistance to metering of individual power consumption among Indian farmers due to the significant "trust deficit" in government and the power utility. In most other countries metering is the accepted norm and meter tampering or power thefts are less extensive.

(b) Corruption and malpractice during data collection for farmer database and electricity grant allocation.

(c) Technical difficulties in designing a formula to calculate quantum of electricity (MES) that would provide an accurate estimate of power requirements acceptable to stakeholders.

(d) Severe fragmentation of landholdings upon succession and difficulty in correlating MES with landholding without an electricity connection.

(e) Need to establish a transparent and evidence-based mechanism for periodic review of MES.

(f) No experience to date in implementing a large-scale scheme for direct delivery of subsidy, in spite of India's technical capacity to establish a direct cash-transfer-based targeted subsidy delivery mechanism.

(g) Regulatory changes needed to make decision of the majority to "opt-in" for new subsidy delivery scheme to be mandatory for all consumers connected to the selected feeder.

(h) Inadequate IT, engineering, and commercial skills at lower levels in the power utility for adopting modern ICT tools.

(i) Making incentive payments for the staff meaningful, immediate, and clearly linked to measurable employee-controlled performance.

28 The elusive employee stock option plan-productivity link: evidence from India, R.K.Dhiman, International Journal of Productivity and Performance Management, Dec 2008.

29 Thomas J. Hackett and Donald G. Mcdermott, DG Mcdermott Associates, September 1999.

C. GENERATING SUSTAINED BENEFITS THROUGH WATER AND AGRICULTURE

There are several recent examples across different States of India that show how well designed interventions can create real incentives for farmers to increase irrigation efficiency and help them raise their incomes. Ideally, the proposed approach for direct delivery of irrigation power subsidy should include such interventions, so that the potential benefits of "last-mile" interventions for maximizing positive impacts at farm-level are captured. In 2008, the Punjab government achieved significant water savings across the State by pushing back paddy transplant time from as early as mid-May to mid-June, thereby aligning peak irrigation needs with monsoon rains.[30] The State legislature is now considering permanently adopting this measure, which succeeded for several reasons: (i) public resistance was limited because yields were not reduced; (ii) lack of compliance was highly visible; and most importantly, (iii) after a critical mass of farmers delay transplanting, farmers that transplant early risk increased pest infestation. This experience indicates that given the technologically progressive nature of farming in the State, measures to increase agricultural productivity could be effective in reducing groundwater use. The Punjab government is considering additional measures such as leveling fields using laser techniques, introducing soil-moisture-based irrigation timing and short-duration rice varieties; and the system of rice intensification and water-saving techniques that also increase crop productivity. The cumulative impacts on water needs and crop yields are as yet unknown but preliminary results (not accounting for return flows and non-beneficial evapotranspiration) indicate significant water-saving potential.[31]

30 The Punjab government prohibits early transplanting of paddy rice, an increasingly prevalent State-wide practice.

31 Potential for such interventions to bridge the demand/supply gap is specific to Punjab and may not be replicable elsewhere. Punjab farmers are progressive, technically aware, and quick to adopt promising new approaches. Moreover, Punjab has reached a saturation point in area under cultivation and net irrigated areas, thus there is almost no unrealized demand for water in the agricultural sector and no risk that these gains would be offset by an increase in area under irrigation.

TABLE 3: Water-saving Potential of Individual Interventions (water savings are not cumulative)

Proposed Interventions for Rice Farming	Reduction in Water Need (mm)
Laser leveling	410
Delay transplanting by one month	210
Timed irrigation with tensiometer[32]	370
Short-duration rice varieties	300
System of rice intensification	370
Baseline water requirement for rice = 1,840 millimeters	

Similarly, modest investments in a revolutionary model of informal farmer education in seven drought-prone districts in Andhra Pradesh have produced the first global example of large-scale success in community groundwater management. Under the Andhra Pradesh Farmer Managed Groundwater Systems Project, communities organized at aquifer-level have collectively brought their groundwater use in line with annual availability estimates while improving net farming incomes[33]. This model of farmer education, which has demonstrated success in safeguarding groundwater availability for drinking water and agricultural supplies, and costs approx. Rs. 100,000 per village per year, is being replicated in other States of India and in a nation-wide pilot program by India's Ministry of Drinking Water and Sanitation.

Other proven approaches for water productivity and agricultural incomes that hold significant potential in most Indian States include investments in conjunctive use of water in canal command areas, and investments in agricultural extension services.

32 A tensiometer is an instrument to measure soil moisture and helps plan irrigation scheduling. It costs less than US$10 and lasts about three years. Columbia Water Center in Punjab pilot projects reported savings of about 22 % for water and about 24% for energy consumption.

33 Deep Wells and Prudence: Towards Pragmatic Action for Addressing Groundwater Overexploitation in India, World Bank, 2009.

D. ALIGNING THE STAKEHOLDER'S INTERESTS

This Section discusses how huge potential for efficiency gains can help create beneficial outcomes for all stakeholders-except those who benefit from theft and corruption.

These objectives and desired outcomes are achievable in the long run since stakeholder interests are convergent and mutually reinforcing. The immediate task is to create

TABLE 4: Stakeholder Incentives: from Distortions and Mistrust to Desired Outcomes

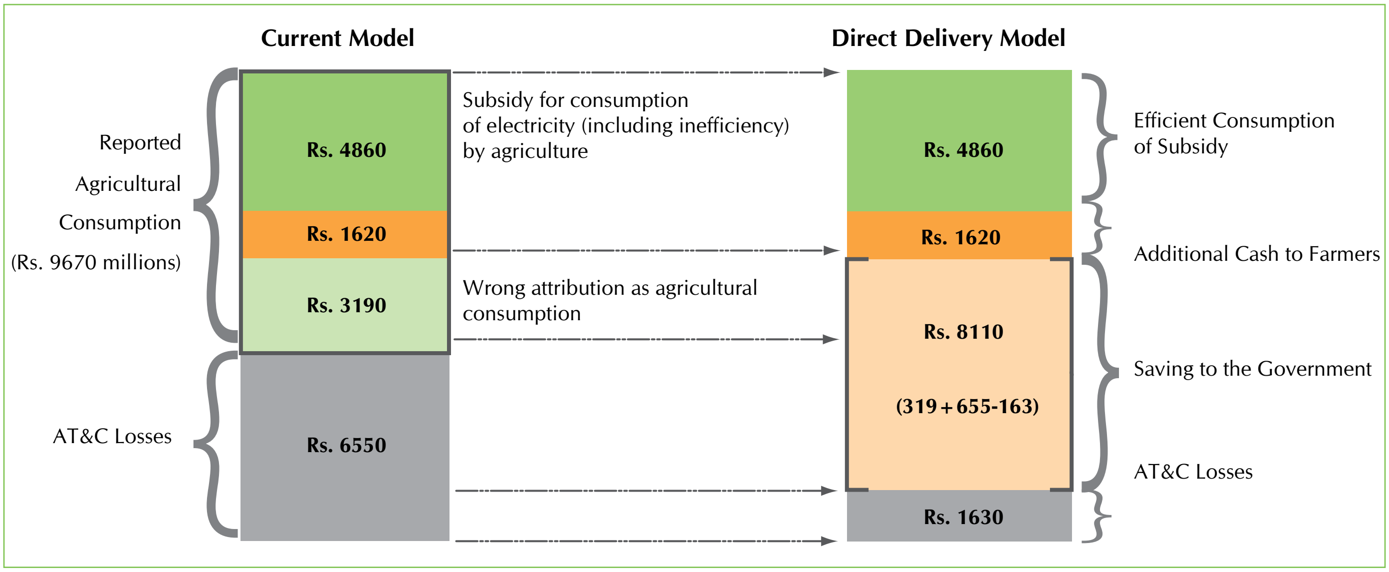
Stakeholders	Existing Conditions (Low Equilibrium)	Desired Outcomes
Farmers	Inadequate (5-6 hours) and inconveniently timed supply. Poor quality supply; unaffordable tariff requires subsidy; high costs for power connection; difficult to get connected. **High coping costs**	Power supply synchronized with irrigation and harvesting needs. Adequate, good quality power supply for agriculture. Tariff subsidy necessary to sustain agriculture.
Rural non-Agricultural Consumers	Limited hours of supply. Poor quality of life (health, education, burden on women). SME investments unattractive due to power shortage; rural economy almost completely dependent on fairly low-productivity agriculture.	Power supply and service equality for agricultural and non-agricultural rural consumers. Tariff concession for vulnerable households. Easy connection and continuous supply to SMEs.
Power Sector Employees	Poor compensation and unsatisfactory career opportunities. Operation and maintenance responds only to dire emergencies. Political interference in tariff, staffing, revenue collection; power theft is overlooked or politically sanctioned. Poor reputation among consumers, media, politicians.	Improved compensation, career opportunities, and professional enhancement. Reduced financial dependence on government, which would reduce political interference. Employees take pride in their work and are committed to the company and consumer satisfaction.
Elected Representatives	High political cost for power company's poor performance. Dissatisfied rural constituents. Inefficient power sector. Instrument of political patronage.	Political benefits from subsidy. Efficient power sector. Development dividend.
Government	Impedes economic growth. Unsustainable fiscal burden. Significant losses and theft. Inefficient electricity/groundwater use.	Power sector drives economic growth. Predictable fiscal burden and lower subsidy costs. Eliminate electricity theft. Efficient electricity/groundwater use.
Power Distribution Company	Politically mandated tariffs, insufficient subsidy. Unable to borrow and invest for system expansion to meet demand. Unable to upgrade staff skills.	Cost-covering tariffs at efficient performance level. Prompt subsidy payment. Meet customer demand and provide quality service. Operates within government policies but without political interference. High quality staff, competitive and well-run company.
Urban Consumers	High tariffs for poor supply and service.	Good supply, professional service, fair tariffs.
Suppliers Lenders Investors	Financially unviable. High political and regulatory risk	Creditworthy borrower.

Source: Authors

a transition from the existing low-level equilibrium to a future "win-win". An illustrative implementation plan is discussed in Chapter V. The key challenge is to build trust among stakeholders by implementing successful pilots and meaningful consultations. This learning-by-doing approach will involve some setbacks that will require mid-course corrections, empowering and supporting implementation teams, and building political support for scaling up. Government must support the scheme for direct delivery of power subsidy with a policy instrument and changes in electricity regulation. There are multiple benefits: defining MES in terms of quantity of supply, while gradually increasing the hours of supply gives the farmer control and flexibility to optimize use of this scarce resource; the government fiscal burden is predictable and covers only the product and service delivered to beneficiaries; the power utility's reduced political and commercial risk improves its creditworthiness, which will allow it to undertake expansion plans using commercial financing; politicians reap the political benefits of satisfied farmers and consumers resulting from improved services; and employees can look forward to career development and incentives for performance and professionalism while sharing in the financial growth of their employer.

In addition to improving quality of power supply to the rural areas and agriculture, implementation of the proposed solution could also create financial benefits for the power utility and the State government. A 2001 World Bank study estimated that about 33 percent of estimated sales to agriculture are actually commercial losses wrongly attributed to agricultural consumption. Farmers can easily save at least 25 percent of their power consumption by using more efficient motors, pumps, valves, and pipes, and can achieve additional savings through adopting water conserving irrigation techniques. Power companies can reduce commercial losses by more than 75 percent by adopting practices that improve corporate governance and accountability as demanded by increased transparency in energy accounting. Figure 6 shows the actual data of agricultural consumption and aggregate technical and commercial (A&TC) losses of an Indian power distribution company ("current model") and the proposed subsidy delivery model. The proposed subsidy delivery model can not only reduce the subsidy burden of the government by almost half but also ensure that the government is able to deliver more than 80 percent instead of 33 percent of that subsidy to the farmers.

FIGURE 6: Direct Delivery Model: Free Power and Additional Cash to Farmers; Reduced Fiscal Cost (All Figures in Rupees Millions)



Alternative Models for Implementing the Proposed Scheme

Chapter 3

Key elements of the proposed scheme are explained in Chapter II. Design criteria adopted for an alternative approach of direct delivery of power subsidy should accomplish the following:

- Supply quality power on-demand to farmers while maintaining existing subsidy benefits;
- Generate powerful incentives to improve the efficiency of power and groundwater use; support accurate energy accounting;
- Monitor efficiency to calibrate performance-linked incentives for employees;
- Improve creditworthiness of power utility;
- Create "modular" increments of implementation that can be adapted to the different starting conditions for each power utility.

Several variants of the model are possible. The entry point for any given State would depend on its starting conditions, technology absorption capacity of farmers, technical and management capacity of the power utility, State capacity to provide quality agricultural extension services, and State government willingness to consult and engage farmers in collaborative design and implementation.

A. KEY COMPONENTS OF THE MODELS

Two components common to all models are the following:

- **Segregation of rural feeders.** An additional, though expensive, investment to improve quality of supply and reduction of technical losses can be conversion of agricultural feeders to HVDS, and use of Aerial Bunched Cables in high theft-prone areas.
- **AMI System.** AMIs must be installed at the outgoing feeder and at consumer connections. Farmers would be provided with a remote switching option through their mobile phones. The power utility would install a data center for energy accounting and auditing, incentives for the employees, meter management, billing and collection.

Two components that vary across the models are the following:

- **MES calculation** can be based on either the consumer landholding (in hectares) or consumer connected load (horsepower or kW). *Landholding* can be used if land records are well organized and (preferably) computerized, which eliminates discretion among administration officials in calculating subsidy allocations; it makes MES completely transparent since villagers have access to landholding information and demarcation on the ground. Since landholding transfers are infrequent and volume is low, this system would be relatively more stable. In cases of cultivation of leased land with electricity connections, the lease rentals will be adjusted by the market for the benefit of subsidized power used by the lessee. *Connected load* is a less preferred option since it may differ across neighbors even if their land holding is the same and it may continue to change based on replacement motors and pumps in case of burnouts. The administrative process of monitoring the nameplate capacity of pumping system is open to abuse by farmers and corruption at the field level administration officers. An illustrative calculation for Punjab, normalized over its five agro-climatic zones, is presented in Annex C.

- **Subsidy denomination** can be in terms of quantity of electricity (kilowatt-hours) or number of hours of power supply. The AMIs would have full functional capability and record all necessary parameters of consumption, hours of usage, time of use, load, outage, tampering, switching, etc., regardless of the subsidy denomination selected. However, a quantity-denominated subsidy provides a clear incentive to farmers to use energy more efficiently since they would have to pay for any excess consumption. By contrast, a subsidy denominated in supply hours lacks incentives for efficient use unless power supply continues to be rationed and rostered, which defeats the fundamental principle of shifting choices and rewards to the consumer since consumer behavioral change is critical to improve end-use efficiency.

B. FIVE MODELS

Based on the above variables, several models are presented below and shown in Figure 3.1.

Business As Usual (BAU): This is the most prevalent model of delivering power supply and subsidy to agriculture in India. It entails mixed feeders, no metering at tube well or feeder level, and farm power rationing through limited hours of 3-phase power supply. Not only does this model suffer from all the problems discussed earlier but also it leads to disagreements among the regulator, power utility and government about agricultural consumption and subsidies, and deep distrust among farmers who suffer inadequate, unreliable, and poor quality supply and service.

Model 1 – Feeder Segregation (FS): Some States have already implemented feeder segregation. A crucial factor for success is feeder and distribution transformer metering, energy accounting and auditing to control losses. This model entails physical separation of rural feeders; improvement in governance; high-cost investments such as ABCs, HVDS, specially designed transformers; and rostering and rationing of 3-phase farm power supply. Feeder meters must be installed for energy accounting and management control. Agricultural consumption and losses must be monitored through an independent third party. Unauthorized connections and increase in connected load must be vigorously monitored and controlled to maintain quality power supply to legally connected customers.

