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Design of Distribution and Retail Consumer’s Tariff

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Two complementary tasks

Determine the size of the pie:
Setting the remuneration

Sharing the pie:
Tariff design
Allowed costs and tariffs

• Regulators have **two basic tasks** related to “tariffs”
  • Determine **how much revenue** a utility will be allowed to earn during the next award period (*the ‘revenue requirement’*)
  • Determine the ‘**rate structure’** or end customer tariff that will yield the required revenue (*i.e., the prices that different classes of customers will be charged*)
Outline

1. The context
2. Challenges determining the size of the pie
3. Challenges slicing the pie
4. The role of regulators
1. The context
India Energy Outlook 2021

“Electricity demand grows much faster than overall energy demand in all of the scenarios examined, putting electricity at the center of India’s modernization.”

Electrification of the economy
“The growth of India’s renewable energy sector has been highly impressive – and India is set to lead the world in areas like solar power and batteries in the coming decades.”

*Based on renewables & storage*
"A defining feature of the outlook is a sharp rise in variability – both in electricity output, from solar PV and wind, and in daily consumption."

Variability will be a challenge
“The pace of change in the electricity sector puts a huge premium on robust grids and other sources of flexibility. India has a higher requirement for flexibility in its power system operation than almost any other country in the world.”

Flexibility will be the solution
“India’s success in bringing electricity connections to hundreds of millions of its citizens in recent years. This is a monumental achievement that has improved the material well-being of a huge number of people.”

Great achievement in electrification
There are several challenges ahead. A key issue is the fragile financial health of state-owned electricity distribution companies (“discoms”).

Still much work to do in the last mile
2. Challenges determining the size of the pie
I shall bring here some of the key recommendations of the MIT “Utility of the future” study

http://energy.mit.edu/research/utility-future-study/
Recommendation
“Enhance distribution regulation”

The regulation of distribution utilities must be improved to enable the development of more efficient & innovative distribution utility business models.
An enhanced distribution business model

• Forward-looking, **multi-year revenue trajectory** with **profit sharing** mechanisms
• “State of the art” regulatory tools to **manage** uncertainty
• **Outcomes-based** performance incentives
• Incentives for long-term **innovation**
Cost reflective revenue requirement (the “Aggregate Revenue Requirement” or ARR)
The costs of electricity supply

- **Network costs**
  - Distribution (*Capex & Opex*)
  - Transmission (*Capex & Opex*)

- **Generation costs**
  - If regulated under cost-of-service (*Capex & Opex*)
  - If under market conditions: price of energy

- **Retailing costs** (*small & typically merged with distribution costs*)

- **Regulated charges**
  - System Operator, Regulator, & any subsidized programs (*efficiency, renewables, domestic fuels, stranded costs, social tariffs, etc.*)

- **Taxes**
Components of the end consumer tariff in some countries

Breakdown of residential electricity bills in different jurisdictions in 2014-2015
The revenue requirement

• All incurred costs to supply electricity must be included
  • Networks, generation, retailing, other regulated charges, & taxes
  • Generation costs may result from energy prices; retail (commercialization) costs may result from retailers’ competition
  • Network costs are regulated directly, under some form of cost-of-service & typically include some performance-based incentives

• The revenue requirement for each activity must be cost reflective
  • Needed for sustainability of the companies providing the activity
  • Needed to attract investment
  • If end customer tariffs are subsidized, subsidies to suppliers or to the end customers will be needed, but the revenue requirement must be cost reflective always.
In some countries the revenue requirement is not cost reflective...
Making Power Affordable for Africa and Viable for Its Utilities
Figure 2  Comparison of electric supply costs with cash collected in 2014 U.S. dollars per kWh billed

Figure 7.16 Performance of India’s DISCOMs

Notes: ACS = average cost of supply; ATC = aggregate technical and commercial; ARR = average revenue realised.
What are the implications?
Implications of non-cost-reflective tariffs

- Non financially viable disco, resulting in poor O&M, inadequate investment, & poor customer attention
- Lack of progress in electrification: reliability & quality of service, C&I customers, technical & commercial losses, demand growth
- Risk of insufficient payment to generation & transmission
- Non creditworthy off-taker, impairing generation investment
- Same for transmission investment
- Customers do not perceive the true cost of electricity => inefficient use of electricity
How to incentivize efficiency?
All regulations result in incentives…

