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# Energy and Growth

Robin Burgess
AGF, Addis Ababa
30th June 2015

# Overview

- Energy is critical for growth & development
- Off-grid has potential but grids are critical to support firms' energy needs
- Useful to focus on demand side, not just supply side
- Energy as a private good not a right
- Political commitment to increasing access to reliable energy critical
- Need for better data and creative research strategies

# IGC's Energy Agenda

**Key focal areas: (directed by Michael Greenstone [Chicago] and Nicholas Ryan [Yale])**

**→ Trying to break out of low cost, low quality equilibrium**

1. Improving the Reliability of Grid Services
2. Rural Electrification
3. Energy Efficiency
4. Minimising External Costs of Energy Consumption

# IGC's Energy Program is Open for Business

1. Looking for projects in Africa
2. Need partners to undertake evaluations with (e.g. distribution companies, energy companies)
3. Cogeneration of knowledge
4. Can draw on IGC Country Offices, IGC Hub in London and IGC Research Network to start projects

# Energy and Industrial Development

- Building on Sutton, Oqubay and Macchiavello
- Industrial revolution driven by access to cheap, reliable energy
- Key to structural change (manufacturing, agribusiness and service sector firms) an urbanization
- Key to making firms more productive and (critically for Africa) to bringing new firms into existence

# Energy and Industrial Development

- Industry used to develop where cheap energy was available
- Now energy mobile
- African countries small – potential large role for energy trade
- Also key to Asia where some countries have fossil fuel deposits and hydro potential and others do not
- Ethiopia 1/250$^{th}$ Bihar 1/100$^{th}$ US

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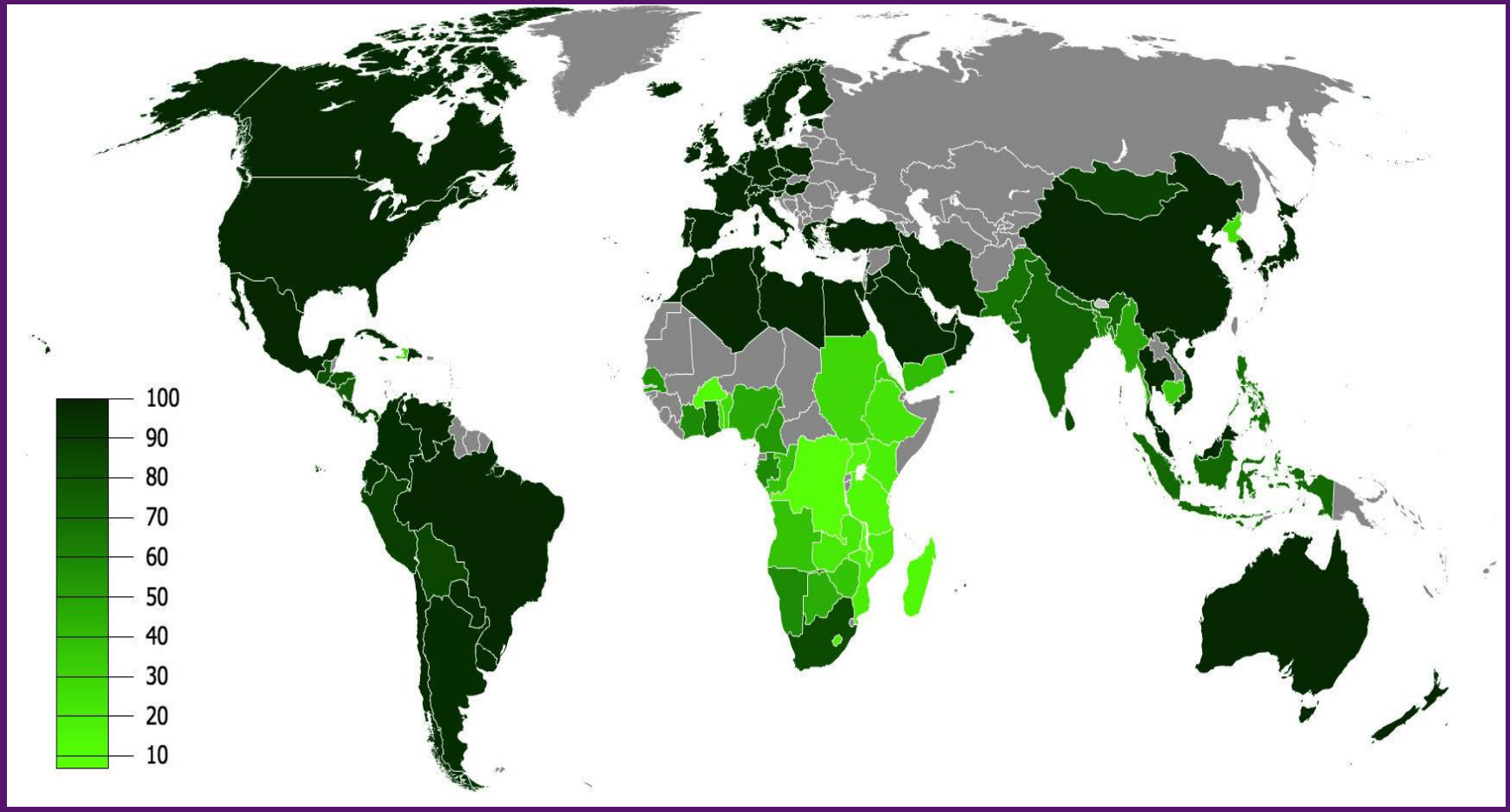
# Percentage of Population with Access to Electricity