Model 2: Feeder Collective with Supply Hours-based Subsidy: This builds on Model 1. The Feeder Collectives (comprising a group of tube well owners served through a common feeder) decide by a majority vote to opt in to the new scheme of subsidy delivery. After a stated period, determined by the regulator, farmers can opt out if they do not like the scheme. Farmers served by an “opt-in” feeder would be offered the following:

a) Longer hours of farm power supply on their feeder over and above normal free roster hours;

b) ToD metering at individual customer level (the utility would install AMIs at the feeder);

c) Customers receive a monthly bill of kWh used *less* the kWh drawn during free roster hours. Additional kWh would be charged at regulator-determined rates, replacing farmers’ supplemental energy source (normally diesel-fired generation) with an attractive cheaper alternative;

d) Night consumption rates are lower than day consumption rates;

e) Farmers use their mobile phones to control their pumping system remotely and receive information on supply, MES allocation, consumption, billing, etc.;

f) Power utility collects payments for extra consumption from customers and for MES consumption from government;

g) Incentives for feeder-team employees, linked to targets for reducing levels of distribution losses, higher rates of bill collection, and user satisfaction with service quality.

Model 3: Feeder Collective, with kWh-based Subsidy. This builds on Model 1 (feeder segregation and related improvements). The Feeder Collectives (comprising tubewell owners served through a common feeder) decide by a majority vote to opt for the new scheme of subsidy delivery. After a stated period, determined by the regulator, farmers can opt out if they do not like the scheme. Farmers served by an "opt-in" feeder would be offered:

a) Existing power ration converted to an annual kWh allocation (MES), which could be apportioned to cropping seasons of winter (Rabi), summer (Kharif) and spring (Zaaid);

b) ToD metering at individual consumer level (the utility would install AMIs at the feeder);

c) Consumers receive a monthly bill of kWh used, less kWh allowed under government-provided MES. Additional kWh, charged at regulator-determined rates, would substitute for farmers' supplemental energy source (normally diesel-fired generation), hence a cheaper alternative;

d) Night consumption rates are lower than day consumption rates;

e) Farmers can use their mobile phones to remotely control their pumping system, receive information on supply, MES allocation, consumption, billing, etc.;

f) Power utility collects payments for extra consumption from customers and for MES consumption from government;

g) Incentive for feeder-team employees is linked to reduced levels of distribution losses, higher rates of bill collection, and user satisfaction with quality of service;

h) Two variants are: (a) **Model 3L,** in which the MES is determined on the basis of landholding (kWh/ha of agricultural land) and (b) **Model 3C,** in which the MES is determined on the basis of connected load (kWh/pump).

Both Models 2 and 3 require that the consumers served by a feeder scheme take a collective decision through consultations and majority voting to opt in or out of the scheme. Regulation should make the majority decision binding on all customers served by a feeder.

Some might argue for using the rural electric cooperative model for managing the scheme. However, the past experience with electricity consumer cooperatives has not been very successful. As compared to "producers' cooperatives" the "consumers' cooperatives" are much less successful in India. Since the rationale for consumers cooperatives is to obtain a scarce resource for its members, the resource and cost allocation becomes inherently a political, opaque, and administratively cumbersome process. Governance of "producers' cooperatives" is more rule-bound, transparent, and less political since benefit sharing is directly proportional to member's inputs and the rationale for their formation is to benefit from economies of scale.

The role of the feeder collective can be as extensive as a consumers' cooperative that develops norms of electricity allocation, distributes costs among members, issues and collects bills, and provides operation and maintenance; or as minimal as one-off decision to opt in or opt out of the new scheme. The preferred model is that all individual tube wells are TOD metered and customers receive separate bills thus eliminating the need for feeder collectives to set consumption and payment norms. Given the dismal experience with electricity cooperatives in the past, limiting the role of the feeder collective to a single decision to opt in or opt out seems to be the most viable model and is consistent with a process defined in electricity regulation.

Models 4 and 5 for farms located close to the village

To test the acceptability of the scheme among farmers, it may be possible to run pilots using village supply feeders if these are segregated and receiving continuous power supply. Under this scenario, opt-out can occur at the level of individual farmers, who can then get reconnected to the 24/7 rural feeders if they want additional supply and are willing to pay for it. The subsidy can be denominated either in number of hours of supply (Model 4) or quantity of energy (kWh) (Model 5) and a smart meter with ToD features is installed on the farm connection to disconnect and discourage electricity consumption during peak hours. This is available *only* if a small percentage of consumers select this model. If many farmers opt for longer hours, then a feeder collective-level consensus will be more viable, otherwise there is a danger that the segregated feeders will again become mixed-load feeders.

FIGURE 7: Subsidy Delivery Models

Basis of Subsidy	**Unit of Subsidy**	
	Land Holding (L)	**Connected Load (C)**
	Model 1: Feeder segregation; power supply synchronized with agricultural operations; AMIs on feeders and distribution transformers; energy accounting and auditing; independent monitoring; HVDS, if necessary.	
Hours of Supply	Model 2. Customers served by the "Opt-in" feeder receive the rostered power supply like any other farmer but for consumption in additional hours of supply they pay for kWhs consumed at a regulator-determined tariff. Land holding or connected load is irrelevant for additional consumption.	
Quantity of Energy (kWh)	Model 3-L: Feeder collective opts for new scheme, gets longer hours of supply, MES in kWh based on land-holding, night consumption set off at rates lower than day consumption, farmers get remote control of pumps through mobile phones	Option 3-C: Feeder collective opts for new scheme, gets longer hours of supply, MES in kWh based on connected load, night consumption set off at rates lower than day consumption, farmers get remote control of pumps through mobile phones
Model for farms located close to the village		
Hours of Supply	Model 4: Individual farmers opt for disconnecting from agriculture feeder and get rewired to 24*7 village feeder at their own cost; charged for consumption in kWh beyond regular rostered hours for other farmers at regulator determined tariff; differential rates of set-off for day and night consumption; bill shows consumption by time of use.	
Quantity of Energy (KWh)	Model 5-L: Individual farmers opt for disconnecting from agriculture feeder and get rewired to 24*7 village feeder at their own cost; MES determined on the basis of landholding; charged for consumption in kWh beyond regular rostered hours for other farmers at regulator determined tariff; differential rates of set-off for day and night consumption; bill shows consumption by time of use.	Option 5-C: Individual farmers opt for disconnecting from agriculture feeder and get rewired to 24*7 village feeder at their own cost; MES determined on the basis of connected load; charged for consumption in kWh beyond MES at regulator determined tariff; differential rates of set-off for day and night consumption; bill shows consumption by time of use.

Evidence from Recent Initiatives and Field Testing

Chapter 4

Power utilities in India are facing multiple challenges: rising electricity demand from agriculture in part due to declining groundwater; persistent and severe power supply shortages; operational losses and inefficiency; consumer dissatisfaction; and increasing public accountability through newly created regulatory agencies. As a result most power utilities have launched some initiatives to improve power supply to agriculture. Government of India also launched schemes to fund feeder segregation, improve access and power supply to villages, reduce technical and commercial losses, and modernize power utilities through increased use of ICT and evidence from the field demonstrates that introducing new technologies is technically feasible and financially attractive. In fact, the availability of cost-effective technology now offers never-before opportunities for innovative applications that can help untangle the complex political economy of agricultural subsidy, but achieving the desired objectives of the schemes will critically depend on simultaneous institutional capacity building and organizational transformation.

A. RECENT INITIATIVES BY THE STATES

Most of the schemes and pilot programs launched by the States and the Government of India have related to demand-side management and energy-efficiency improvement; metering feeders, distribution transformers, and agricultural consumers; reduction of transmission and distribution (T&D), and aggregate technical and commercial (AT&C) losses; public-private partnership (PPP) through distribution franchisees; and incentives for power utility employees. This study reviewed a few key initiatives and conducted further evaluations with target audiences in the States of Punjab and Karnataka using field surveys, focus group discussions, and specially designed games to uncover actual (as opposed to stated) preferences. A desk review of energy-groundwater nexus was also carried out for Andhra Pradesh.

Gujarat pioneered with its much acclaimed and successful Jyotigram scheme launched in 2004. USAID funded a program called Distribution Reform, Upgrade and Management (DRUM) and Water and Energy Nexus (WENEXA) that piloted a program in Doddaballapur Sub-Division in Karnataka. Andhra Pradesh Southern Power Distribution Company (APSPDL) tested energy efficiency and conservation measures on a variety of agricultural pumps that yielded more than 15% energy savings and 28% increase in discharge while reducing the operating hours of the pumpsets. Similar results were achieved by Noida Power Company Limited in UP. The Bureau of Energy Efficiency (BEE) has launched a program of agricultural demand-side management to establish a PPP program to implement such projects and a test pilot yielded more than 20% increase in weighted average operating efficiency. More recently, Columbia Water Center (CWC) is running a pilot in Kukarwad in North Gujarat and with paddy growers in Punjab to test water and energy savings from use of energy efficient pumping systems and irrigation technologies. In Gujarat CWC has reported water savings of 30% yielding cash back to the farmers since they pay a flat tariff, and in Punjab synchronizing irrigation to soil moisture using tensiometers, the farmers reported water and energy savings of more than 22%. Bihar implemented a successful proof-of-concept pilot to use solar-powered agricultural pumps to rehabilitate 34 old State-owned diesel-powered pumps through private sector participation (Annex D).

A recent study by Kumar *et al*., 2013 compared water use by 600 farmers across eastern UP, south Bihar, and Gujarat under different categories (pump-owners: flat electricity tariff, metered electricity tariff, diesel, water buyers from electric and diesel pump owners etc.) and found that pump owners with metered connections use almost 30% less water per hectare of land than flat-tariff consumers; and that water buyers achieved higher productivity than pump-owners. In spite of the reduction in pumping, the net return from unit area of land was found to be higher for water buyers than for well owners. This indicates that introducing a marginal cost for water and electricity promotes not only efficient use of water, as manifested by higher farm-level water productivity, but also more sustainable use of water. The approach of direct delivery of power subsidy proposed in this paper introduces a proxy pricing in a regime of free power through Minimum Energy Support beyond which the farmer has to pay but can benefit from savings from MES allocation. Energy demand response to price ("proxy price" in this paper) results in the following: (i) efficiency of water abstraction devices (motors, pumps, valves, pipes), (ii) improving technical efficiency of water use by optimizing water application, (iii) improving agronomic efficiency of water (kg/m3 of water) and (iv) shifting to crops with higher water productivity in economic terms.

Jyotigram in Gujarat

The success of Jyotigram in Gujarat led other states in India to invest in rural feeder segregation schemes, with the Government of India providing funds. Gujarat launched a scheme to bifurcate rural feeders to segregate village power supply from agricultural power supply, primarily power supply for groundwater pumping. The feeder segregation scheme enabled Gujarat to provide 24-hour supply to villages and improve the quality and schedule of supply to agriculture. Within three years, Gujarat not only achieved continuous supply to all 18,000 villages but also attained a high quality supply and a pre-announced schedule of eight hours per day supply to farmers for a flat tariff. This was a paradigm shift from "power for irrigation" to "power *and* irrigation". At a cost of about Rs. 13 billion (US$300 million) within three years, Gujarat constructed about 48,000 kilometers of high-tension lines, installed about 18,000 transformers and the associated infrastructure. Simultaneously, the Water Resource Department created about 500,000 groundwater recharge structures, and about 240,000 farm ponds, check dams and other water infrastructures.

Agricultural electricity consumption declined by about 37 percent (5800 GWh); the electricity subsidy declined from US$788 million in 2002 to US$388 million in 2007, with significant socio-economic benefits for a diverse group of stakeholders. A 2007 study of 55 villages in ten districts of Gujarat[34] revealed that electricity supply improvements meant that women could cut the time spend on household chores by 25 percent; they could increase time spent on income-generating activities by about 20 percent, education and entertainment by more than 80 percent, and exercise more discretion in organizing their daily schedule of activities. Thanks to an improved household electricity supply, children at home increased their study times by more than 80 percent; rural industries such as agro-processing, diamond polishing, toiletry manufacture increased their outputs; and rural households could extend their work hours, generating more employment and reducing rural out-migration by almost one-third.

Though water recharge interventions in conjunction with improved power supply (voltage, reliability, predictability) has helped reduce energy and groundwater consumption, the system does not offer flexibility to farmers and does not synchronize power supply to agriculture, which does not need eight hours/365 days per year. Further efficiency gains can be achieved through changing the flat tariff regime to metered supply and changing the incentives of stakeholders, as demonstrated by Columbia Water Center in a recent pilot in Kukarwada in a water-stressed region of North Gujarat. However, a 2012 World

34 Shah *et al*., 2008. Groundwater governance through electricity supply (2008); also reported by Devika Devaiah, Erehwon Innovation Consulting (2010).

Bank feeder-segregation study showed that feeder segregation alone delivers only an improved power supply to villages. Further benefits can be realized only if feeder segregation is accompanied by robust monitoring and evaluation; strengthening institutional capacity; and changes in institutional incentives.

Wenexa

In Karnataka, USAID funded an innovative pilot to improve energy efficiency in agriculture using a PPP model. The program started with setting up baseline consumption on selected feeders in 2009 and is expected to last ten years. Interim results indicate the need to integrate interventions in energy and groundwater; to coordinate among agencies dealing with energy, groundwater and agriculture; and to create incentives for end-users to benefit from saving subsidized resources. The proposed scheme of direct delivery of power subsidy incorporates these lessons.

BOX 2: WENEXA: Addressing Inefficient and Unregulated Groundwaterand Energy Use in Agriculture*

The Program was designed to use a public/private/civil society partnership to replace energy-inefficient water pumps with energy-efficient pumps at no cost to farmers; it was implemented in Doddaballapur in Karnataka. The Energy Services Company (ESCO) and the power utility (BESCOM) struck an agreement under which they share about 12 percent of energy savings above the baseline consumption recorded in 2009.

Another WENEXA program component was watershed management and water table replenishment through the construction of a catchment dam, plus bunding and trenching activities in the pilot area. There were demonstrations of drip irrigation and some attempts to inform farmers about the availability of subsidies for drip irrigation. The program conducted a water balance study at the basin level to assess area water resources. Water component activities were undertaken in a piecemeal and isolated manner with no verifiable impact in the area.

Current status. In spite of many challenges, the ESCO achieved 23 percent energy savings. As of March 2011, only 460 pumpsets of the total of 604 had been energy audited; 35 farmers did not agree to have their inefficient pumps replaced, even after the pump energy audits; about 43 pumps dried up making it difficult to replace them. Some farmers re-bored their tube wells due to groundwater depletion; some farmers abandoned the wells and shifted the pump set to a new tube well when the previous one dried up; some tube wells are deeper than the reported during baseline (thus require more energy to pump water), and others have technical problems.

Lessons Learned. An integrated approach is essential and must address energy and groundwater end-use efficiency and support groundwater. In Doddaballapur, the WENEXA project has not promoted collaboration among energy providers and others involved with water provision/regulation services in agriculture such as the Water Resources and Agriculture Departments and others. Energy savings in groundwater irrigation depend upon not only efficient pumps but also on groundwater levels (which depend upon the extent of rainfall recharge), regulation of groundwater use as a common property resource based on collective action rather than individual action, and changes in cropping pattern towards less water-intensive crops over a period (influenced by markets). This approach has been proven to be useful by some of the NGOs working on Ground Water Management in dry regions of India. Hence, an integrated approach is essential to improve efficient utilization of water and electricity resources.