• Any regulatory scheme implies incentives for the regulated firm
  • E.g., strict cost-of-service regulation leads to
    • The Averch-Johnson effect
    • Lack of interest in efficiency gains
  • Cost-of-service based on standard costs or some other scheme not based on the actual costs & performance of the firm leads to
    • Strong stimulus to improvements of efficiency, but no benefit for consumers & poor quality of service
RPI-X or the Multi Year Tariff (MYT)

- A formalized regulatory lag between price reviews gives companies an incentive to operate efficiently in the interval between reviews
  - “Revenue cap”, also called revenue-yield control: the trajectory of maximum revenues of the company is established for the review period.
  - Once all the future costs of the firm for the control period have been somehow estimated, the value of X must be such that the net present value of the stream of estimated costs and revenues for the entire control period are equal
The calculation of X

• TCPV is the present value (PV) of the estimated total incurred cost at the initial year t of the 4 year price control period

• Revenue cap trajectory & calculation of X: Match the NPV of costs & revenues R(t) for the control period

\[ TCPV = R(t).d + R(t).(RPI-X).d^2 + R(t).(RPI-X)^2.d^3 + R(t).(RPI-X)^3.d^4 \]

• d is the discount factor (to move money in time)

• NOTE (key issue): The effect of the expected change in the cost drivers (such as the supplied demand) is already included in TCPV
How to estimate the trajectory of costs in an uncertain future with DER penetration?

Computer-aided tools can help to estimate efficient distribution costs
Approaches to estimate future distribution costs

• Extrapolation
  • The future will not resemble the past

• Benchmarking
  • Lack of a data base of comparable situations

• Reference network models
  • Realistic approximation to the estimated future scenarios with computer-based engineering optimization models

Results shown below have been obtained with the model RNM ”Reference Network Model”, IIT Comillas University
GPS location of consumers

SOURCE: RNM model, IIT Comillas University
MV/LV transformers & LV lines

SOURCE: RNM model, IIT Comillas University
MV urban network

SOURCE: RNM model, IIT Comillas University
MV urban network (zoom)

Street map, LV and MV network, LV customers and MV/LV transformers

SOURCE: RNM model, IIT Comillas University
MV urban/rural network

HV/MV substation

Network loops

MV feeder

SOURCE: RNM model, IIT Comillas University
Increasing levels of rooftop solar penetration - 1

RNM Model, from the MIT “Future of solar” study
Increasing levels of rooftop solar penetration

RNM Model, from the MIT “Future of solar” study
Increasing levels of rooftop solar penetration

RNM Model, from the MIT “Future of solar” study
Increasing levels of rooftop solar penetration

RNM Model, from the MIT “Future of solar” study
Changes in network costs with growing PV penetration

From the MIT “Future of Solar Study”
Between reviews, the regulator has nothing to do...
The basic control formula for the total revenue of the firm is (all amounts in t):

\[
\text{Total regulated revenue (t+1)} = \text{Total regulated revenue (t)} \times (1 + \text{RPI-X}) \times \\
\times (1 + \sum_k (\Delta\text{revenue driver } k \times \text{weighing factor } k))
\]

where

- a typical revenue driver is the total volume (physical, not monetary) of sales
- \( \Delta\text{revenue driver } k \) is the deviation with respect to the estimate of change of revenue driver \( k \) that has been already included in the cost estimate for the entire price control period
- Then \( \Delta\text{revenue driver } k = 0 \) if the value of the revenue driver \( k \) during the price control period has been estimated correctly
Other improvements on RPI-X or MYT

• Add ad hoc incentives for reliability, loss reduction, revenue collection, or innovation (RIIO, by OFGEM)
• “Incentive compatibility” to make the firm truthfully reveal their best cost estimates ("menu of contracts" method)
• Improve the efficient cost estimates of the regulator
  • to reduce its information disadvantage (the “adverse selection problem”)
  • not endangering the viability of the regulated firm (the “budget constraint”)
  • while encouraging managerial effort of the firm (to be as efficient as possible, while preserving quality of service & low losses) by allowing it to capture rents that cannot be clawed back (the “moral hazard” problem)
Readings -1

• “Regulation of monopolies”, by T. Gómez. Chapter 4 of the textbook “Regulation of the electric power sector”, Springer Verlag 2013, edited by Ignacio Pérez-Arriaga.