**1.3 billion people lack access to electricity, (Africa - 600 million), 2.5 billion underelectrified**

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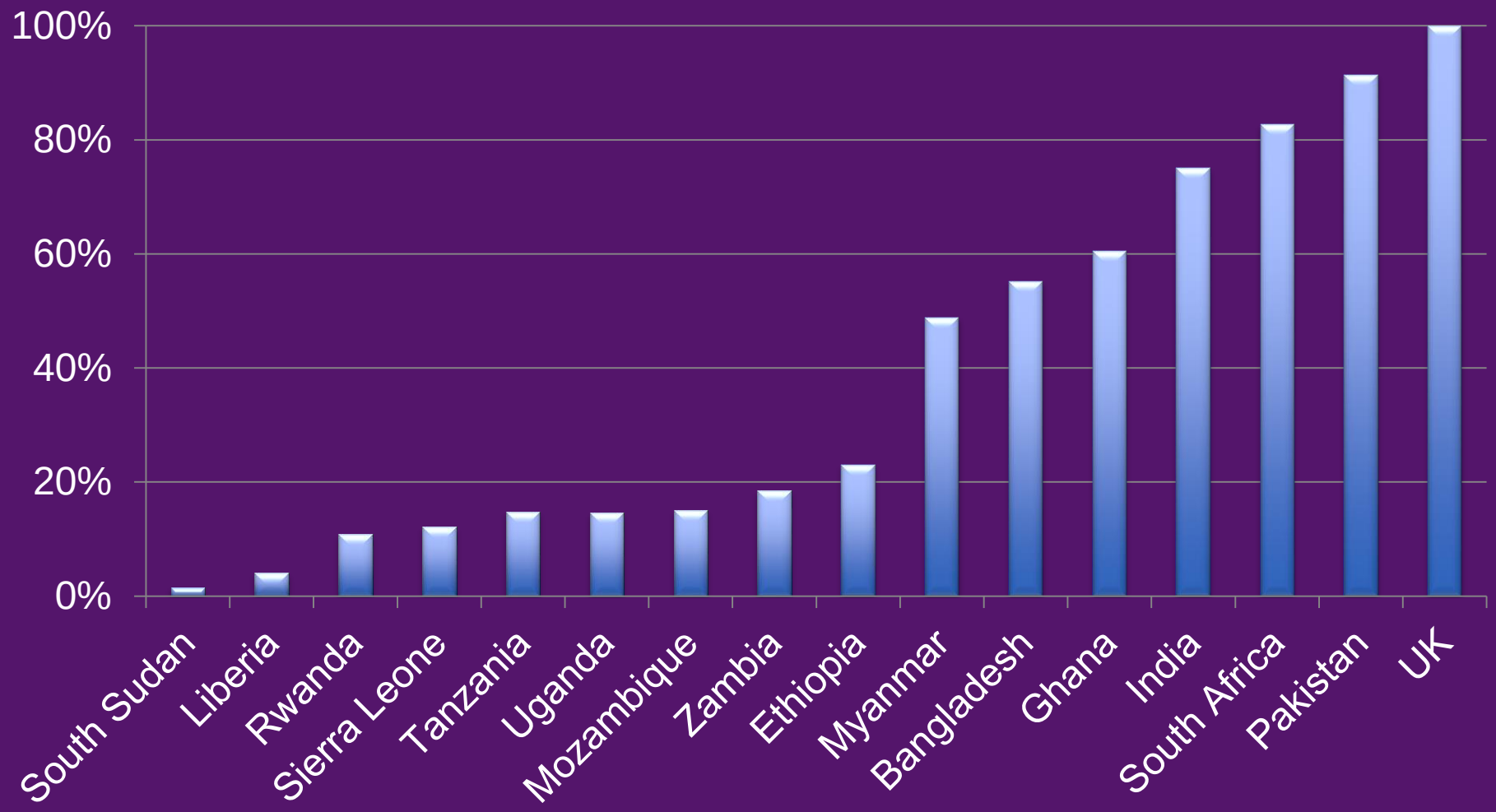
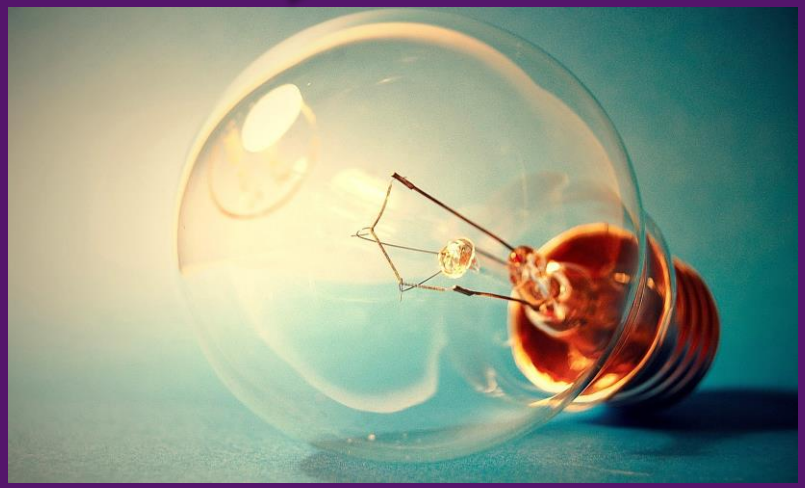
# Access to Electricity (% of population) 2010



# Annual Per-Capita Electricity Consumption

| Country | Population (millions) | KWh/Capita |
|---|---|---|
| USA | 312 | 13,246 |
| Ethiopia | 94 | 52 |
| Russia | 143 | 6,486 |
| China | 1,357 | 3,298 |
| India | 1,252 | 684 |
| Bihar | 104 | 122 |
| Ghana | 26 | 344 |