Establish a baseline to measure outcomes. The program established a baseline for energy consumption but not for groundwater or cropping. Establishing a revised baseline is expensive and labor-intensive to fix new pumps and meters, and record data for a reasonable period before establishing the new baseline.

Coordinate among groundwater and agricultural agencies and farmers to plan and manage the project. WENEXA implementation lacked an integrated approach; it neglected aspects such as groundwater recharge, coordinating with other water and agriculture agencies, and involving farmers' organizations.

Provide economic incentives for efficient use of subsidized resources. A basic implementation problem of this model in Karnataka is that free electricity supply offers farmers no incentive for efficient use. Also, since groundwater use is unregulated, resource-rich farmers in the community will use more than their share, leading to skewed usage.

*(Evaluation of DRUM and WENEXA, USAID April 2011).

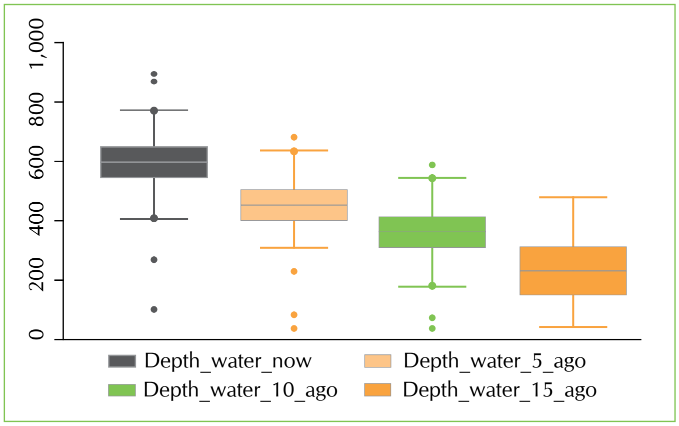
Columbia Water Center

Columbia Water Center (CWC) pilots demonstrated that technical feasibility, financial viability, and economic attractiveness are necessary but insufficient for people to adopt new technology and abandon entrenched behavior patterns. People need incentives to use electricity and water efficiently.[35] In Gujarat, CWC carried out a field study in Mehsana and Gandhinagar over about 180 sq km, of 170 farmers out of 700 agricultural consumers served by 22 feeders. Based on observation wells and farmer surveys, the study found that water tables have been falling steadily over the last 15-20 years at a rate of 9-20 feet per year to their current state of about 600 feet below ground level, which risks irreversible salinization of aquifers (Figure 8). As a result, farmers drill deeper wells and install more powerful pumps; horsepower usage and the depth of wells have increased dramatically but an average well can now irrigate only about 60 percent of its command area. Nearly all respondents expected the water table to continue to decline, and on an average, expect water to last for another six years. When the water table declines or aquifers become depleted, more than half of farmers plant to abandon irrigated agriculture.

As the water table declined over the last two decades, energy use appears to have increased but without a matching increase in irrigated area. This continued deterioration is encouraged through the incentive of large government subsidies. Using groundwater extracted from these unsafe depths to irrigate crops is not financially viable. Therefore, the project offered an incentive scheme; farmers would receive a discount in their flat tariff equivalent to whatever they managed to save compared to their baseline consumption; these incentives were combined with multifaceted support for water-saving approaches, including the following:

- Farmer-level implementation of identified crop-specific water/energy saving strategies (tensiometers, drip irrigation, furrow irrigation and mulching, among others)

FIGURE 8: Gujarat: Declining Water Table in Kukarwada Region



Source: Addressing the Water Crisis in Gujarat, India, Columbia Water Center, March 2011.

TABLE 5: Savings from improving energy efficiency of pumping systems for irrigation

(Denominated in Indian Rs.)	Gujarat	Haryana	Punjab	Maharashtra	All of India
No. of IPsets (million)[36]	0.85	0.52	1.012	2.8	15
Electricity consumed (MkWh)	12,400	10,200	11,500	13,000	104,085
Capital investment for 100% replacement (Rs. billion)[37]	34	20.8	40.48	112	600
Yearly savings (MkWh)[38]	3,720	3,060	3,450	3,900	31,225.5
Yearly savings (Rs. billion)[39]	11.16	9.18	10.35	11.70	93.68
Simple payback (years)	3	2.3	3.9	9.6	6.5
CO_2 emission reduction[40] ('000 tn)	3,868.8	3,182.4	3,588	4,056	46,800

35 http://water.columbia.edu/files/2011/11/Gujarat-WP.pdf

36 Bureau of Energy Efficiency, 2010 for India data; ARRs of utilities for State specific data, 2010.

37 Cost of an energy-efficient IPset is taken as Rs 40,000.

38 Assuming 30 percent savings.

39 Using average power purchase prices of Rs 3/kWh.

40 Emission factor of 0.78 kg/kWh {Greenhouse Gas Mitigation in India: Scenarios and Opportunities through 2031, The Energy and Resources Institute (TERI) and The Center for Clean Air Policy (CCAP), 2006}.

- Extensive farmer-level agricultural extension activities to raise awareness and build capacities.
- Farm-level GIS maps that capture the landholding size, cropping pattern, and area.
- Crop diversification (less water-intensive higher value crops) introduced.
- Electricity bill redesigned to highlight water savings.
- Energy meters installed for each tube well to measure savings; load rectification completed.

Clearly opportunities exist in Indian power and groundwater sectors to reduce overall power consumption, improve efficiencies of groundwater extraction and reduce the subsidy burden on the States without sacrificing the service obligation to the farmers. See Table 5 below for potential savings.

In addition to the savings noted above from reduced electricity flows, about 17,845 MVA of electricity network capacity will be released.[41] With a nationwide investment of Rs 600 billion, India could reduce its electricity demand-supply gap from an existing 11 percent to 3.0 percent and its annual agricultural tariff subsidy by Rs. 94 billion. The multiplier effect of fresh investments would create employment and generate income, not only in the industrial sector where 15 million energy-efficiency pumpsets would be required, but also in ancillary industries and SMEs. Furthermore, rural employment would be given a boost by the need to replace existing irrigation pumps. Finally, improved power reliability and quality would provide incentives for farmers to run their IPsets more efficiently, which would reduce groundwater losses.

B. ESMAP STUDY AND FIELD TESTING OF CONCEPTS

The ESMAP Study was launched to explore alternative models of subsidy delivery to farmers using appropriate technologies to improve the efficiency of energy and groundwater use and address the challenge of aligning stakeholder incentives-a problem identified by other studies and pilots. The International Water Management Institute (IWMI) and Infosys (an IT solutions provider) were engaged as consultants for the study. The Planning Commission in India coordinated the India case study and invited those States that had high agricultural power consumption to volunteer for participation. Two States, Punjab and Karnataka volunteered immediately. Andhra Pradesh volunteered later but no fieldwork was carried out there.[42] The study had three steps: (i) desk reviews, consultation meetings and farmers surveys; (ii) an irrigation-energy game designed to be played by farmers and power utility officials to understand their preferences, followed by further consultations to design options; and (iii) detailed analysis of options selected by each participating State, followed by designing an implementation pathway. A summary of the methodology follows.

Desk reviews and consultations with farmers. The study team carried out a review of international experience and selected China, Mexico, and India, three countries with intensive use of groundwater for agriculture. The Planning Commission organized a consultation with representatives from Bangalore Electricity Supply Company Limited (BESCOM), Karnataka, PSPCL Punjab, Andhra Pradesh, AP Transmission Company, Ministry of Power, Bureau of Energy Efficiency, Central Groundwater Board, World Bank, IWMI, and Infosys. The IWMI team followed up with visits to Punjab and Karnataka and in-depth discussions with several levels of power utility managers. Insights and results from ongoing IWMI studies in Gujarat, Rajasthan, Madhya Pradesh, Tamil Nadu and Kerala were also used in developing project concepts. The IWMI team also studied the Annual Revenue Reports (ARRs) filed by DISCOMs and their exchanges with State electricity regulators. In Punjab and Karnataka, IWMI surveyed 250 tube well irrigators on hours of power availability and the impact on agriculture, and satisfaction levels on power availability.

41 Annual Report, Central Electricity Authority, 2004-05.

42 After a few months of commencement of the study, Haryana also expressed willingness to participate but could not be included at that late stage.

INFOSYS reviewed international experience in direct delivery of subsidies to the poor to assess alternatives and estimate the cost of using information and communication technology for direct delivery of power subsidies. INFOSYS reviewed adoption of AMIs and talked to manufacturers. Detailed discussions were held with the two mobile operators associations (CDMA and GSM) to better understand technology interface, spatial coverage of mobile phone networks, and inter-operability among service providers.[43] Desk reviews and discussions with stakeholders and experts clarified problems and generated options to address challenges. Chapter II provides a summary of the review.

Irrigation-energy game and further consultations for designing options. The study team consulted experts from national and State governments, power utilities, and industry to develop alternative subsidy delivery models. The challenge was to design a methodology that would accurately predict whether farmers, utility staff and political leaders would accept such a win-win option if it were made available.[44]

To achieve this, the IWMI team designed a simulation game that modeled a village agricultural economy in which power supply conditions determined the welfare of farm households and the agricultural economy. The game simulated several alternative power subsidy regimes and was played with a group of farmers in Sangrur and a group of PSPCL officials in Patiala; and a group of farmers in Karnataka (Dodaballabpur) and BESCOM officials in Bangalore. Its key advantage was that player preferences for alternative power supply and pricing regimes were revealed by their choices as farm households regarding everyday decisions on ways to improve their livelihoods. The second advantage was that the game revealed how alternative power supply conditions would influence water markets, labor markets, village economic output and utility finances. Invariably players preferred the option of subsidy benefits with longer hours of metered power supply that provided flexibility and opportunity to evaluate tradeoffs, an option that also tended to maximize village economic output. Game results were discussed in another round of consultations with farmers, utilities, power, finance and groundwater ministries.

Some farmers expressed willingness to pilot metered supply despite widespread mistrust of the utility and government, which remains a recurring theme and major barrier to implementing any scheme. In Punjab and Karnataka farmers were surveyed (see Annex E for survey questionnaire).[45] In Punjab surveys were carried out in Sangrur, Kapurthala, and Ludhiana districts; block selection was based on different groundwater levels, and village selection was based on connected feeder loads.[46] Most paddy growers that supplement irrigation through diesel-fired power generation expressed willingness to pay for additional power supply. Typically, farmers defined *supply quality* as, "better voltage, fewer fluctuations, longer hours of supply, and daytime supply," since nighttime supply makes it difficult to monitor water distribution. Farmers expressed willingness to pay for additional supply and metered consumption if additional costs were reflected in the MSP. About 74 percent farmers expressed willingness to accept metered electric connections (Fig 5.2) and to pay for good quality supply but farmers opinions differed across regions. For example, farmers in Sangrur were more receptive to trying the new scheme as compared to farmers in Patiala who were opposed to metering. Most farmers have no confidence in power company ability to implement the scheme. The surveys also highlighted the need to update land records. The PSPCL officials suggested some pilots be carried out in the "Doab" region.

43 Meetings held with associations of GSM and CDMA cellular operators in Delhi on December 20, 2011.

44 One option was a 'contingent valuation' survey to expose farmers' ordinal scale of preferences for the options outlined above. However, it is widely recognized that contingent valuation surveys can produce misleading results. A World Bank willingness-to-pay survey of farmers in Haryana and Andhra Pradesh revealed high willingness to pay for quality farm power supply. But when confronted with the choice, farmers tend to prefer status-quo partly because of the 'trust deficit'.

45 Details of surveys are available in background papers: Groundwater and electricity linkages: Evidence from farmers' survey in Punjab (September 2011) and Karnataka (October 2011), IWMI.

46 Additional surveys from a different study in Patiala, Barnala, and Fatehgarh Sahib were also used for analysis.

FIGURE 9: Willingness of Farmers in Punjab to Accept Metering

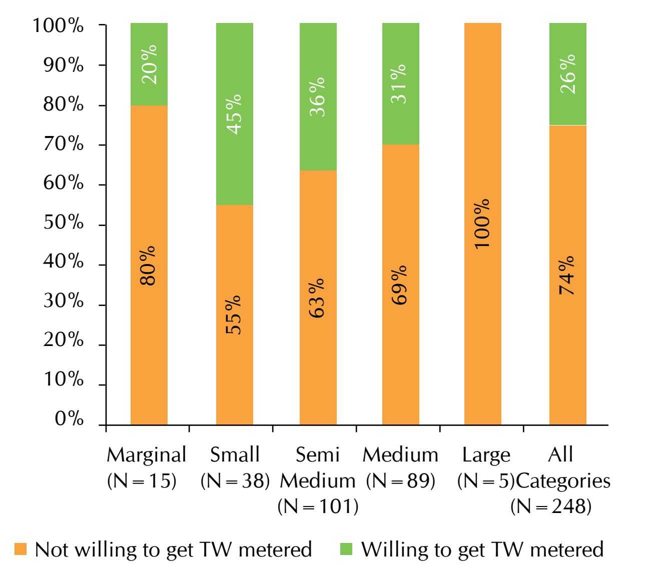
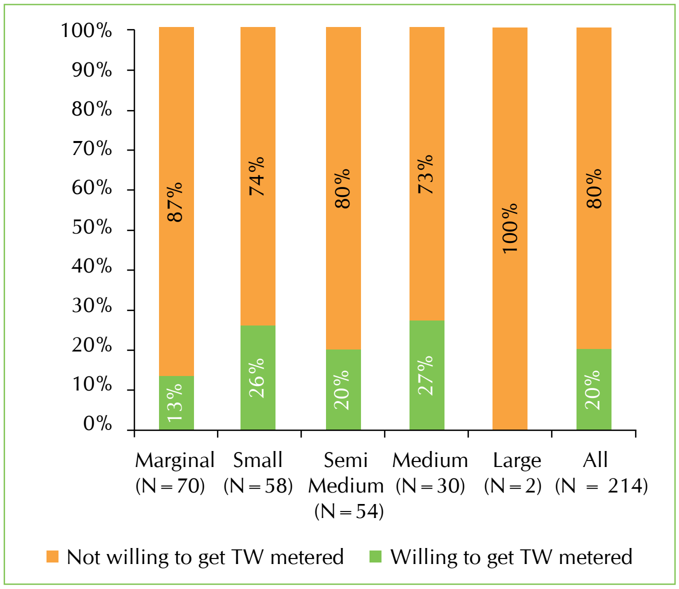


FIGURE 10: Willingness of Farmers in Karnataka to Accept Metering



Similar survey and consultations were held in the Tumkur and Kolar districts of Karnataka, where stiff resistance to metering became abundantly clear. However, officials note that without metering it is impossible to quantify agricultural consumption. Only 20 percent of farmers expressed willingness to accept metered supply and only 33 percent said they would consider paying for good supply quality (Figure 9). The HVDS has yielded good results but feeder segregation (Nirantar Jyoti) remains at an early stage; consumer connection records are incomplete and inconsistent. Therefore, Karnataka is focused on feeder segregation and is not yet ready to consider further steps in direct delivery of power subsidies.

Detailed analysis of the options and an implementation pathway. Based on these consultations with State-level officials and farmers, the study team produced a detailed design and broad implementation pathway for the option chosen by stakeholders. States can be categorized into the following three stages, based on existing electricity governance:

Stage 1: States with limited agricultural electricity consumption, such as the Eastern Indian States of Assam, Bihar, Orissa, and West Bengal and parts of eastern Uttar Pradesh.

Stage 2: States with incomplete feeder segregation and major challenges in accurate energy accounting, illegal connections and theft (such as Karnataka, Madhya Pradesh).