  (for details go to the Master thesis of Jesse Jenkins, MIT TPP ESD, May 2014)
Readings -2

• **OFGEM** revisions to their RPI-X system
  http://www.ofgem.gov.uk/Networks/rpix20/ConsultDocs/Documents1/RPI-X@Recommendations.pdf

Recommendation

“Rethink industry structure to minimize conflicts of interest”

The structure of the electricity industry should be carefully evaluated to minimize potential conflicts of interest.
Establish independence between the Distribution System Operator and the agents performing activities in markets and if independence is legal or functional, apply significant regulatory oversight and transparent mechanisms to provide services.
2. Challenges slicing the pie
Tariff design principles
RESOLUTION

No 23/2/2005-R&R(Vol III)

TARIFF POLICY

1.0 INTRODUCTION

1.1. In compliance with section 3 of the Electricity Act 2003 the Central Government hereby notifies the Tariff policy in continuation of the National Electricity Policy (NEP) notified on 12th February 2005.

1.2. The National Electricity Policy has set the goal of adding new generation capacity of more than one lakh MW during the 10th and 11th Plan periods to have per capita availability of over 1000 units of electricity per year and to not only eliminate energy and peaking shortages but also have a spinning reserve of 5% in the system. Development of the power sector has also to meet the challenge of providing access for electricity to all households in next five years.

1.3. It is therefore essential to attract adequate investments in the power sector by providing appropriate return on investment as budgetary resources of the Central and State Governments are incapable of providing the requisite funds. It is equally necessary to ensure availability of electricity to different categories of consumers at reasonable rates for achieving the objectives of rapid economic development of the country and improvement in the living standards of the people.

1.4. Balancing the requirement of attracting adequate investments to the sector and that of ensuring reasonableness of user charges for the consumers is the critical challenge for the regulatory process. Accelerated development of the power sector and its ability to attract necessary investments calls for, inter alia, consistent regulatory approach across the country. Consistency in
4.0 OBJECTIVES OF THE POLICY
The objectives of this tariff policy are to:

(a) Ensure availability of electricity to consumers at reasonable and competitive rates;
(b) Ensure financial viability of the sector and attract investments;
(c) Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimise perceptions of regulatory risks;
(d) Promote competition, efficiency in operations and improvement in quality of supply.
## PRINCIPLES OF TARIFF DESIGN

1. Effectiveness of yielding total revenue
2. Stability and predictability of revenue
3. Stability and predictability of rates
4. Discouraging wasteful use of services
5. Understanding of present and future private and social costs and benefits of service provided
6. Fairness of rates in the apportionment of total costs of service among different consumers
7. Avoidance of discrimination in rates
8. Promotion of innovation and cost-effectiveness in the face of changing demand and supply patterns
9. Simplicity, understandability, public acceptability, and feasibility
10. Freedom from controversies as to proper interpretation

SOURCE: Slide presentation by ISMAIL ALI KHAN, Chairman TSERC
Regulatory principles for tariff design

REGULATORY PRINCIPLES

- ECONOMIC EFFICIENCY
- EQUITY
- SUSTAINABILITY
- SIMPLICITY
- CONSISTENCY
- TRANSPARENCY
- STABILITY
- ADDITIVITY
Regulatory principles

• (economic) **Sustainability**: guarantee of recovery of all regulated costs so that the electrical power sector is economically viable

• **Equity or Non Discrimination** in the allocation of costs to consumers: Same charge should apply to the same provision of a service, regardless the end use of the electricity.
  • This would be in line with a cost allocation procedure based on cost causality
Regulatory principles

- **Economic efficiency:** Tariffs must send economic signals that promote efficient consumption of the good in the short & long term (allocative efficiency), leading to efficient operation & investment. This requires that costs should be assigned to those who are responsible for them (criterion of cost causality)
  
  - Then, use marginal costs / prices whenever possible
  - And, if there are still costs to be assigned
    - apply “cost causality” as far as it is possible
    - &, finally, try to minimize any inevitable distortion in the economic decisions of the consumers
Regulatory principles

• **Transparency:** in the methodology, so that all employed criteria & procedures are made public

• **Stability:** in the adopted methodology, so that the concerned agents have the least possible regulatory uncertainty. Stability is compatible with a gradual process of adaptation of the present tariffs to the new system