It takes 131 KWh to use a 60 watt bulb for 6 hours per day for a full year



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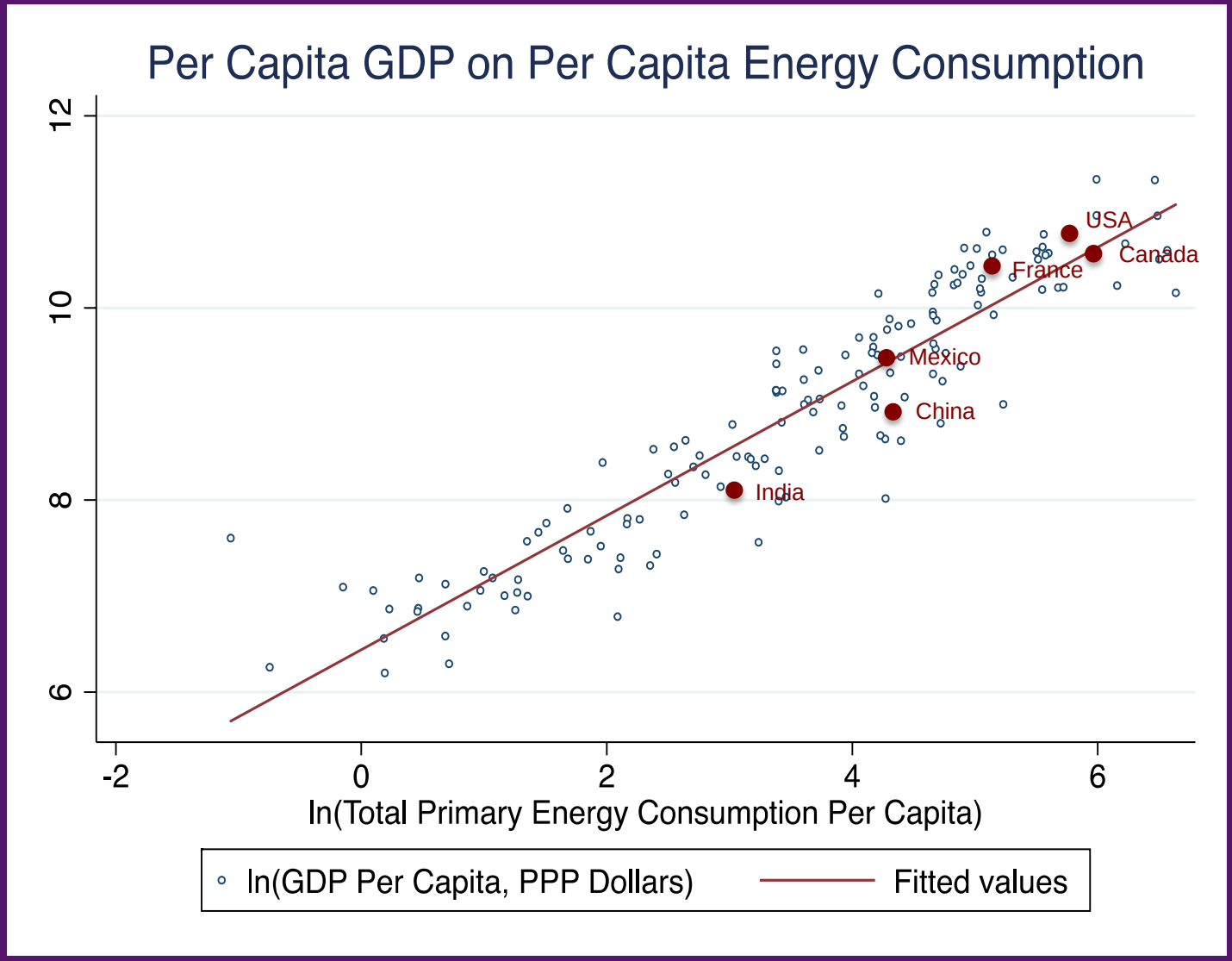
# Energy is critical to growth