Stage 3: States with completed feeder segregation, feeder metering for energy accounting, and smart rostering of supply to tube wells (such as Jyotirgram scheme in Gujarat and Urban Pattern Supply in Punjab).

The move towards an efficient and effective electricity governance could be accomplished in two stages:

Stage 4: Implement the new scheme comprising longer hours of supply, free power allocated by kWh per year, and metered consumption. This would allow farmers to use more power than the free allocation at a tariff to be fixed by the regulator (Gujarat and Punjab would be the most eligible candidates because they have the institutional capacity, technology infusion, and improved governance at feeder level).

Stage 5: Provide incentives (such as cash back) to encourage farmers to consume energy and water more efficiently, and to use less than their allocation. In north Gujarat where farmers already pay a non-trivial flat tariff, Columbia University is conducting a small experiment. Initial results of the pilot indicate that farmers who received discounts on their electricity bill would voluntarily agree to metering. Punjab may not yet be ready for this stage but can quickly progress after successful implementation of a few pilots.

FIGURE 11: Five Stages of Electricity Governance and Conditions required for Moving to the Next Stage

Stage 1: Business As Usual	**Stage 2: Feeder Segregation plus**	**Stage 3: FS plus MES and AMI**	**Stage 4: FS plus MES and AMI, direct delivery of subsidy**	**Stage 5: FS plus MES and AMI, direct delivery of subsidy; cash back for savings**
Low agricultural load; low density rural population; small sized villages, hilly areas, states with low grid-access, shallow water table and large solar radiation that could use solar irrigation pumping instead of grid-connected electric pumps	Significant agricultural load; supply shortages; poor quality supply to villages, relatively dense rural population and large sized villages	Stage 2 plus: Institutional capacity in Ministry of Finance to use ICT for subsidy delivery; commitment to honor subsidy obligations and pay the vouchers; support access to internet in rural and semi-urban areas; organizational transformation in power utility	Stage 3 plus: Institutional capacity and political mandate to enforce MES; improve corporate governance and commercial incentives of staff and management of power utility	Stage 4 plus: Financially viable, commercially strong power utility with IT-skilled workforce having performance-based incentives; well established subsidy delivery system with strong financial controls

Key Challenges in Implementation

Chapter 5

Although direct delivery of power subsidies to farmers constitutes a paradigm shift in the political and commercial relationships among government, the farmer, and the power utility, the current demand for good governance can no longer be ignored, nor should it be since conditions are right to support these changes.

A confluence of emerging factors now makes it possible to design solutions that reduce the heavy political cost of changes that are long overdue. These factors include the opportunity for strong collaboration between Ministry of Power and the State; acceptance of innovative solutions such as frequency-linked availability tariff in wholesale power market and segregation of rural feeders; the ability of States to learn from one another and build on successful pilots; and the availability of affordable proven technologies such as AMI in conjunction with ICT.

Nevertheless overcoming farmers' trust deficit, strengthening institutional capacity and inter-agency coordination remain major challenges. A segmented, sequenced, and gradual approach of learning-by-doing could demonstrate to stakeholders the substantial benefits of new subsidy delivery mechanism. Detailed preparations, resource commitment, empowerment of the implementing agencies, well-prepared communications and consultation programs, and a robust monitoring and evaluation arrangement are essential ingredients of a successful implementation plan. Support by the Government of India through a centrally-sponsored scheme would help bring uniformity in technology choice and cross-fertilization of implementation experience.

This chapter presents a strategic framework and an institutional arrangement for implementation at the State level. It is important to test this scheme through a few pilots in two or three States to evaluate farmer adoption of technology, learning by the implementing agencies, and refining the scheme based on feedback. After testing some pilots, Government of India may consider offering technical and financial support to the States using a centrally sponsored scheme to implement direct delivery of power subsidy to farmers. A separate note providing a detailed implementation plan for the Central and State Governments was submitted to the Planning Commission.

A. STRATEGIC FRAMEWORK

The Strategic Framework presented below comprises four phases and can be implemented over three to four years. The framework is premised on a scalable pilot program. Implementation costs for such a scheme and a pilot are in Chapter VI. Implementation period depends in part on the progress in rural feeder segregation.

- Phase 1: Conceptualization (six months).
- Phase 2: Planning and detailed design (one year simultaneously with Phase 1).
- Phase 3: Pilot-testing, monitoring and assessing scale-ability (one to two years).
- Phase 4: Rollout through the State (two to three years, with some overlap with Phase 3).

Phase 1: *Conceptualization.* This phase involves intense consultations with stakeholders and therefore requires political and administrative support at the highest level for the implementation team. Key activities during this phase would be:

- Political and administrative decision to implement the scheme.
- Establish a high-level, empowered team with expertise in communication, power distribution, billing and collection, AMI, ICT, and finance. Include representatives of regulatory agency, and finance, agriculture and groundwater departments.
- Provide necessary budget for hiring communication and technical consultants, and operating costs of the implementation team.
- Hire communication consultants for consultations, communications, and farmer engagement.
- Prepare high-level details of the scheme and communication material that explains the rationale for the new scheme.
- Identify feeders for pilot testing based on willingness of farmers.
- Hold consultations with key stakeholders to present the scheme, clarify the objectives, and refine the scheme and implementation plan to reflect feedback from consultations.
- Select CSOs to work as Feeder Coordinators for engagement with the farmers, communication, and field level monitoring.

Phase 2: *Planning and detailed design*. Detailed engineering design, collection and validation of land records and consumer data, and estimation of subsidy allocation (Minimum Energy Support) would be key activities in this phase. Assuming feeder segregation has been implemented in areas where the pilots will be tested, those activities are not included in the list.[47] Activities would be functionally grouped under various working groups such as power utility (network, AMIs, Communications, commercial, staff incentives), subsidy estimates, policy and regulation, communication and consultations. Key activities during this phase would be the following:

- Engage technical consultants to help prepare engineering, AMI and ICT components, and estimate of MES.
- Finalize technical specifications for: (a) AMIs, (b) software for meter data management system, energy accounting, billing and collection, and (c) communications technology to be used.
- Prepare procurement plan and bidding documents for purchase of AMIs and software.
- Negotiate agreement with communication service provider for data download from AMIs.
- Establish mobile phone based facility for the farmers to enable them to remotely switch their motors on and off, and to provide them information on supply schedule, real-time status of power supply, up-to-date consumption and subsidy allocation.
- Collect and validate land records and connected load of agricultural consumers and synchronize the two databases. Prepare a GIS mapping and indexation of agricultural connections with feeders and distribution transformers (DTs).
- Select feeders for pilot testing; install AMIs on selected feeders and DTs.
- Launch procurement of AMIs and software, and train the staff in using new technology and systems.
- Estimate current electricity consumption and MES on the basis of agreed parameters (land holding, water table, cropping pattern) for the pilot feeders.
- Incorporate provision in electricity regulation that would require all consumers served by an agricultural feeder to accept the new scheme

47 A strategic framework for implementation of feeder segregation is available in "Lighting Rural India: Experience of Rural Load Segregation Schemes in States" (World Bank, February 2012).

if majority of consumers (60 percent or more) vote to opt in or opt out of the scheme.[48]

- Select implementation contractors.

Phase 3: *Pilot-testing, monitoring and assessing scalability*. Considerable preparatory work would be carried out in the previous phase. This phase would require intense engagement with the farmers, proactive communication and quick response to feedback from the field. This phase would also require intense coordination among members of the implementation team and agriculture and groundwater departments to ensure extension services, and benefits of other government schemes (such as subsidy for water-conserving irrigation technologies) are packaged together and delivered simultaneously. Key activities during this phase would be the following:

- Establish implementation team for each feeder that includes utility staff, contractor, ICT consultants, communication consultant, and farmer representatives.
- Establish monthly coordination with corporate implementation team, and quarterly review at the senior corporate and government levels.
- Build majority support among farmers served by the "opt-in" feeders through consultations and communication.
- Secure acceptance of energy-quantity-based MES among farmers on pilot feeders, and establish daily and seasonal schedule of power supply.
- Update consumer records (preferably GIS-mapped) and synchronize with land records.
- Establish baseline of land, load, electricity consumption, technical and financial performance parameters (distribution losses, commercial losses, quality of supply), socio-economic status.
- Establish a protocol for sharing supply, consumption, and loss information with the farmers using the website, mobile phones, electricity bills and consultation meetings.
- Establish feeder team for operation and maintenance; assign young qualified staff at sub-station, and corporate level to respond to the consumers and monitor energy accounts and consumer complaints.
- Determine staff incentives for: (a) implementing the scheme, and (b) at feeder level for efficient operation and maintenance (quality of supply and service, losses, collection, consumer satisfaction).
- Conduct monthly consultation with farmers, review how grievances are redressed, and proving feedback to corporate team.
- Establish monitoring and evaluation (M&E) arrangements, including metrics that may include agricultural electricity consumption and hours of supply, estimated technical and non-technical losses, number of electricity consumers, status of land records and distribution of landholding, groundwater levels, agricultural production, and socio-economic survey. In addition, the M&E framework would specify who is responsible for measuring (preferably independent third party), who is responsible for monitoring (at the State and at power utility level), and how the information will be used (such as incentives for executing agency and staff, regulatory review, scaling up, etc.).
- Appoint independent third party for verification of baseline, electricity consumption, losses, and redressing grievances, and disclosing the information to the public.

Phase 4: *Roll-out*. State-wide roll out would require strengthening and scaling up the Implementation Team, developing a spatially-segmented and sequenced program of implementation, and commitment of political and financial resources. Key activities during this phase would be similar to those during pilot-testing phase. Communication and

48 Electricity Act 2003 prohibits power distributors from supplying electricity without a meter, within two years of enactment but allows regulatory authorities to extend the period for a class of consumers (Section 55); and requires the State government to pay subsidy if it seeks to grant subsidy to any consumer and in case of non-payment of subsidy requires the regulator to ignore the direction of the State government (Section 65).

consultation with stakeholders would include State-level farmers' organization, employee organizations, political parties, CSOs, and the media. In addition, the monitoring would need to be carried out at higher levels in the government and the power utility. Visibility for successful pilots would be a critical part of the roll-out campaign.

B. INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTATION

Implementation arrangements are defined at three levels: (a) State Government, (b) Power Distribution Company (Discom), and (c) Feeder-user community-supplied electricity from segregated agricultural feeders.

(a) State Government

A Project Steering Committee (PSC) headed by the Chief Secretary and including representatives of the Departments of Power, Finance, Revenue, Agriculture, Water Resources, Power Utility, and the farmers could guide and advise the design and implementation of the direct subsidy delivery scheme in the State. It could also provide a coordination mechanism between power utility, groundwater and agriculture department, revenue department (responsible for land records), and providers of extension services. The PSC could guide and advise on the engagement with the farmers, review subsidy allocation, and carry out mid-course corrections in implementation. The Secretary of the PSC (preferably the Energy Secretary) could interface with the Government of India agencies and the State-level implementation agencies. Power utility, Groundwater Department, and Finance Department would be responsible for implementing their respective scheme components in coordination with each other and report implementation progress to the PSC. The PSC could oversee the strategy and implementation of a State-wide communication program.

The Finance Department could be responsible for implementing the mechanism for subsidy delivery payment instruments to farmers, make advance and replenishment payments of subsidy vouchers honored by the power utility, and maintain subsidy payment financial accounts and auditing. The power utility could be responsible for integrated software between Finance Department and the power utility for subsidy delivery. However, during early implementation a simpler scheme would be to issue bills to the farmers showing their subsidy allocation, consumption, and savings or amount due from the consumer for excess consumption.

The Revenue Department could establish systems to maintain updated land records and provide online access to the power utility to ensure alignment of electricity connection for farm power, subsidy allocation, and land records.

The Agriculture and Groundwater Departments could help design the subsidy allocation by providing adequately disaggregated information on agricultural productivity, costs and prices, groundwater resources, and design of groundwater efficiency improvement investments, and in outreach to the farmers. The Groundwater Department could also be responsible for implementing an incentive scheme to improve groundwater efficiency.

(b) Power Utility

The Power Utility could be responsible for power-related components, i.e. feeder segregation, AMI, communication infrastructure, metering and billing system, GIS, consumer database and linkage with land records. Other key activities that the power utility could undertake include communicating with farmers and other stakeholders, supervising the CSOs and others hired for political engagement with farmers served by segregated feeders, and responsibility for originating farmer acceptance of the Scheme. The power utility could establish a dedicated implementation team that might include the necessary skills in AMIs, ICT, communication and consultation, monitoring and evaluation, power distribution, metering and billing (including using consultants). The team could manage the scheme from conceptualization through roll-out, report to the corporate management and the State government, and coordinate with other agencies of the State and national governments. The power utility could launch a campaign to: (i) update consumer records and connected loads; (ii) regularize unauthorized/illegal connections; (iii) facilitate easy transfer of connection to legal heirs/transferees of land titles; and (iv) synchronize consumer records with land records.

(c) Feeder-user Community

The Feeder-user Community is the most important element of the design and implementation of the direct subsidy delivery scheme. It is critical that farmers understand the scheme and receive strong assurances that their power subsidy allocation is secure. It is essential to build consensus among farmers who are supplied by the selected feeder to opt for the new scheme, and provide a mechanism for redressing grievances during implementation. For these activities, it would be useful to engage CSOs or other agencies (Feeder Coordinators) for farmer engagement. These Feeder Coordinators would require training in the details of scheme design, implementation plan, responsibilities of stakeholders, and a range of communication skills. Feeder Coordinators would be compensated for initial engagement, origination of demand for new scheme, and help during implementation. A standard methodology for compensating Feeder Coordinators can be included in the implementation plan. Some States may find it easier or more efficient to use a franchisee or ESCO model for implementation.

Illustrative Cost of Implementation

Chapter 6

The Scheme has two main cost components: (i) feeder segregation and (ii) automatic meter readers/subsidy delivery infrastructure (Table 8). In addition, the government and the power utility would need to fund cost of communication and outreach to the farmers, capacity-building of the implementing agencies and the community organizations, and technical assistance. Of the infrastructure costs, feeder segregation is estimated to account for about 80 percent and the subsidy delivery model about 20 percent. Costs of feeder segregation vary across States. Assuming a power distribution company serves about one million agriculture consumers and the consumer density per feeder is 125, a State would have 8,000 feeders and feeder segregation may cost between Rs. 30-40 billion. The costs of feeder segregation and the ongoing agricultural and groundwater schemes are not included in Table 8, which shows only incremental costs of implementing a scheme of direct delivery of power subsidy to farmers.

The second component includes the advanced metering infrastructure capable of two-way communication and associated data and information-management software and hardware, costs for establishing subsidy voucher production and delivery for agricultural consumers, and staff training, hardware and software costs at billing centers that process subsidy vouchers. For an illustrative power distribution company serving one million agricultural consumers, the incremental costs of implementing direct delivery model will cost about Rs. 12.5 billion (US$250 million) spread over a period of four to five years. In addition to capital expenditures itemized in Table 8, about Rs. 70-80 million would be required during start-up years to build IT systems to identify beneficiaries from existing records with village Panchayat, land record office, State Utility, and so forth, and integrate them with the proposed subsidy delivery mechanism (including providing vouchers to beneficiaries).

It may take some time for farmers to see the benefits of the new subsidy delivery mechanism but the rate of adoption will accelerate over time. Hardware and software should be in place, tested, and ready to deliver subsidies before the scheme is launched but feeder segregation can proceed ahead of the roll-out.