• **Simplicity:** in the methodology & its implementation, as far as possible
Regulatory principles

• **Additivity**: derived from the principles of efficiency & sustainability. End user tariffs must be the outcome of adding all applicable cost concepts

• **Consistency**: with the specific regulatory process of each country

• **Other principles:**
  • Protection of low-income / vulnerable consumers
  • Protection of the environment *(include in the tariffs the environmental costs)*
Regulatory principles
A pragmatic summary

• Tariffs (*the size of the pie & sharing it*) must comply with the accepted regulatory principles. At least they should:
  • **Guarantee recovery** of the total regulated cost for each activity
  • Be **additive**
  • Be reasonably **efficient**
    • Send adequate economic signals both in the short & the long term
  • Be **simple & transparent**
After examining how distributed energy resources (DERs) will be changing the provision of electricity services, over the next decade & beyond, our first recommendation was...
Recommendation #1
“Create a comprehensive & efficient system of prices & charges”

The only way to put all resources—centralized & distributed—on a level playing field and achieve efficient operation and planning in the power system is to dramatically improve prices and regulated charges for electricity services.
Prices & charges are the nervous system of the electricity sector, reaching everywhere.
A mindset change
Create a comprehensive & efficient system of prices & charges *(Like a nervous system, reaching every corner of the power system)*
DERs could deliver large savings by improving the utilization of electricity infrastructure, but many opportunities to deliver greater value are left untapped without a comprehensive system of efficient prices & regulated charges for electricity services
Consumers (will) have unprecedented choice regarding how to manage their power supply…
… & the technologies are ready for the agents to decide how to manage their energy
Implications of a rigorous adherence to the principles
Any **cost-reflective** component of prices & charges should be exclusively based on the **individual injection & withdrawal profiles** at the network connection point & should be **symmetrical**.

This requires the use of **advanced meters**

**Diagram:**
- Power Flows
- Meter with "User Profile"
- DERs and Loads
Challenge: In principle, no discrimination between prices of kWh under same conditions of time, voltage & location

End-user prices in India are categorized by consumption group and there is a large variety of tariffs in each state, with cross-subsidy between industrial and residential users.

Retail prices at state level show a wide range of tariff structures and methodologies, leading to a wide spread of categories.

Table shows average end-user prices in INR/kWh for the fiscal year 2015/16 for four types of customers: domestic, commercial (non-domestic), agricultural and industrial (average of both high-tension and low-tension type).

Agriculture (around 22% of total sales) is charged a flat tariff with a monthly fee and unmetered power for water pumping.
We want to create a comprehensive and efficient system of prices & charges

How to do it? First, remember…
The costs of electricity supply

• **Network costs**
  • Distribution (*Capex & Opex*)
  • Transmission (*Capex & Opex*)

• **Generation costs**
  • If regulated under cost-of-service (*Capex & Opex*)
  • If under market conditions: price of energy

• **Retailing costs** *(small & typically merged with distribution costs)*

• **Regulated charges**
  • System Operator, Regulator, & any subsidized programs *(efficiency, renewables, domestic fuels, stranded costs, social tariffs, etc.)*

• **Taxes**
The basic components of the end consumer tariff

Breakdown of residential electricity bills in different jurisdictions in 2014-2015
Tariffs are applied with a structure *(Time zones & voltage levels)*

<table>
<thead>
<tr>
<th></th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak</td>
<td>Intermediate</td>
</tr>
<tr>
<td><strong>LV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 tz.</td>
<td>€/kW</td>
<td>€/kWh</td>
</tr>
<tr>
<td>2 tz.</td>
<td>€/kW</td>
<td>€/kWh</td>
</tr>
<tr>
<td>3 tz.</td>
<td>€/kW</td>
<td>€/kWh</td>
</tr>
<tr>
<td><strong>MV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 tz.</td>
<td>€/kW</td>
<td>€/kWh</td>
</tr>
<tr>
<td><strong>HV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 tz.</td>
<td>€/kW</td>
<td>€/kWh</td>
</tr>
<tr>
<td><strong>VHV</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 tz.</td>
<td>€/kW</td>
<td>€/kWh</td>
</tr>
</tbody>
</table>

Tariffs are applied with a structure *(Time zones & voltage levels)*.
Let’s do it one step at a time…

• **STEP 1:** Reflect *time differentiation* in the energy charges
Capture the wholesale energy price evolution in time

(one week in July 2015 in Austin, ERCOT)
… compared to the usual constant rate…

(one week in July 2015 in Austin, ERCOT)
… or to Time of Use (ToU) pricing
(one week in July 2015 in Austin, ERCOT)
Challenge: Small volume of energy traded in the Indian wholesale market (despite progress being made & CERC’s efforts)

90% of all generation was priced through regulated long-term contracts, with only 4% through the exchange.

End customers do not see the real time energy price

- Most generators are remunerated based on the traditional classification of
  - fixed (capital) costs, which go to the demand component of the tariff
  - & variable (production) costs, which go to the energy component of the tariff
 & this is how discos purchase most power & reflect it in the tariffs
End customers do not see the real time energy price

- Most generators are remunerated based on the traditional classification of
  - fixed (capital) costs, which go to the demand component of the tariff
  - & variable (production) costs, which go to the energy component of the tariff
  & this is how discos purchase most power & reflect it in the tariffs
- On the other hand, in well-developed wholesale markets the marginal price of energy pays for the total cost of power plants & this is the energy component reflected in the end customer tariff
  - In some markets there is an additional (minor) capacity payment to encourage investment & plant availability under system stressful conditions
Challenge: Smart meters & tariff structures must go beyond prepayment & time-of-use pricing

Bihar's 'smart prepaid meter scheme' to be extended nationwide

The 'smart prepaid meter' scheme implemented in Bihar will now be extended nationwide. Union Finance Minister Nirmala Sitharaman proposed to introduce the meter throughout the country in the Budget presented in Parliament on Monday.
9.1. Tariff Schedule

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Consumer Category</th>
<th>Fixed Charge INR/kW/month</th>
<th>Energy Charge INR/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>DOMESTIC SUPPLY (DS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.</td>
<td>LT Domestic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>0-150 kWh per month</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>151-400 kWh per month</td>
<td>4.80</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Above 400 kWh per month</td>
<td>5.50</td>
<td></td>
</tr>
<tr>
<td>II.</td>
<td>HT Domestic</td>
<td>10.00</td>
<td>4.80</td>
</tr>
<tr>
<td>2.</td>
<td>COMMERCIAL/ NON RESIDENTIAL (NRS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.</td>
<td>LT Commercial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a.</td>
<td>0-150 kWh per month</td>
<td>INR. 20/kW/Month for Single Phase</td>
<td>5.00</td>
</tr>
<tr>
<td>b.</td>
<td>151-400 kWh per month</td>
<td>INR. 100/kW/Month for Three Phase</td>
<td>5.30</td>
</tr>
<tr>
<td>c.</td>
<td>Above 400 kWh per month</td>
<td>5.60</td>
<td></td>
</tr>
<tr>
<td>II.</td>
<td>HT Commercial</td>
<td>100.00</td>
<td>5.30</td>
</tr>
<tr>
<td>3.</td>
<td>INDUSTRY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.</td>
<td>Large Industrial Power Supply (LPS)</td>
<td>200.00</td>
<td>5.00</td>
</tr>
<tr>
<td>II.</td>
<td>Medium Industrial Power Supply (MPS)</td>
<td>200.00</td>
<td>4.70</td>
</tr>
<tr>
<td>III.</td>
<td>Small Industrial Power Supply (SIPS)</td>
<td>300.00</td>
<td>4.80</td>
</tr>
<tr>
<td>4.</td>
<td>AGRICULTURAL PUMPING SUPPLY (AR)</td>
<td>-</td>
<td>2.90</td>
</tr>
<tr>
<td>5.</td>
<td>PUBLIC LIGHTING (PL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.</td>
<td>Public Lighting system managed by Municipal Corporation, Panchayat and Street Lights maintained / outsourced to an external agency</td>
<td>100.00</td>
<td>5.35</td>
</tr>
<tr>
<td>II.</td>
<td>Advertisement/ Moon-sign Boards Advertising boards, billboards (apart from advertisement boards installed on commercial establishments and charged under commercial tariff)</td>
<td>100.00</td>
<td>7.10</td>
</tr>
<tr>
<td>6.</td>
<td>BULK SUPPLY (BS)</td>
<td>200.00</td>
<td>4.90</td>
</tr>
<tr>
<td>7.</td>
<td>TEMPORARY SUPPLY</td>
<td></td>
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<tr>
<td></td>
<td>Tariff shall be Fixed/ Demand charges (if any) plus energy charges (for relevant slab, if any) under corresponding permanent supply category plus 50% of both. For multi activity pursuit, applicable Tariff for temporary connection shall be with reference to that of commercial category for permanent supply.</td>
<td>-</td>
<td>3.60</td>
</tr>
<tr>
<td>8.</td>
<td>ELECTRIC VEHICLE CHARGING STATION</td>
<td>-</td>
<td>3.60</td>
</tr>
</tbody>
</table>
# RETAIL SUPPLY TARIFF EFFECTIVE FROM 1ST OCTOBER, 2020