TABLE 6: Cost Components, Estimates Annual Capital Expenditure for a Four-year Implementation (Rs. millions)

Component	Total Cost	Year 1	Year 2	Year 3	Year 4
1) Metering Unit	**12,160**	**3,132**	**3,132**	**2,986**	**2,940**
Data Server and Interface	225.6	112.8	112.8	-	-
Signal accumulators and concentrators	225.6	84.6	84.6	56.4	-
Single phase meter with radio and disconnect feature (including installation)	4,000	1,000	1,000	1,000	1,000
Three-phase meter with radio and disconnect feature (including installation)	7,730	1,930	1,930	1,930	1,940
Data Management system for 1 million users	9.4	4.7	4.7	-	-
2) IT Hardware and Software Requirements	**175**	**175**			
Dedicated data center for housing all the servers and system operations	20	20	-	-	-
4 servers (Data acquisition and decoding, Meter data management, billing and collection, reporting)	14.5	14.5	-	-	-
Metering, Billing Collection application	30	30	-	-	-
Other software applications (IDMS, anti-virus etc)	20	20	-	-	-
Configuration, data migration and deployment	50	50	-	-	-
Parallel run	10	10	-	-	-
Meter data acquisition software	30	30	-	-	-
3) Cost at Collection Centers	**48**	**16**	**16**	**16**	
Computers at collection center - 2 units per location (including UPS, LAN etc)	0.24	0.08	0.08	0.08	-
Printer, bar code reader and other systems required at the payment center	0.15	0.05	0.05	0.05	-
Secure VPN connectivity cost (512 KBPS) per location	0.075	0.025	0.025	0.025	-
No. of collection centers to be set up for subsidy delivery	46.5	15.5	15.5	15.5	-
4) Training Cost	**20**	**20**			
Training infrastructure (classroom, PC, AC, LAN)	5	5	-	-	-
Training and other server	10	10	-	-	-
Training cost (about 1000 people)	5	5	-	-	-
5) Communication and consultations	**100**	**30**	**25**	**23**	**22**
Stakeholder survey	1	1			
Design communication strategy and materials	1	1			
Produce communication material	1	1			
Implement communication plan	17	7	5	3	2
Cost of consultations	80	20	20	20	20
7) Implementation Team costs (travel, consultants)	**30**	**15**	**5**	**5**	**5**
Total Costs (rounded off)	**12,560**	**3,340**	**3,390**	**3,180**	**2,970**
Meter Data Acquisition Cost per Annum					
GPRS connectivity cost per year/meter	600	150	150	150	150

Source: Cost estimates from industry sources; personal communications, and recent project bids.
Note: Estimates include installation but exclude cabling, antennas, mounting hardware, site rental, communication fees, etc.

It would be important to run a few pilots before launching the scheme at a larger scale. The number of consumers supplied through a typical 11 kV feeder ranges between 150 and 300. Taking the highest number of 300 consumers per feeder, the cost of implementing such a pilot is calculated for 10 feeders in a Discom. Due to the small volume purchase for a pilot, advance meters would cost more and the cost estimates presented in Table 6.2 assume a cost per meter of Rs. 20,000-almost three times the cost in a bulk purchase order.

TABLE 7: Capital and Operating Cost of a Pilot Program for ten feeders in a Discom

CAPITAL EXPENDITURE			
Cost elements	**Unit cost (Indian Rs.)**	**No.**	**Net Cost (Indian Rs. millions)**
Metering Unit	20,000*	3,000	60
IT infrastructure including MBC (up-gradation and configuration)	40,000,000	1	40
Consumer Outreach and Education	2,000,000	1	2
Training for employees	1,000,000	1	1
Program Management Cost (@ 5% of total)	5,000,000	1	5
Communications and consultations (3 years)			5
Implementation team costs (3 years)			1
Total Cost			**114**
OPERATING EXPENDITURE			
Cost elements for Operating Expenditure			
Metering Unit @ 5% every year			3.0
Meter data acquisition cost			1.8
Total Annual Operating Cost			**4.8**

*Metering unit cost is higher due to the small quantity for the pilot. Costs for large volume purchase are significantly lower.

Conclusions and the Way Forward

Chapter 7

A review of international experience in managing the energy-groundwater nexus reveals that India is the only country that provides unmetered power supply to the agriculture sector for irrigation. While farmers are supposed to be the beneficiaries of this subsidy, the mechanism of subsidy delivery has broken the links that keep power utilities accountable to famers. Therefore, farmers are suffering from poor quality of electricity delivery. In most States, the power sector is in deep financial distress and it has become a fiscal burden for Government[49]. The power sector is unable to finance and invest in the capacity needed to expand the distribution network and meet increasing demand, or meet the minimum standards required to provide high quality service. At the current rate of groundwater overexploitation, 60% of all aquifers in India will be in a critical condition by 2022. Already, 4 percent of the groundwater resources in Gujarat, Haryana, Maharashtra, Punjab, Rajasthan and Tamil Nadu is categorized as either semi-critical, critical, or over-exploited.

Attempts to adjust tariffs of agricultural power supply to cost-recovery levels have been a resounding failure in most States in India. This study on Direct Delivery of Power Subsidy to Agriculture assumes as a given the public policy choice of providing free or subsidized power to agriculture, in exploring the possible solutions for the energy-groundwater nexus. Solutions must be implemented within existing institutional frameworks and must leverage and coordinate ongoing schemes to improve irrigation technologies and agricultural practices.

Currently, farmers, the power utility, and State governments are held in gridlock of a downward spiral of distrust. Even when farmers express willingness to accept a new mode of subsidy delivery, they doubt whether the government and the power utility will deliver. It is therefore critical that new schemes have adequate financial and managerial resources in place, including the following steps: (a) establish a detailed communication and consultation program before implementation; (b) base the design on results from in-depth consultations with farmers; (c) conduct pilot programs and use the results and feedback to improve scheme design before replicating and scaling up; (d) ensure flexibility to opt-in or opt-out at a feeder collective level to mitigate distrust of the power utility and government.

The proposed scheme combines mature and proven technologies and management tools. All components of the proposed feeder segregation scheme, including the use of HVDS, AMI, ICT for subsidy delivery, and performance-based incentives for employees (ESOP)

49 In September 2012, Government of India announced a plan to restructure US$35.5 billion (Rs. 1900 billion) that represents a part of outstanding debt of State power distribution companies. The State power sector has accumulated losses of about Rs. 700 billion, up from about Rs. 400 billion in 2002 when a similar restructuring was carried out by the Government of India. The financial distress of the power sector is affecting the banking sector. As of July 2012, outstanding loans of Indian commercial banks to the power sector were about Rs. 3500 billion, close to 18% of their total lending. The Reserve Bank of India advised banks to pay special attention to exposure to any industry that exceeds 10 percent of aggregate credit exposure, according to RBI circular DBOD No. BP.BC.16/21.06.001/2012-13, July 2, 2012.

are proven and well established. India has widespread coverage of mobile phone networks, which can provide information on electricity consumption and has the capacity for remote control of irrigation pumping systems so that farmers are no longer held hostage to a power supply schedule and can redeploy this time into higher-value activities.

Depending on their starting conditions and opportunities afforded by political economy, the States can choose their entry point in a five-stage modular subsidy delivery model. A State with low agricultural load, low density rural population and small villages may choose to improve performance of the power sector through institutional improvements. If they are endowed with a shallow water table and large solar radiation potential (as it is for States in Eastern India), those States could encourage the use of solar irrigation pumps instead of extending grid-power for irrigation. States with large agricultural load, power supply shortages, relatively dense rural population and large villages could segregate rural supply feeders to improve power supply and the quality of life. States with institutional capacity both in the government and the power utility, and the ability to use ICT-based systems with the participation of farmers could install AMIs and shift from a power supply system of rationing and roster to MES with longer hours of supply. States with a more progressive agricultural sector, institutional and financial resources could take the next step by moving to direct delivery of power subsidy and finally to a system of cash back for energy savings to tap into latent potential for end-use efficiency and conservation in energy and groundwater.

Groundwater-based irrigation farming is the engine of rural India's economic productivity, with very major multipliers in rural agri-businesses, produce and service markets, labor generation and livelihoods. State governments, utilities, and farmers urgently need to address the groundwater-energy nexus through a set of politically and financially feasible and socially acceptable alternatives centered on the direct delivery of power subsidy to farmers. This report provides a clear rationale and evidence for the way forward, and has been developed through a review of international best practices and broadly vetted through a stakeholder consultation process. Implementation of the proposed scheme may begin with a range of different starting points, which will allow all stakeholders concerned at the State level to take important steps towards addressing the energy-groundwater nexus in India.

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Annex A

Evaluation of Metering and Communication Technologies

The study adopted a three-phase approach to identify AMI specifications appropriate for the Indian rural context. First, it identified potential elements of a scheme; second, it defined parameters and evaluated options for rural consumers; and third, based on the evaluations it recommended a metering technology.

REVIEW OF METERING TECHNOLOGY

Metering technologies available in India and globally were studied to identify the best technologies for India's requirements. The study team contacted metering vendors to assess innovative solutions that have been implemented or are now under research and development. Three types of meters were identified as suitable for study:

1. *Digital*-the most common form of metering available in India. The meter simply provides consumption information and few other important parameters for billing and revenue protection, and must be read manually by a meter reader.
2. *Prepaid*-the consumer must prepay for electricity supply and is disconnected when the prepaid balance in the meter is exhausted.
3. *Automated metering reading (AMR) and advanced metering infrastructure* (AMI) – both meter reading and billing can be done remotely using a range of devices.

Digital metering. The study found that it is standard practice at all power utilities in India to procure and install digital meters only, which is in line with utility rules, regulations and standards.[50] Utilities' requirements have evolved and for the past few years, the following features comprise standard procurement specifications for three-phase meters (used for irrigation or other purposes) of most utilities:

- Event logging (voltage, current, PF, tamper, etc.).
- Billing period registration.
- ToU (time of use) energy registration.
- Load survey logging (interval data).
- Data download capability.
- Programmable at site or remotely.

The Power Finance Corporation (PFC) and Ministry of Power (MoP) reinforced these specifications/guidelines for meter procurement for Restructured Accelerated Power Development and Reforms Program (RAPDRP), begun in the 11th Five-Year Plan of Government of India. These specifications are now being implemented in almost all State-owned Distribution Utilities in India.[51]

50 Notification no. 502/70/CEA/DP&D, 17th March 2006, issued by Central Electricity Authority (CEA) for "Installation and Operation of Meters" mandates the use of static/digital meters for all purposes–consumer, interface and energy audit.

51 These features were also mandated by Indian Standard (ETD 13 (6211), "Data Exchange for Electricity Meter Reading, Tariff and Load Control – Companion Specification" released April 2010 by Bureau of India Standard (BIS). This is an adoption of IEC 62056 and DLMS/COSEM for India.

The digital meter, with base features for automated reading, is the default option for Utilities in India for metering any type or category of consumer.

Prepaid metering. In prepaid metering, the customer must pay in advance for power supply at Utility offices, designated shops, online, banks, ATMs, or using a cell phone. When the prepayment is exhausted the meter switches off the supply and upon recharge the supply is restored automatically. For whole current meters, the disconnection switch can be integrated inside the meter but for CT-connected meters, the disconnection switch is external and receives signals for turning on and off from the meter.

Several Utilities in India such as TATA Power Delhi Distribution Ltd (TPDDL), erstwhile North Delhi Power Ltd (NDPL), Madhya Gujarat Vij Company Ltd (MGVCL), Maharashtra State Electricity Distribution Company Ltd (MSEDCL), West Bengal Power Distribution Company Ltd (WBSEDCL), BSES, etc. have experimented with prepaid metering, primarily in urban areas with mostly residential consumers and have produced mixed results. These projects have exposed key operational and regulatory/legal challenges such as the following:

1. Tariff structure and revision (How to account for recovery of taxes, duties and fuel surcharge, tariff revisions, etc.).
2. Serving of bills (Prepaid voucher is not treated as bill for several other purposes).
3. Incentive for consumers for prepayment (How to get regulator to approve it?).
4. Creation of large vending infrastructure and acceptable modes of recharge.
5. Limited number of suppliers in the market.
6. Interoperability of systems of various vendors.
7. Tampering and bypassing of meter.

Prepaid metering technology is still evolving in India and the existing regulatory/legal framework needs to be needs to be modified to resolve several operational issues and define standards for adoption.

Automated metering reading (AMR) and advanced metering infrastructure (AMI). The first automated meter reading (AMR) devices collected meter readings electronically and matched them with accounts. Advanced technology AMRs can now capture, store, and transmit additional data such as event alarms, tamper data, leak detection, reverse flow, interval data, and log data, and the utility can analyze and use the data to make decisions. Generally, AMR meters do not feature intelligence functions and communication is one-way. Advanced metering infrastructure (AMI) is the new networking technology for fixed network meter systems that surpasses AMR functions and can be used for remote utility management. The AMI system meters (also called "smart" meters) can use collected data based on programmed logic and can provide a home gateway to connect to household appliances.

Utilities in India have been experimenting with AMR technology; AMI pilots have also begun but the most widespread adoption of AMI in India is under RAPDRP. Utilities are mandated to meter all HT consumers and distribution transformers in RAPDRP towns using AMI.[52] The proposed technology under RAPDRP can provide more functionalities than traditional AMR technology but is more limited than AMI. AMR technology has been used for consumer metering in most parts of the world but in India it is also being used for network monitoring and analysis at the substation, feeder, and distribution transformer level. Although it is no substitute for SCADA or DMS but it can help post-facto analysis and taking preventive and corrective actions for system improvements.

Though smart meters are expensive than the digital meters, prices are rapidly coming down due to technology advancements and global large-scale deployment. The India Smart Grid Task Force (ISGTF), chaired by Mr Sam Pitroda is trying to develop a Smart Meter at a price point of US$20-30, which could enable large-scale deployments in India. Many global and Indian manufacturers are also working to

52 RAPDRP towns: Urban areas–towns and cities with population of more than 30,000 (10,000 in case of special category states) as per the census of 2001. These towns have been selected by MoP and PFC for implantation of RAPDRP.

develop low-cost smart meters to tap into the vast Indian market. In addition, distribution Utilities are undertaking pilot projects on AMI and smart metering to try out the technology, help define a roadmap, standards, specifications, and a business case for implementation, funded in part by the Ministry of Power. As a result, large-scale smart meter roll outs in India could be possible in the next few years.