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Category of Consumers</th>
<th>Voltage of Supply</th>
<th>Demand Charge (Rs/KW/Month)</th>
<th>Energy Charge (Ps/KVA/Month)</th>
<th>Customer Service Charge (Rs/month)</th>
<th>Monthly Minimum Fixed Charge for first KW or part (Rs)</th>
<th>Monthly Fixed Charge for any additional KW or part (Rs)</th>
<th>Remarks (Ps/KVA)</th>
<th>D/P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Domestic</td>
<td>LT</td>
<td>FIXED MONTHLY CHARGE-&gt;</td>
<td>80</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Rural</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>1.1.1</td>
<td>Rural (Consumption &lt;= 30 units/month)</td>
<td>LT</td>
<td>270.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1.1.2</td>
<td>Rural (Consumption &gt; 30 &lt;= 200 units/month)</td>
<td>LT</td>
<td>450.00</td>
<td></td>
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<td></td>
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<tr>
<td>1.1.3</td>
<td>Rural (Consumption &gt; 200 &lt;= 400 units/month)</td>
<td>LT</td>
<td>580.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>1.1.4</td>
<td>Rural (Consumption &gt; 400 units/month)</td>
<td>LT</td>
<td>550.00</td>
<td></td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>2</td>
<td>General Purpose &lt;= 110 KVA</td>
<td>LT</td>
<td>540.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>General Purpose &lt;= 110 KVA (Consumption &lt;=100 units/month)</td>
<td>LT</td>
<td>540.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>General Purpose &lt;= 110 KVA (Consumption &gt; 100 &lt;= 300 units/month)</td>
<td>LT</td>
<td>720.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2.3</td>
<td>General Purpose &lt;= 110 KVA (Consumption &gt; 300 &lt;= 500 units/month)</td>
<td>LT</td>
<td>720.00</td>
<td></td>
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<tr>
<td>3</td>
<td>Irrigation Pumping &amp; Agriculture</td>
<td>LT</td>
<td>150.00</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Allied &amp; Industrial Activities</td>
<td>LT</td>
<td>150.00</td>
<td></td>
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<tr>
<td>5</td>
<td>Public Water Works &amp; Sewage Pumping &lt;=110 KVA</td>
<td>LT</td>
<td>550.00</td>
<td></td>
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<tr>
<td>6</td>
<td>Public Water Works &amp; Sewage Pumping &gt;110 KVA</td>
<td>LT</td>
<td>550.00</td>
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<tr>
<td>7</td>
<td>Large Industry</td>
<td>LT</td>
<td>550.00</td>
<td></td>
<td></td>
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<tr>
<td>8</td>
<td>Power Intensive Industry</td>
<td>LT</td>
<td>550.00</td>
<td></td>
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<tr>
<td>9</td>
<td>Emergency Supply to UPL</td>
<td>LT</td>
<td>750.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>Emergency Consumption</td>
<td>LT</td>
<td>750.00</td>
<td></td>
<td></td>
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</tbody>
</table>

**Note:**
- The above tariffs are effective from 1st October, 2020.
- For more details, please refer to the OERC Notification for FY 2020-21.
Let’s do it one step at a time…

• Reflect **time differentiation** in the energy charges

• **STEP 2**: Apply forward-looking peak-coincident capacity charges for networks & firm generation capacity (*if applicable*)
Challenge: Very diverse demand charges & having to deal with residual charges

• Strict application of this principle would result in
  • high demand charges to customers connected in areas with networks close to present or near future congestion & contributing to the congestion peak
    • No charges if no contribution to the peak
    • Credits if contribution to reduce the congestion at the peak
  • zero demand charges to customers connected in areas where networks are not close to present or near future congestion at any time

• Implication: The costs of the non-congested networks must be recovered by some other non-cost-reflective method => residual charges
Relevant tariff design principles for the allocation of network costs

- **Sustainability**: Network charges should fully recover the cost-of-service determined by regulator
- **Economic efficiency**: Contribution of the tariff to maximization of social welfare
  - Do not overdo the signal: Use “cost causality” (“responsibility in incurred network costs”) just for those assets whose existence is a direct consequence of the behavior of the network users
  - Allocate any “leftover costs” (“residual network costs”) with Ramsey-like criteria
Let’s do it one step at a time…

• **STEP 1**: Reflect **time differentiation** in the energy charges

• **STEP 2**: Apply forward-looking peak-coincident capacity charges for networks & firm generation capacity *(if applicable)*

• **STEP 3**: Progressively increase the **locational component** of prices & charges
Energy prices at transmission level may vary significantly if there are binding network constraints.

Wholesale LMP variation across more than 11,000 PJM nodes on July 19, 2015, at 4:05 pm.
Bidding zones in European market coupling
Bidding zones & prices at IEX
There is locational differentiation in energy prices also at distribution level
Getting deep into distribution
(just losses)
Getting deep into distribution
(losses & network constraints)
Locational differentiation of prices has important policy implications, since the value of the services provided by DERs may depend on their location.
Some DERs can only be deployed at a specific scale level...
... while others can be deployed at different scales

Utility Scale

C&I Scale

Residential Scale
Locational Value of Distributed Solar PV: Long Island, New York Example
High Value Case

Average value per MWh produced

- Locational energy value: transmission
- Locational energy value: distribution losses
- Conservation voltage reduction
- Network investment deferral
- Generation capacity premium
- Reliability
- Total locational value

Values:
- Locational energy value: transmission: $24.0
- Locational energy value: distribution losses: $5.6
- Conservation voltage reduction: $11.1
- Network investment deferral: $41.2
- Generation capacity premium: $2.9
- Reliability: $0.0
- Total locational value: $84.7
Locational Value of Distributed Solar PV:
Mohawk Valley, New York Example
Average Value Case

Average value per MWh produced

$0  $20  $40  $60  $80  $100

Locational energy value: transmission  Locational energy value: distribution losses  Conservation voltage reduction  Network investment deferral  Generation capacity premium  Reliability  Total locational value

2.3  3.1  1.7  0.0  0.9  0.0  7.9
For DERs that can be deployed at different scales (e.g., solar PV, storage)...

Locational value competes with economies of scale
Economies of Unit Scale Still Matter
Solar PV (2015 costs)

10-100 MW

1-2 MW

1-10 kW

+57%

+146%
Economies of Unit Scale Still Matter
Lithium-ion Energy Storage (2015 costs)

+12%

+68%
Distributed or centralized?

• From a societal viewpoint, the locational value versus the incremental cost due to loss of economies of scale determines the best option.

• From the customer viewpoint, the locational value enhances the economic viability of the distributed resource, which will be a factor among others to make a decision.
Recommendation
“Carefully evaluate the economic opportunities and costs of DERs”

Better utilization of existing assets and smarter energy consumption hold great potential for cost savings.

Economies of scale still matter, and the distributed deployment of solar PV or energy storage is not cost-effective in all contexts and locations.
Perhaps the most important step…
Let’s do it one step at a time…

• **STEP 1**: Reflect *time differentiation* in the energy charges

• **STEP 2**: Apply forward-looking peak-coincident capacity charges for networks & firm generation capacity (if this is the case)

• **STEP 3**: Progressively increase the *locational component* of prices & charges

• **STEP 4**: Policy & residual network costs should be charged minimizing *distortion* of cost-reflective signals
Policy costs & residual network costs should not be recovered with volumetric charges ($/kWh). We recommend a fixed annual charge distributed in monthly installments.
Implementation

• Policy costs & residual network costs **should be removed from the volumetric ($/kWh) component of the tariff** & charged differently. How?
  • Preferably as an **annual lump sum** (conveniently distributed in monthly installments), with the magnitude of each customer charge depending upon **some proxy metric of lack of price elasticity or some measure of wealth**, such as the property tax or the size of the system user’s dwelling, or just via ordinary taxes.