REVIEW OF COMMUNICATION TECHNOLOGY

This review covered a communication technologies to achieve data downloads from meters. The simplest form can include data downloads from meters using common meter reading instruments (CMRIs), to automatic transmission of meter data using wireless networks. Four communication technologies were considered relevant for adoption in rural India:

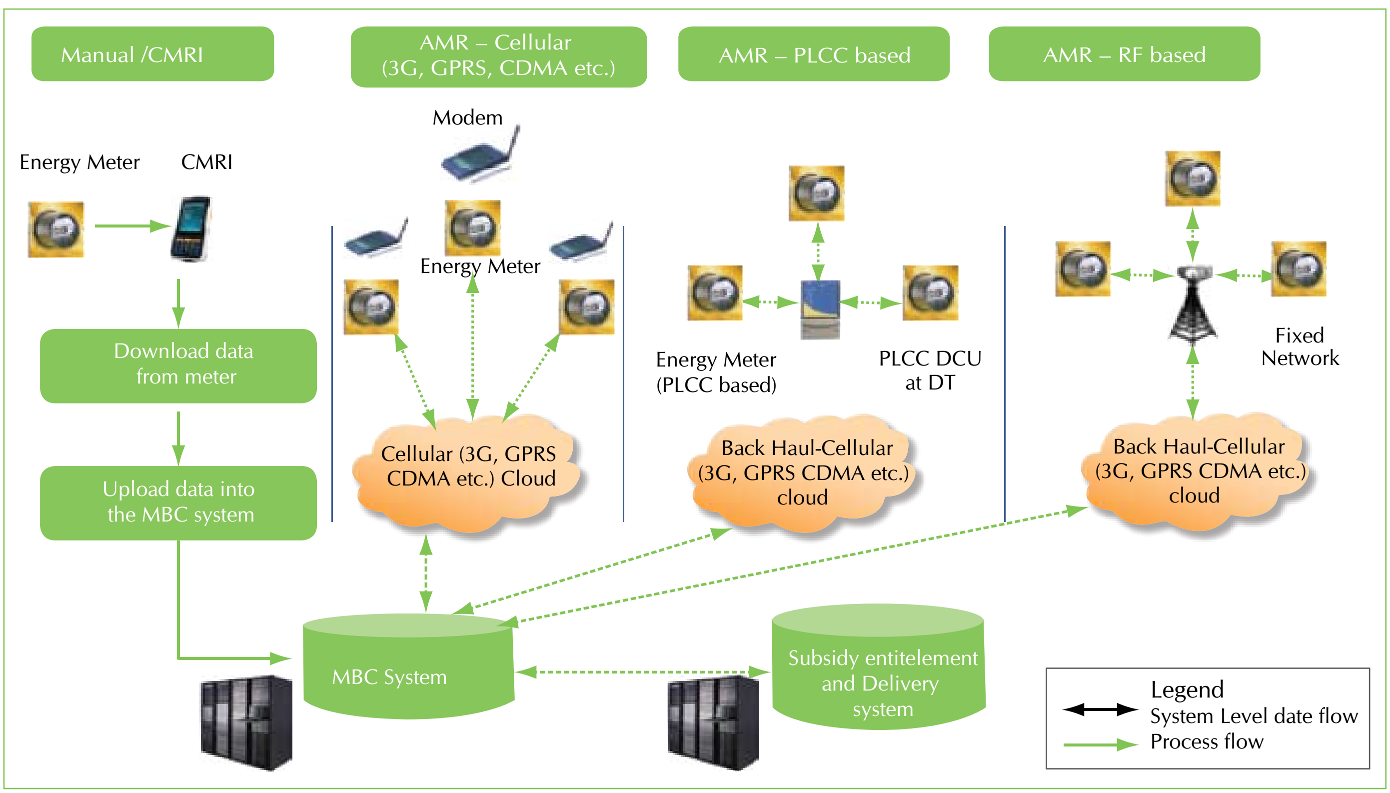
- ***Manual-CMRI.*** From an electronic meter installed at service point, data is periodically downloaded using a handheld device called CMRI and uploaded to the metering, billing and collection system by plugging it into a computer.
- ***Cellular.*** The electronic meter can communicate using publicly available cellular networks (GPRS, CDMA, 3G, etc.) and is installed by the power utility. Typically the communication network (last mile and backhaul) is owned and managed by the communication service provider for a fee. Both GSM and CDMA service providers in India confirmed that they could not only provide the service in most rural areas but also offer inter-operability functions.
- ***Power line carrier communication (PLCC).*** In this technology the electronic meter communicates through the power line. Data concentrator units are installed in the network (generally at the distribution transformer). The power utility or the communication service provider can manage backhaul communication from DCU to the utility's servers. Some PLCC pilots undertaken in India were unsuccessful and were abandoned for cellular technology due to its widespread availability.
- ***Radio frequency (RF)*** Electronic meters installed at service points are fitted with RF communication that can be implemented using RF mesh, fixed network, or mobile network. The power utility must invest in setting up RF network for last-mile connectivity and also maintain it.

A comparative assessment of the identified technology options was carried out based on a set of rating parameters selected after interaction with power utilities, farmers, and meter manufacturers. Metering technology choices were rated and ratings were consolidated to arrive at a composite score, which was used to select the most suitable technology for the Indian context. Framework details appear below.

Sr. No.	Evaluation Parameters	Description
1	Availability and maturity of technology in India	Several metering technologies are available in the world but few have been successfully used in India due to social, economic and technical constraints. E.g. RF and PLCC are two main communication technologies for AMI deployments in western countries but cellular technology is most popular for deployments in India.
2	Potential to reduce relative capital cost of implementation	Though all metering options are costly, this parameter compares the relative cost of various technology choices vis-à-vis stand-alone/manual metering option.
3	Potential to reduce ongoing operation cost	All devices that have to be installed have some operation cost associated with them, e.g., Manual/CMRI meter reading incurs costs of meter reader and cellular incurs costs of service provider.
4	Potential to reduce ongoing maintenance cost	Maintenance costs are directly proportional to # of devices installed; includes costs for preventive maintenance and breakdowns.

Sr. No.	Evaluation Parameters	Description
5	Potential to reduce tampering and manual intervention	Every option has potential for tampering but automated systems offer the possibility of identifying tamper in near real-time.
6	Availability of technology providers in India	All technology options are available in the world but few technology providers exist in India for all technology options. However, cellular technology is already widespread throughout India.
7	Interoperability with existing technology and processes of Utilities	Almost all Utilities have cellular-based metering systems so people are trained to handle such systems and existing processes and technology will allow scaling up. Other technology options have technical potential for interoperability but carry costs for technology and training.
8	Cyber security	Automation carries the risk of cyber insecurity. Breach can happen on the device or the network so Utilities must continuously upgrade technology for the devices and their network.
9	Physical security	Physical damage is always possible for metering devices. Risk of physical damage is directly proportional to the # of devices in the field.
10	Relative ease of implementation	Most common and most severe implementation challenge is meter installation, which is the same for all technology options. Other challenges are in planning, installation and commissioning network devices.
11	Capable of facilitating energy audit	All options that can provide time-stamped data at a predefined frequency can facilitate an energy audit.
12	Ease of administering metering, billing and collection	All options that can provide time-stamped data at a predefined frequency can facilitate MBC.
13	Level of accuracy	Accuracy is highest in the completely automated system.
14	Potential to facilitate load management	All options that can provide time-stamped data at a predefined frequency can facilitate load management.

Diagram below provides a logical view of all these technology options:



The identified metering options were rated on evaluation parameters as High/Medium/Low. These ratings correspond to numeric scores, which are then consolidated to arrive at a composite score.

The technology option with the highest composite score is considered to be the most appropriate for metering power consumption in the agriculture sector in India.

Low – 1, Medium – 3 and High – 5

Sr. No.	Parameters	Manual – CMRI	AMR – Cellular (3G, GPRS, CDMA etc.)	AMR – PLCC	AMR – RF
1	Availability and maturity of technology in India	**High (5)** (Many Utilities are already using this for billing and data analysis)	**Medium (3)** (Technology has started maturing and cost is coming down due to extensive use in RAPDRP)	**Low (1)** (Only pilot in few places with issues reported in data transmission)	**Low (1)** (Only pilot in few places)
2	Potential to reduce relative capital cost of implementation	**High (5)** (Capital cost is only in meters and few CMRIs)	**Medium (3)** (Additional capital cost in communication devices)	**Medium (3)** (Additional capital cost in communication devices at DTs)	**Medium (3)** (Additional capital cost in communication devices at several locations)
3	Potential to reduce ongoing operation cost	**Medium (3)** (Operation cost of meter readers)	**Low (1)** (Operation cost to be paid to service provider)	**High (5)** (Much lower operation cost)	**High (5)** (Much lower operation cost)
4	Potential to reduce ongoing maintenance cost	**High (5)** (Maintenance of meters and CMRIs only)	**High (5)** (Maintenance of meters and modems)	**Medium (3)** (Maintenance of meters, modems and DCUs)	**Medium (3)** (Maintenance of meters, modems and DCUs)
5	Potential to reduce tampering and manual intervention	**Low (1)** (Only post-mortem analysis of data possible)	**High (5)** (Tampering can be detected in near-real time)	**High (5)** (Tampering can be detected in near-real time)	**High (5)** (Tampering can be detected in near-real time)
6	Availability of technology providers in India	**High (5)** (CMRI manufacturers are available)	**High (5)** (Cellular technology is already available throughout the country)	**Low (1)** (Few manufacturers have implementation track record in India)	**Low (1)** (Few manufacturers have implementation track record in India)
7	Inter-operability with existing technology and processes of Utilities	**Medium (3)** (Already in use by most of the Utilities but there will be manual intervention)	**High (5)** (Already implemented in most of the Utilities)	**Low (1)**	**Low (1)**
8	Cyber security	**Low (1)**	**High (5)** (Based on standard protocols and security is managed by service provider, who can manage latest cyber security updates)	**Medium (3)** (Owned by the Utility, security must be managed by the Utility)	**Medium (3)** (Owned by the Utility, security must be managed by the Utility)

Sr. No.	Parameters	Manual – CMRI	AMR – Cellular (3G, GPRS, CDMA etc.)	AMR – PLCC	AMR – RF
9	Physical security	**Low (1)** (Limited to meter but Utility will detect physical tampering only after inspection)	**High (5)** (Limited to meter and in-built/retrofitted modem but Utility can get immediate information from meter automatically)	**Medium (3)** (Apart from meter and in-built/ retrofitted modem, DCU has to be secured but Utility can get immediate information automatically)	**Medium (3)** (Apart from meter and in-built/ retrofitted modem, DCU has to be secured but Utility can get immediate information automatically
10	Relative ease of implementation	**Medium (3)** (Apart from meter installation, special processes and people are needed for implementation and maintenance)	**Medium (3)** (Meter/modem installation effort is similar to option 1. Rest of the processes can be highly automated)	**Low (1)** (Apart from meter/ modem, DCUs must be installed and configured)	**Low (1)** (Apart from meter/ modem, DCUs must be installed and configured)
11	Capable of facilitating energy audit	Low (1)	High (5)	High (5)	High (5)
12	Ease of administering Metering, Billing and Collection	Low (1)	High (5)	High (5)	High (5)
13	Level of accuracy	Low (1)	High (5)	High (5)	High (5)
14	Potential to facilitate Load Management	Low (1)	High (5)	High (5)	High (5)
	Composite score	**36**	**60**	**46**	**46**

Evaluations carried out by this study show that India could leapfrog the technology frontier by combining AMIs with cellular communication technology for agricultural consumers.[53] The AMI specifications for agricultural consumers must comply with Indian Standard ETD 13 (6211) "Data Exchange for Electricity Meter Reading, Tariff and Load Control-Companion Specification" (BIS April 2010) which adopts IEC 62056 and DLMS/COSEM for India. These meters must have the following features:

- Event logging (voltage, current, PF, tamper, etc.).
- Billing period registration.
- ToU (Time of use) energy registration.
- Load survey logging (interval data).
- Remote and on-site- data download capability.
- Two-way communication.
- Inbuilt (or support for plug and play) communication module based on cellular technology or any other technology chosen by the utility at the time of installation.
- Capacity to be configured and programmed on site and remotely.
- Capacity to support remote reconnection/ disconnection.

53 Three types of meters were reviewed-digital, prepaid, and AMR/ AMI. In 2006, the Central Electricity Authority decreed digital meters mandatory for all electricity consumers. Prepaid meters have been tried primarily in urban areas. Not only have they yielded mixed results but also they face regulatory and legal barriers and a limited supply market. Indian power utilities have used AMR, which has only one-way communication. The AMR technical specifications proposed by RAPDRP are an improvement over earlier AMRs but not as comprehensive as the AMIs available in the market.

Annex B

Review of ICT-Based Subsidy Delivery Models

This annex provides a summary of a background paper "Review of global experience in use of ICT for subsidy delivery" prepared by Infosys for this Study. The background paper reviewed the role of technology and how it was implemented in selected ICT-based subsidy delivery programs and assessed its appropriateness in Indian context. Five different types of programs were considered relevant for the Study:

- Voucher based agricultural input subsidy (Malawi).
- Smart card based agricultural input subsidy (for diesel purchase) – (Bangladesh).
- Use of pre-paid electricity cards (China).
- Mobile based cash transfer (Kenya).
- Conditional cash transfer using debit cards (Brazil and Mexico).

Similar programs are run in South Africa (Child Support Grant), Nicaragua (bar-coded electronic cards) and Paraguay. Several programs in India use one form or another of ICT in delivering benefits or services. A few programs reviewed for the study include: (i) Karnataka Land Record Digitization (BHOOMI) that computerized and created a database of land records and biometric identification of operators at BHOOMI centers to ensure system integrity; (ii) Targeted Public Distribution System in Chattisgarh that has computerized the whole supply chain including Unified Ration Card database, and dissemination of information of movement of food grains to public through voluntarily registered mobile phones; (iii) Andhra Pradesh using web-based MIS for Indira Awas Yojana and Rajiv Awas Yojana.

A cross-sectoral selection of ICT-enabled systems of direct delivery of subsidy was assessed for appropriateness in the Indian context against the following parameters:

- Is the system technically feasible to implement? Is the required technological infrastructure available in rural areas?
- Are the required policies and regulations in place to support the delivery system?
- Does the State have administrative support systems and experience in using similar ICT-based systems?
- Do stakeholders agree on the benefits? (Farmers, power utilities, government, and policy makers).
- Does the system offer potential for desired financial outcomes-reduced subsidy leakages, improved energy accounting to reduce technical and commercial losses, recovery of capital and operating costs of subsidy-delivery mechanism?
- Is the technology well established in India? Is it compatible with existing power utility technical infrastructure?

A stylized list of programs evaluated is provided in Table B-1.

TABLE 8: Summary of ICT-based Subsidy Delivery Models

Sr. No.	Name of the subsidy model	Program Description	ICT tool used Benefits from ICT application
1	Oportunidades, Mexico	Anti- poverty program: (i) improve health and nutritional status of poor households; (ii) encourage school enrolment, attendance and educational performance.	Debit card Easy cash disbursal through ATMs and POS devices; reduced leakages
2	Agricultural Input Subsidy Program (AISP), Malawi	To boost national maize production by promoting the use of maize fertilizers and seeds amongst small farmers	Vouchers Easy subsidy accounting
3	Agricultural Input Subsidy Program (AISP), Bangladesh	Direct delivery of cash subsidy to farmers to buy diesel and other agricultural inputs	Smart card Reduced leakages
4	Integrated Circuit Card Automatic Irrigation Collection system, China	To collect water usage charge from farmers; To promote water-use efficiency	Pre-paid IC card Easy payment collection for utility
5	Kerio Valley Cash Transfer Project (KVCTP), Kenya	To assure minimum income for poor households; Provide social safety net	Cash transfer through mobile phone Reduced leakages; better coverage in rural areas
6	National Rural Employment Gaurantee Scheme (NREGS), Andhra Pradesh, India	To disburse National Rural Employment Guarantee Scheme (NREGS) payments; To disburse Social Security Pension Scheme (SSPS)	Cards for biometric identification and electronic cash transfer Accurate beneficiary ID; reduced leakages
7	Bolsa Familia, Brazil Similar program in Colombia, called Programma Familias en Accion	To assure minimum income for poor households; Provide social safety net Improvement in health and education outcomes of children, reduction in maternal mortality	Cash transfer through electronic card Easy cash disbursal through ATMs and Point-of-service devices, Reduced leakages
8	Dowa Emergency Cash Transfer Program, Malawi	To provide emergency food support during crop failures	Electronic cards for biometric identification and cash transfer Accurate beneficiary ID; reduced leakages

Each of the ICT tools was rated on these evaluation parameters as High/Medium/Low. These ratings correspond to numeric scores (Low – 1, Medium – 3 and High – 5), which are then consolidated to arrive at a composite score.