• The seriousness of the **threat of grid defection** must be carefully considered in determining which costs are included in the electricity tariff.
Let’s do it one step at a time…

• **STEP 1:** Reflect **time differentiation** in the energy charges

• **STEP 2:** Apply forward-looking peak-coincident capacity charges for networks & firm generation capacity (*if applicable*)

• **STEP 3:** Progressively increase the **locational component** of prices & charges

• **STEP 4:** Policy & residual network costs should be charged minimizing distortion of cost-reflective signals

• **STEP 5:** Reconsider **which costs are included** in the electricity tariff if inefficient **grid defection** is a serious threat
Depending on the seriousness of the threat of grid defection, which costs are included in the electricity tariff must be carefully considered.
Remember…
Challenge: In principle, no discrimination between prices of kWh under same conditions of time, voltage & location

End-user prices in India are categorized by consumption group and there is a large variety of tariffs in each state, with cross-subsidy between industrial and residential users.

Retail prices at state level show a wide range of tariff structures and methodologies, leading to a wide spread of categories.

Table shows average end-user prices in INR/kWh for the fiscal year 2015/16 for four types of customers: domestic, commercial (non-domestic), agricultural and industrial (average of both high-tension and low-tension type).

Agriculture (around 22% of total sales) is charged a flat tariff with a monthly fee and unmetered power for water pumping.
Challenge: Captive producers

- High industrial tariffs & unreliable supply have led to a gradual transition towards industry generating power itself (captive generation) or purchasing it from dedicated generators (open access).
- Around 18% of grid-connected capacity stems from so-called captive power plants, which satisfy 71% of India’s industrial electricity consumption.
- India has around 80 GW of installed capacity in the form of captive power plants owned by industrial customers for localized production and use.
- The captive plants run on coal (54 GW or 68% of the total), natural gas (9.5 GW or 12%), diesel/fuel oil (3.5 GW or 4%) and renewables (bagasse, biomass, wind and solar) (15 GW or 16%).

Readings


• Visit: http://energy.mit.edu/research/utility-future-study/
A new frontier in regulation

Economic signals at the “last mile” & the interface on- & off-grid
The “last mile” & the interface on- and off-grid

From information available on the Draft Electricity (Amendment) Bill, 2020

Inclusion of Distribution Sub-licensee and Franchisee:

“To ease the burden of distribution licensees and in order to promote some form of demographic specialization, the distribution licensees, can appoint another entity for distribution of electricity on its behalf, within its area of supply. This entity can be either a distribution sub-license appointed with prior permission of the State Commission or it may be a franchisee appointed by merely informing the State Commission. This move could possibly give more leeway to power generators and licensed distributors sub-contract the obligations and allot risk to specific parties, where they belong.”

However, there is no addition of further clauses which specifically govern either of these newly introduced entities, wherein the extent of statutory obligation of each of the entities is co-extensive with one another.
Open issues -1

• Generation & storage “behind the meter”: is net metering a sound regulation?
  • Yes, if netting is done in “real time” & just for the energy component of the tariff, & network charges are applied to the real time injection or withdrawal
  • No, if netting is done over a long time period (standard meters) including all tariff components & network charges are not determined correctly
Open issues -2

• After the outstanding electrification effort of the last few years in India, some discoms still have serious problems at the last mile, where non-discoms organizations have deployed or are deploying off-grid solutions

• Approaches are needed to establish a collaborative framework benefiting customers, discoms, & off-grid developers
  • “Microgrids under the grid”, better connected than not
  • Recapturing C&I customers, either defected or with expensive & dirty backups
  • Outsourcing metering, billing, revenue collection, retailing, network O&M, or promotion of electricity services & efficient appliances
Open issues -3

• Is “all-connected” the least cost option?
  • In a future electrified economy grid connection appears to be the obvious model except for exceptional situations
  • However, perhaps grid extension has gone too far in some cases, & presently, disconnection from the main grid & supply with local generation can be the least cost solution, at least until demand grows much more
  • Could the Direct Benefit Transfer (DBT) apply to non-grid-connected customers if supply meets some required minimum conditions?
  • Could regulated cost-of-service remuneration apply to collaborative schemes between discoms & off-grid providers?
4. The role of regulators
“As for the future, your role is not to foresee, but to enable it”

Antoine de Saint Éxupéry
Thank you