Sr. No.	Parameters	Voucher based agricultural input subsidy – Malawi	Smart card based agricultural input subsidy – Bangladesh	Mobile based cash transfer – Kenya	Pre-paid IC card based system – China	Conditional cash transfer – Brazil & Mexico
1	What is the maturity level of the technology in India	**High (5)**	**Medium (3)**	**Medium (3)**	**High (5)**	**Medium (3)**
2	Availability of required policies and regulations	**High (5)**	**Medium (3)**	**Low (1)**	**High (5)**	**Low (1)**
3	Availability of required technological infrastructure in rural areas	**High (5)**	**Medium (3)** (Rural Banking infrastructure is already available)	**Medium (3)** (Telecom network is available)	**Medium (3)** (Used by Telecom companies)	**Low (1)** (requires large databases and communication system)
4	Experience in using similar ICT based system for implementation of other schemes/services in the State	**High (5)**	**Medium (3)** (Banking)	**Low (1)**	**Medium (3)** (Telecom)	**Low (1)** (making NREGS payments through smart cards is in trial stage)
5	Availability of required administrative support system in the States for implementing similar delivery model	**High (5)** (Utility staff can be used for voucher distribution and settlement)	**Medium (3)** (Utility and banking systems can be used)	**Low (1)** (Cash collection centers will be required)	**Medium (3)** (Utility's offices could recharge the cards and accept payment)	**Low (1)** (will need a set up for collecting and updating data on farmers)
6	Relative ease of managing the subsidy delivery mechanism being reviewed (in terms of managing with semi-skilled workforce)	**High (5)** (Doesn't require much skill)	**Medium (3)** (Needs some skills to operate the system)	**Medium (3)** (Needs some skills to operate the system)	**Medium (3)** (Needs some skills to operate the system)	**Low (1)** (Needs computer literate operator)
7	Potential to reduce the capital cost of ICT implementation	**High (5)** (No major investments required)	**Medium (3)**	**Medium (3)**	**Medium (3)**	**Low (1)** (Requires huge investment in IT systems)
8	Potential to reduce the leakages in subsidy delivery	**Low (1)** (Dependence on utility for issue and settlement of vouchers)	**Medium (3)**	**High (5)** (Minimal intervention of intermediaries)	**High (5)**	**High (5)** (Automated system with minimal human intervention)
9	Potential to reduce the administration cost	**Low (1)** (Manual system needs supervision)	**Medium (3)** (Manual intervention is reduced)	**Medium (3)** (Manual intervention is reduced)	**High (5)**	**High (5)** (Involves automatic cash transfer to the beneficiary)

Sr. No.	Parameters	Voucher based agricultural input subsidy – Malawi	Smart card based agricultural input subsidy – Bangladesh	Mobile based cash transfer – Kenya	Pre-paid IC card based system – China	Conditional cash transfer – Brazil & Mexico
10	Preference of the farmers	**Low (1)** (vouchers can't be used for other expenses)	**Medium (3)**	**High (5)** (will prefer receipt of cash)	**Low (1)** (Not used to pre-payment of electricity bills)	**High (5)** (will prefer receipt of cash)
11	Preference of the utilities	**Low (1)** (Collection of dues from the government might take time)	**Medium (3)**	**Low (1)** (The farmers might take the cash and delay/avoid bill payment)	**High (5)** (Advance payment improves cash flow)	**Low (1)** (The farmers might take the cash and delay/avoid bill payment)
12	Preference of the political establishment	**High (5)** (can use voucher distribution for gaining political mileage)	**Medium (3)**	**Low (1)** (loses the touch point with farmers)	**Low (1)**	**Low (1)** (loses the touch point with farmers)
13	Compatibility with the existing technical infrastructure and systems used by the utilities	**High (5)**	**Medium (3)**	**High (5)** (Famers can pay in cash)	**Medium (3)** (Pre-paid meters are being used in India)	**Medium (3)** (POS devices can be installed in the utility offices)
	Composite score	**49**	**39**	**35**	**45**	**29**

Based on the framework used for evaluation of various ICT tools, the use of Vouchers similar to those used in Malawi appear to be the most appropriate for power subsidy delivery in India.

An Illustration of Calculation of Minimum Energy Support

Annex C

MES can be calculated either on the basis of load or landholding. Data from Punjab was used to prepare the illustration in this Annex. In case of Punjab, calculating MES on the basis of load appears to be easier as PSPCL already has load details of all tube wells. Also an argument can be made that the PSPCL-sanctioned load is directly proportional to the landholding, but some stakeholders have raised concerns about the available load records. Hence PSPCL should evaluate both calculation options. Since the scheme allows voluntary farmer opt-in, landholding size can be captured and verified at the time of opting in, if landholding is the basis for MES calculation.

Punjab has 3900 agricultural feeders, which are located based on the broad design the utility electricity distribution network setup. The connected load on the feeder is determined by electricity demand subject to feeder capacity technical restrictions. An average connected load for a rural feeder in Punjab is 2065 kW, and the average feeder serves 350 to 600 agricultural consumers. Attempting to determine electricity allocations at the feeder level will amount to fixing 11 lakhs different levels of allocations in Punjab and the derived level of allocations are likely to vary over a very wide range across feeders, such that even allocations for two neighboring feeders could vary widely. Farmers are unlikely to accept this.

Aggregating feeder-level information to the district-level aggregations could help surmount some problems associated with attempting to establish allocations at the feeder level, which could reduce the extent of potential disagreements. However, Table 7.1 shows estimated district-level allocations (data based on aggregating and averaging 2009-10 and 2010-11), also vary substantially across districts. Even for two districts with similar cropping patterns, MES estimates for free electricity differ. The MES level based on electricity consumption per unit of connected load (kWh/HP) varies from a low of 758 in Barnala to a high of 1457 in Gurdaspur. Similarly, consumption per hectare of net groundwater irrigated area (kWh/ha) varies from a low of 1801 in Barnala to a high of 12019 in Faridkot.[54] Even though these use the default value of free electricity, explicitly using them as MES will cause farmers to resist due to the high variations.

To overcome some of the problems associated with establishing allocations at the district level, the study examined the feasibility of aggregation at the level of agro-climatic zones, which are established based on uniform prevailing agro-climatic conditions. This avoids problems of differential allocations across two districts with similar cropping patterns, and normalizes allocations over a much larger area, which would likely to be more acceptable to farmers.

Punjab has five agro-climatic zones and for illustration purposes, the district boundaries have been realigned to match the zonal boundaries. Realigning feeder-level information on electricity variables to match agro-climatic zone boundaries is necessary to estimate zone-based allocation levels but a one-to-one match

54 Faridkot and Mukhtsar seem to be outliers, perhaps due to problematic data quality. Calculations (zone-wise) excluded these districts, which meant MES was marginally at 2235 kWh/ha for Zone IV and 3251 for Zone V.

TABLE 9: Determining Level of Allocation in Punjab – District Level

	Basis of calculating of allocation	
District	**kWH/HP**	**kWH/Ha***
GURDASPUR	1457	3081
HOSHIARPUR	1160	2168
ROPAR	1218	2458
NAWANSHAHAR	1187	2596
AMRITSAR	1160	3379
TARANTARAN	1327	7266
KAPURTHALA	1019	2577
JALANDHAR	1069	2831
LUDHIANA	977	2556
F G SAHIB	946	2985
SANGRUR	899	4863
PATIALA	911	3755
MOHALI	1081	2361
FARIDKOT	1068	12019
FEROZPUR	954	2235
MOGA	1068	3729
BARNALA	758	1801
MANSA	772	2370
BATHINDA	821	4894
MUKATSAR	874	10164

*Per hectare of net groundwater-irrigated area

is not attempted here. Results show that estimated allocations levels based on consumption per HP of connected load vary between 900 in Zone V to 1326 in Zone I. If measured based on per unit of groundwater irrigated area, allocations vary from 2536 in Zone II to 3994 in Zone III (Table 7.4).

TABLE 10: Determining Allocations in Punjab – Agro-Climatic Zone Level

Zone	***Districts***	**kWH/HP**	**kWH/ha***
I	Gurdaspur, Hoshiarpur	1326	2648
II	Ropar, Nawanshahar	1200	2536
III	Amritsar, TaranTaran, Kapurthala, Jalandhar, Ludhiana, FBSahib, Sangrur, Patiala, Mohali	1095	3994
IV	Faridkot, Ferozpur	981	2823
V	Moga, Barnala, Mansa, Bhatinda, Mukhtsar	900	3565

*Per hectare of net groundwater irrigated area

A State-level allocation could be calculated but wide variations in estimated allocations across districts and across zones would likely make a uniform allocation level unacceptable.

Solar Powered Agricultural Pumps: Results of a Pilot Study in Bihar

Annex D

Solar radiation over India is over 5000 trillion kWH/year. Cost-effective solar power could be the answer for most energy needs including critical activities such as irrigation for agriculture. A solar powered pump could be more environmentally friendly and economical to operate compared to pumps powered by internal combustion engines (ICE) or other energy sources. Solar power driven pumps could service remote areas with little or no grid connectivity; solar-driven pumps are easy to maintain; solar technology adds value; and localized energy production and consumption will avoid transmission and distribution losses, among others.

Usually a system having PV array capacity of 1800 watt and 2 HP pump can discharge about 140,000 L of water per day from a depth of 6-7 meters. This amount water can be used for irrigation of about 5-8

FIGURE 12: Schematic Diagram: Solar Powered Pumping System

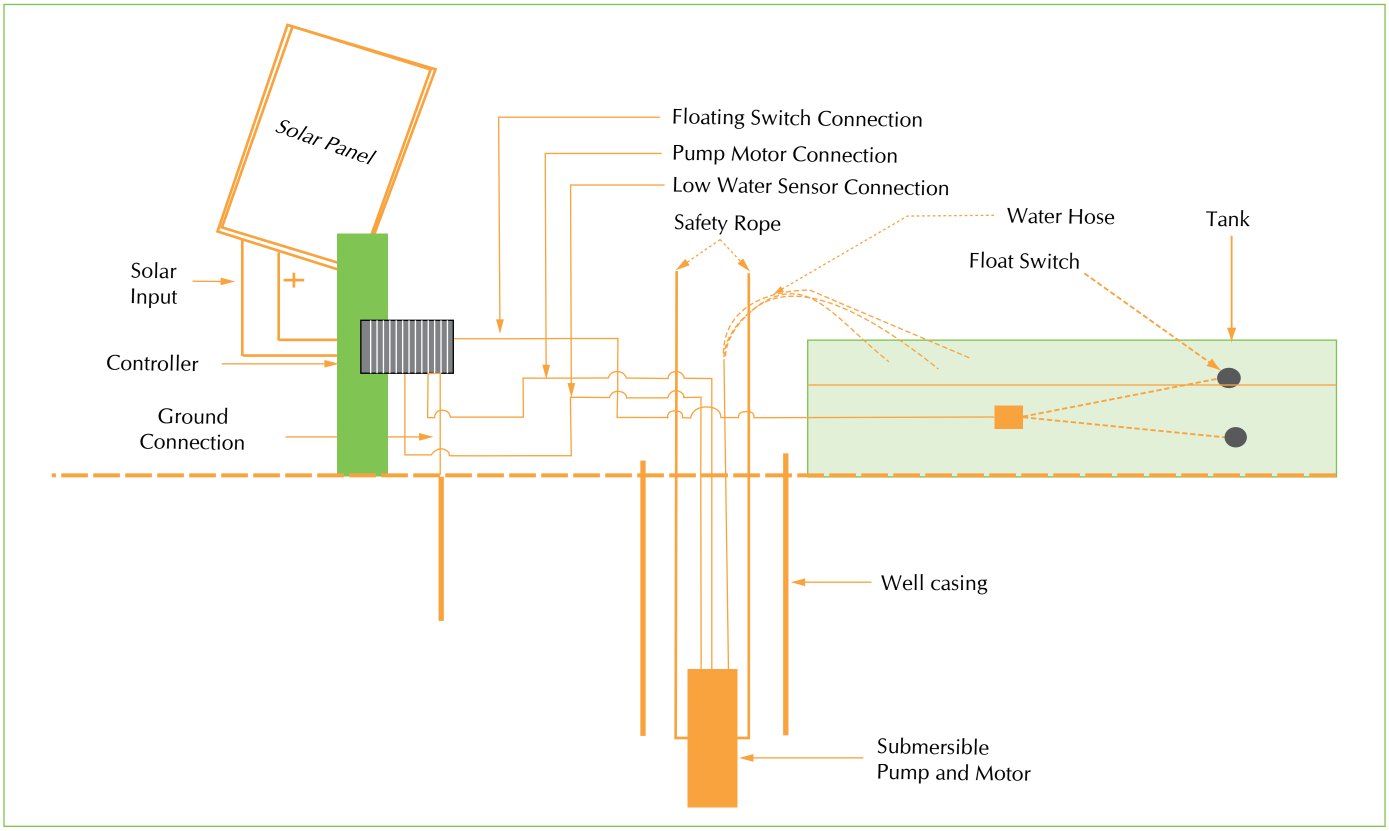
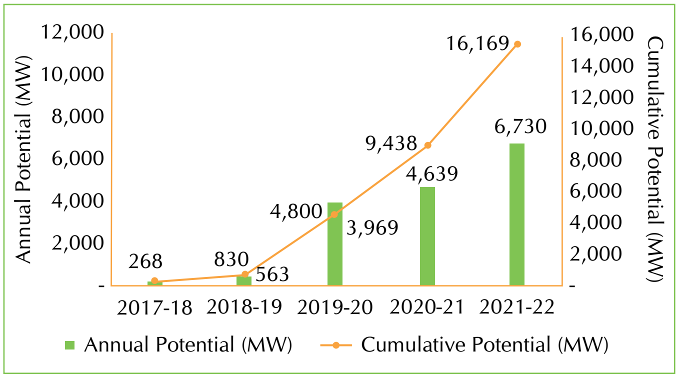


FIGURE 13: Solar Powered Agriculture Pump Set Potential



acres of landholding for several crops. Total cost for installation and commissioning an SPV water pump system varies from Rs. 190,000 to 290,000. On average, the lifetime cost (capex, operating, maintenance, replacement) of a diesel pump is almost double that of a solar pump. A typical schematic diagram appears previous page.

Solar water pumps have been substantially improved during the last 25 years and now provide cost-effective options that can pump larger volumes of water up to 200m heads, and some models can be backed-up by a electric powered generator to pump additional water with the same pump during the night or during overcast days or when necessary. Price is an important factor in selecting a pump model. According to a KPMG report, the potential of solar-powered agriculture pump-sets is on the rise (see figure D2 below). Potential for 2017-18 is from new demand in agriculture category, driven by government policies and availability of viable financing options. Potential for 2019-20 is from existing agriculture demand, driven by economics of solar power and availability of viable financing options.

Bihar: Pilot Experimental Project. The State of Bihar stretches between 20°58′10″ to 27°31′15″ north latitude and 82°19′50″ to 88°17′40″ east longitude. Average annual global solar radiation is in the range of 4.79 – 5.42 kWh/sq.m (NASA data). The State is having 2665 MWp SPV pump potential in the field of irrigation/agriculture. State-specific schemes are being formulated so potential can be fully harnessed.

The State, through NABARD Phase 8, installed 7.5 HP AC pump-sets, most of which are now past their useful lifespan and nonoperational. The Government of Bihar Minor Irrigation Department initiated a pilot program to transform some of these existing pump sets into solar-powered pumping systems and invited tenders. The successful bidder was mandated to set up a pilot project comprising 34 installations across multiple villages in Nalanda District of Bihar (and integrate them with existing 7.5 HP AC pump-sets). The solar technology design includes solar modules, variable frequency drive and a power electronics middleware, which controls the pump. In partnership with a local engineering firm, the bidder also developed a proprietary intelligent controller and a variable frequency drive solution that facilitates optimized system configuration. The pilot project can be broadly divided into three segments, which are elaborated below.

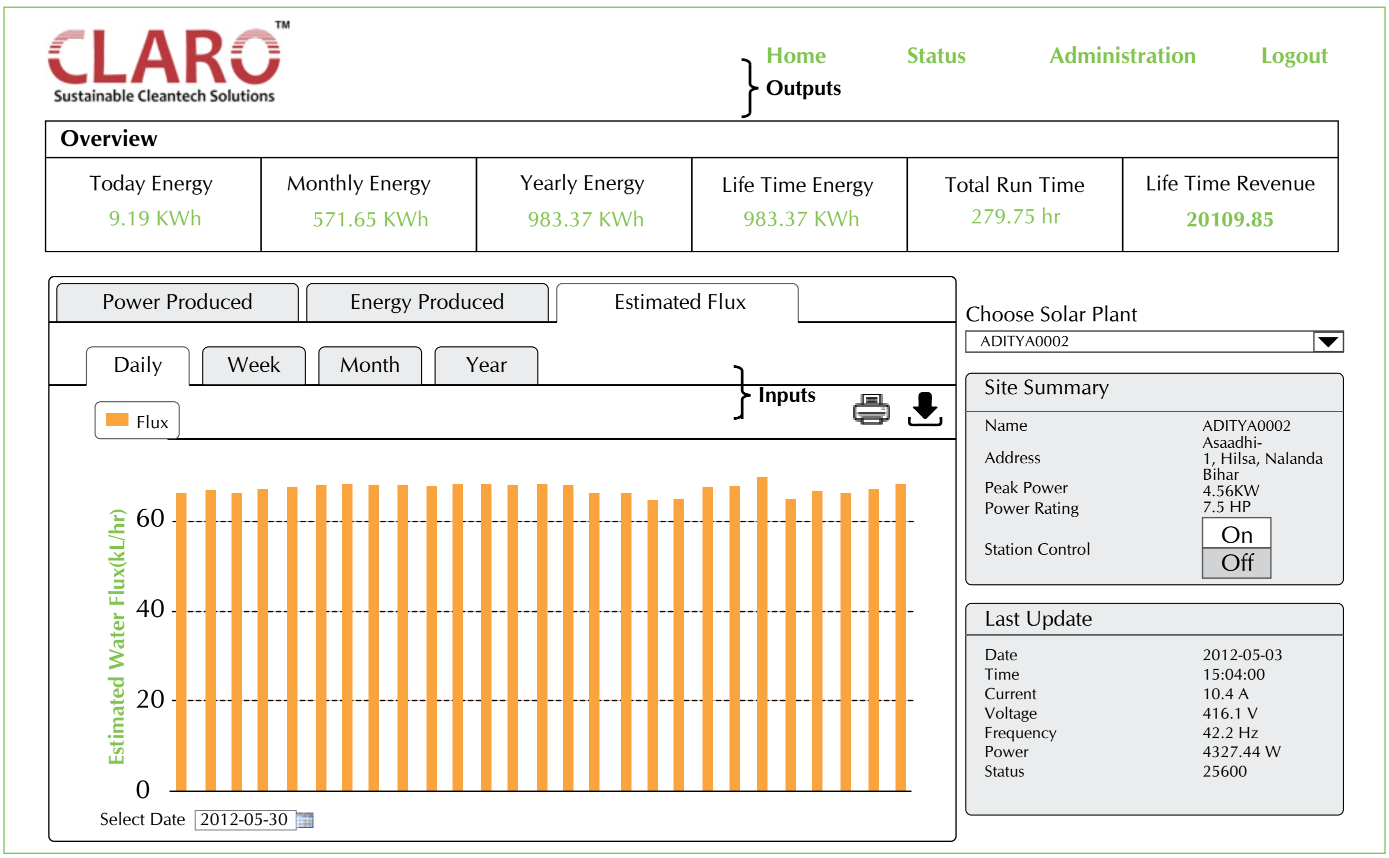
Ground Situation. Bihar (Nalanda District-pilot project location) offers multiple challenges. It has a long history of failed efforts for operational tubewells and other support mechanisms; farmers have a negative attitude to any technology/policy; and Nalanda District lacks operational experience with technology. The bidder, working with the Minor Irrigation Department was able to address these challenges and make the solar pumping pilots operational in 34 locations and regain farmers' trust. Typically the pumps are equipped to cater to an annual command area of 40 hectares (Kharif –20 hectares, Rabi – 15 hectares and Garma – 5 hectares) and average volumetric output is 70 m3/hr.

Technology. The successful bidder used a basic solar setup comprising solar panels, inverter and a variable frequency drive to run the AC pumps (available at site). A cost benefit analysis must be carried out on the impact of using old inefficient pumps. New pumps would be efficient, reliable, and require less power, which could lower the cost of the whole system.

FIGURE 14: Images – Pilot Experiment

Control module monitoring.

FIGURE 15: Screen shot of Monitoring Control



The successful bidder developed proprietary software to control and monitor the performance of pump set/tube wells, which can be used by local operators, Minor Irrigation Department staff, or central control centers. The outputs displayed are calculated through an algorithm that uses variable frequency drive as an input.

Summary. This pilot project demonstrated the "proof of concept" of operating existing pumps through solar power by setting up working models in 34 locations. The lessons learned from this Pilot project would be useful in scaling up the concept of "solarization" of agricultural pump sets in Bihar and also in far flung areas which are not grid connected or have inadequate electricity supply. At diesel prices of Rs. 40 per liter, a life cycle cost analysis for a 7.5HP (8kWp installed) pump shows that an equivalent diesel pumping system would cost about 2.8 times the cost of solar pump over a 20-year life span.

Questionnaire used for survey of Electric Tubewell Owners in Karnataka and Punjab

Annex E

1. Interviewer's information	
1.1 Name of the interviewer:	**1.2** Date:
1.3 Time:	**1.4** Consent of interviewee taken **(Yes/No):**

2. Respondent information	
2.1 Name of the electric pump owner:	
2.2 Village:	**2.3** Block/Taluka:
2.4 District:	**2.5** State:
2.6 Pin Code	**2.7** Mobile (if any):
2.8 Distance of nearest distribution transformer to farmers field (km):	
2.9 Respondent code:	

3. Land Holding and Cropping Pattern Information

3.1 Land holding (Acres)			
3.1.1 Total land owned	**3.1.2** Net sown area including leased in land in 2010-2011	**3.1.3** Total irrigated Area in 2010-11	**3.1.4** Reasons for keeping your land un-irrigated, if any in **2010-11***(see codes below)

3.2 Cropping Pattern for 2010-2011 (note down maximum of 5 crops according in order of importance)

3.2.1 Name of the crop	**3.2.2** Name of the season (sowing to harvesting)	**3.2.3** Area (acres)	**3.2.4** Total no. of irrigations given from all sources	**3.2.5** No. of irrigation from electric TW only	**3.2.6** No. of irrigation from diesel TW only	**3.2.6** Hours needed per irrigation	**3.2.7** Total Production (quintal)

3.3 Did you grow the same crops 5 years ago (in 2006-07) (Yes/No?)

3.3.1 What changes have you done in terms of crops grown	**3.3.2** Reasons for the same

** 1. Not enough GW, 2. Not enough canal or tank water, 3. Not enough number of hours of electricity, 4. Any other (Pl. specify)*

4. Sources of irrigation, electric tube well & groundwater related information						
4.1 Source of irrigation and area irrigated by source (acres)						
4.1.1 Rain fed (no irrigation)	**4.1.2** Canal	**4.1.3** Electric tube well or well fitted with electric pump	**4.1.4** Diesel tube well or well fitted with diesel pump	**4.1.5** Neighbors well or tube well (both electric and diesel)	**4.1.6** Conjunctive use of canal and groundwater	**4.1.7** Any other source (Specify source)
4.2 Electric Tube well statistics (Numbers)						
4.2.1 Total number	**4.2.2** Functional	**4.2.3** Abandoned	**4.2.4** If abandoned, which year was it abandoned?	**4.2.5** Reasons for abandoning the well/ bore well?		

4.3 Particulars of only ONE tube well/borehole/open dugout well to which an electric pump is attached	
4.3.1 Type of well? (tube well/open dugout well)	
4.3.2 Year of construction	
4.3.3 Did you strike water at very first attempt? **(Yes/No)**	
4.3.4 If no, then number of attempts after which you struck water in this well/bore well?	
4.3.5 Depth of well in feet	
4.3.6 Average depth of GW before monsoon in feet	
4.3.7 Electric pump Statistics	
4.3.7.1 Electric Pump HP	
4.3.7.2 Year of purchase of electric pump	
4.3.7.3 Cost of pump, when bought	
4.3.7.4 Brand of Pump	
4.3.7.5 Is this an ISI brand? **(Yes/No/don't know)**	
4.3.7.6 Does it have BEE star rating? **(Yes/No)**	
4.3.7.7 Do you use a capacitor? **(Yes/No)**	
4.3.7.8 Do you use an auto-starter? **(Yes/No)**	
4.3.8 Number of times your motor/pump burnt out in 2**010-2011**	
4.3.9 Operating cost of well/tube well per year (Rs) in **2010-11**	
4.3.9.1 Electricity bill, if any (if yes, why)	
4.3.9.2 Motor repair costs, if any	
4.3.9.3 Any other repair and maintenance costs	
4.3.10 Number of times well/bore was deepened?	
4.3.10.1 Depth (m) of total deepening	
4.3.11 Approximate hours of operation of well/tube well in 2010-11	
4.3.11.1 Average hours of operation per day	
4.3.11.2 Total number of days operated in a year	
4.4 Is there a problem of groundwater depletion in your village? (Yes/No)	
4.4.1 If yes, over the last 5 years, what has been the rate of depletion (m/year)	
4.5 Does groundwater depletion concern you? (Yes/No)	
4.5.1 Would you like to adopt any interventions, which can reduce groundwater depletion? **(Yes/No)**	
4.5.2 If yes, would you like to adopt following interventions for **(Yes/No):**	

4.5.2.1 Reducing number of hours of tube well operation	
4.5.2.2 Changing cropping patterns to less water intensive crop	
4.5.2.3 Growing basmati or short duration paddy (only for Punjab farmers)	
4.5.2.4 Zero tillage or similar in-situ water conservation methods	
4.5.2.5 Drip or sprinkler or similar water application techniques	
4.5.2.6 Any other intervention that you can suggest	
4.6 Do you think reducing area under paddy crop will reduce groundwater depletion **(Yes/No)**	
4.7 If reducing paddy area can solve the groundwater water depletion problem, which other cropping pattern or agriculture activity would you prefer the most **(You can tick more than one option)**	
▪ Animal husbandry (milk production)	▪ Growing oil crops or pulses
▪ Growing vegetables	▪ Growing Fruits
▪ Anything else: Specify	

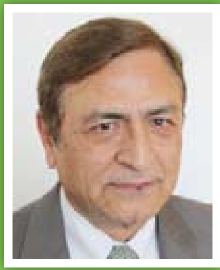
5. Power supply details		
5.1 Do you pay any Electricity bill? (Yes/No): If so, at what rate?		
5.1.1 Electricity **(Rs./Unit)**:	**5.1.2** Electricity Flat Rate **(Rs/HP/year)**:	
5.2 Are you connected to a separate Agricultural feeder **(Yes/No/Don't Know)**		
5.3 How many hours of domestic power supply do you get per day:		
5.4 How many hours of agricultural power supply do you get per day:	**Day time:**	**Night time:**
5.5 Is this number of hours sufficient for your irrigation purposes **(Yes/No)**		
5.5.1 If No, how many extra hours do you want per day?		
5.5.2 If you get these extra hours of electricity, then what will you do **(Tick, you can tick more than one option)**		
Irrigate more amount of land (how much more?)	Change my cropping pattern (to what?)	
Sell water to my neighbors	All of above	
Any other **(specify):**		
5.6 Does agricultural power supply come according to the schedule **(Yes, always/Generally/Rarely)**		
5.7 Do you face voltage fluctuation problem? **(Yes/No)**		
5.8 Did you experience damage to your pump because of poor quality power supply during the past one year **(Yes/No)**		
5.8.1 If yes, what was the nature of the damage?		
5.9 In 2010-11, was there any case of distribution transformer burn out? (Yes/No)		
5.10 If yes, how many times in a year (Number)		
5.11 How long does it take to repair a distributor transformer, once it is burnt (Number of days)		
Now we will ask a series of questions asking your opinion on a number of issues. These are hypothetical questions and will be used for our research purposes only. Answers are confidential and your individual opinion will not be disclosed to anyone.		

5.12 What in our opinion is "better power supply" both in terms of quantity and quality?	
5.13 Are you willing to pay for better power supply? **(Yes/No)**	
5.13.1 If not, why not?	
5.14 If you could continue to get free power but were offered money for the electricity you saved, and better quality and longer supply hours, would you accept metering of your tube well? **(Yes/No)**	
5.14.1 If no, why not?	
5.15 If Government were to supply you the same quantity of power in a year as now but more in months when you need it and less in months when you do not need it, then in which months would you want it and how many hours a day in those months?	

Month	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
No. of hours/day												

6. Water transaction details			
6.1 Did you help other farmers by providing them with irrigation water from your well/tube well when they needed it in 2010-11? (**Yes**/**No**), if yes;			
6.1.1 Number of farmers assisted	**6.1.2** Total hours of irrigation supplied to them during the past one year		**6.1.3** Total area served (**Acre**)
6.2 Did you charge for water you supplied to your neighbors in either cash or kind? (**Yes**/**No**), if yes; At what price?			
Rs/Hr	Rs/acre	A part of crop	Others (specify)

About the Authors



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DESIGNATED REMARKS

"This report presents innovative and highly practical approaches to address a pervasive challenge at the nexus of electricity, irrigation, and agriculture: how to best supply electrical power to pump groundwater for food production. Meticulously researched, rigorously assessed, and tested through stakeholder engagement, the public policy choices considered here provide a tangible way forward to ensure water, energy, and food security. The findings based on the Indian context are relevant to conditions that are rapidly unfolding in numerous other world regions — in both emerging and more mature economies."…………..

Christopher Scott

Professor and Distinguished Scholar at University of Arizona and Co-Director at Center of Excellence for Water Security (AQUASEC), USA

"Most Indian States are stuck in an perverse negative spiral on the nexus between energy subsidies and groundwater depletion. Political leaders of all hues are reluctant to break this spiral due to the fear of losing their vote-banks. This report successfully explores a radical, innovative and yet a politically feasible approach to unlocking the negative spiral. It argues for a win-win scheme of incentivizing farmers to conserve energy and groundwater, while also improving the finances of the electricity industry."…………..

Tushaar Shah

Senior Fellow at the International Water Management Institute (IWMI), India

"The complex problem of inefficient consumption of power and water by agriculture created unwittingly in India needs to be resolved without further delay. Long-term solutions can be found by the government and the power utilities only with the participation of farmers in collaboration with other stakeholders such as the food industry, farm equipment manufacturers, agricultural input producers, and agricultural universities. A nation that cannot motivate and involve its farmers in wisely using land, water, and power cannot develop in a sustainable way. The solution proposed in this book is a practical way forward and should be tried."…………..

Chengal Reddy

Chief Advisor at Consortium of Indian Farmers Association

ESMAP
Energy Sector Management Assistance Program

SUSTAINABLE ENERGY FOR ALL

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