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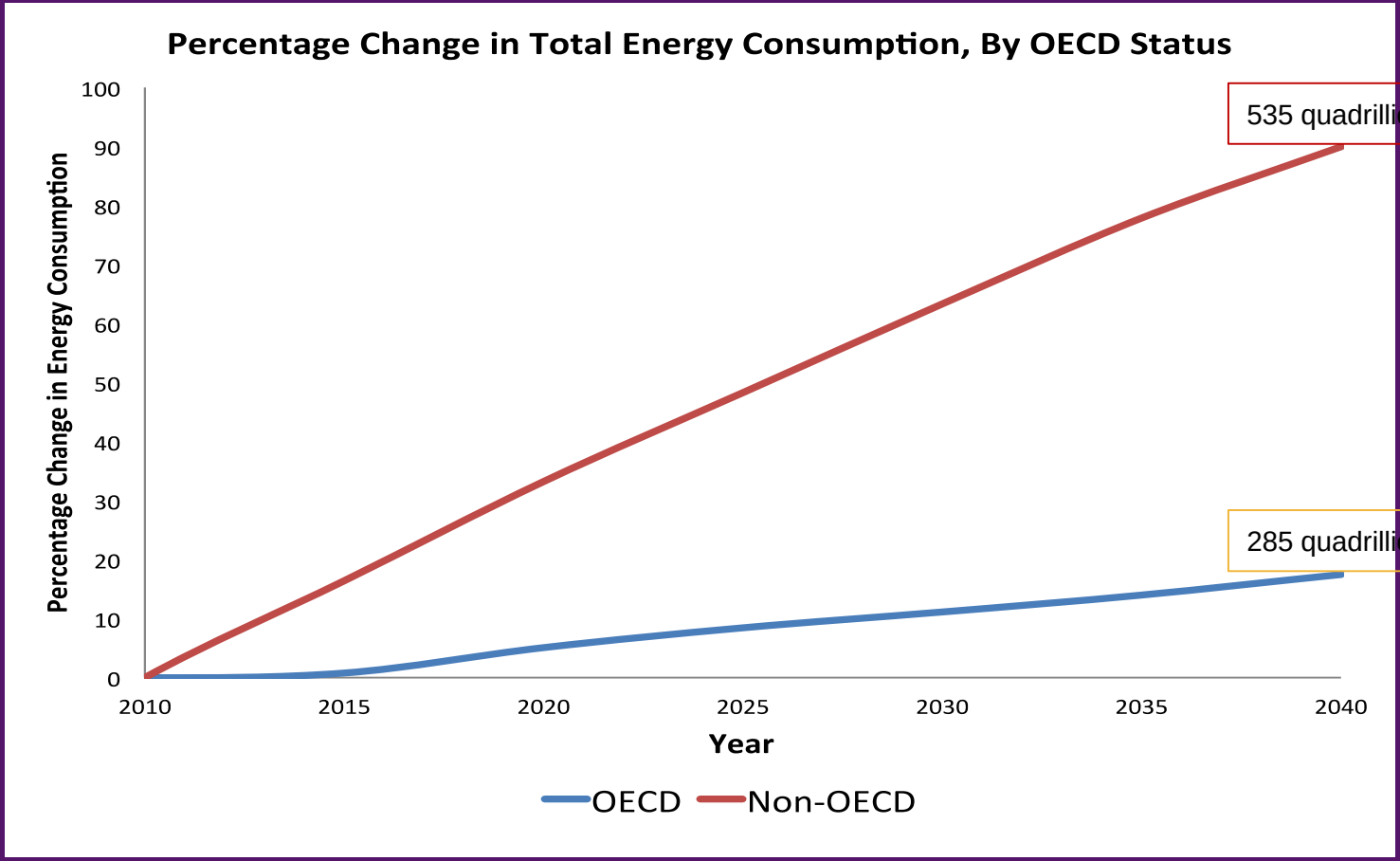
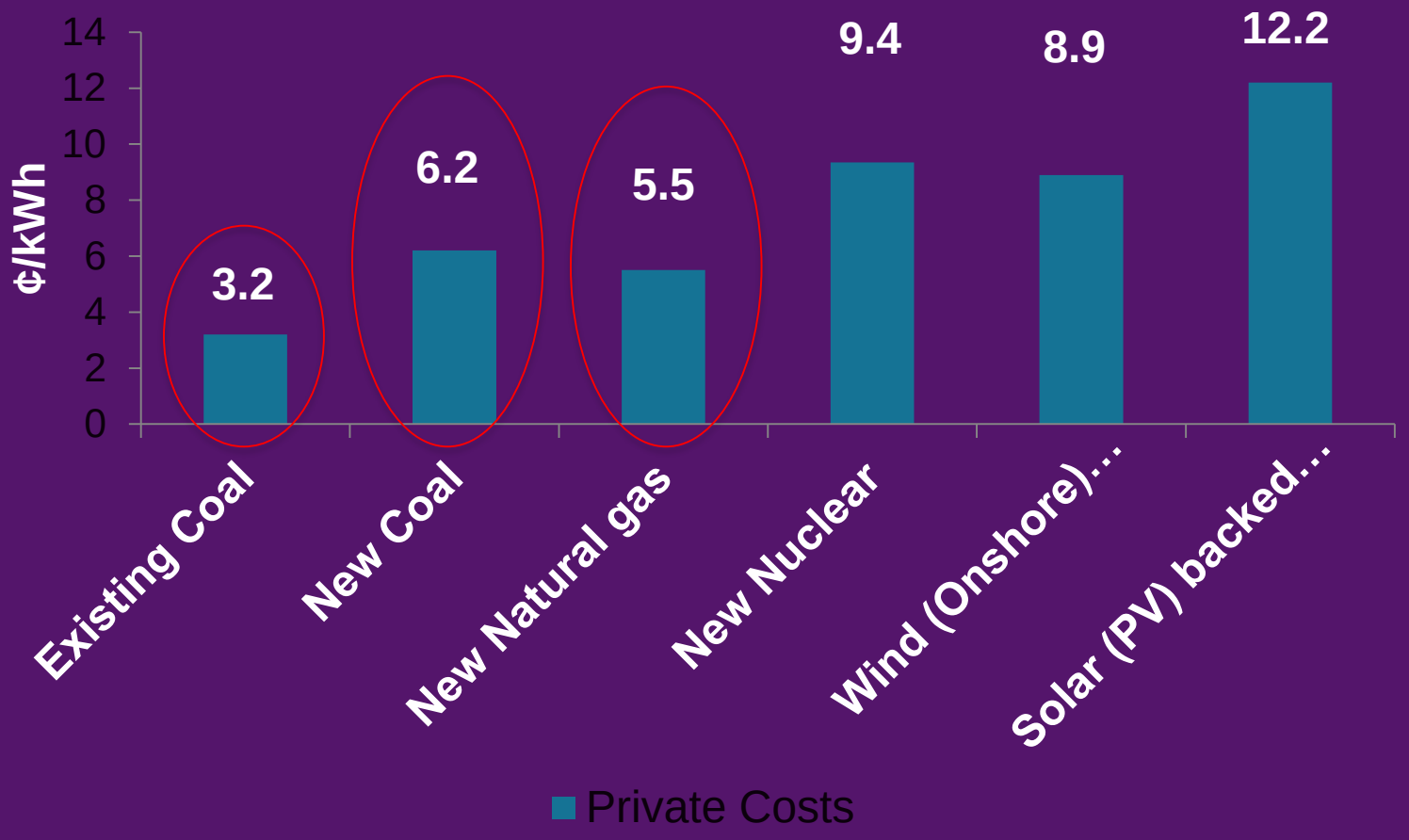
# Energy Consumption Growth Will be in Non-OECD Countries



# Production Costs of Fossil Fuel-Based Electricity are Low (USA)



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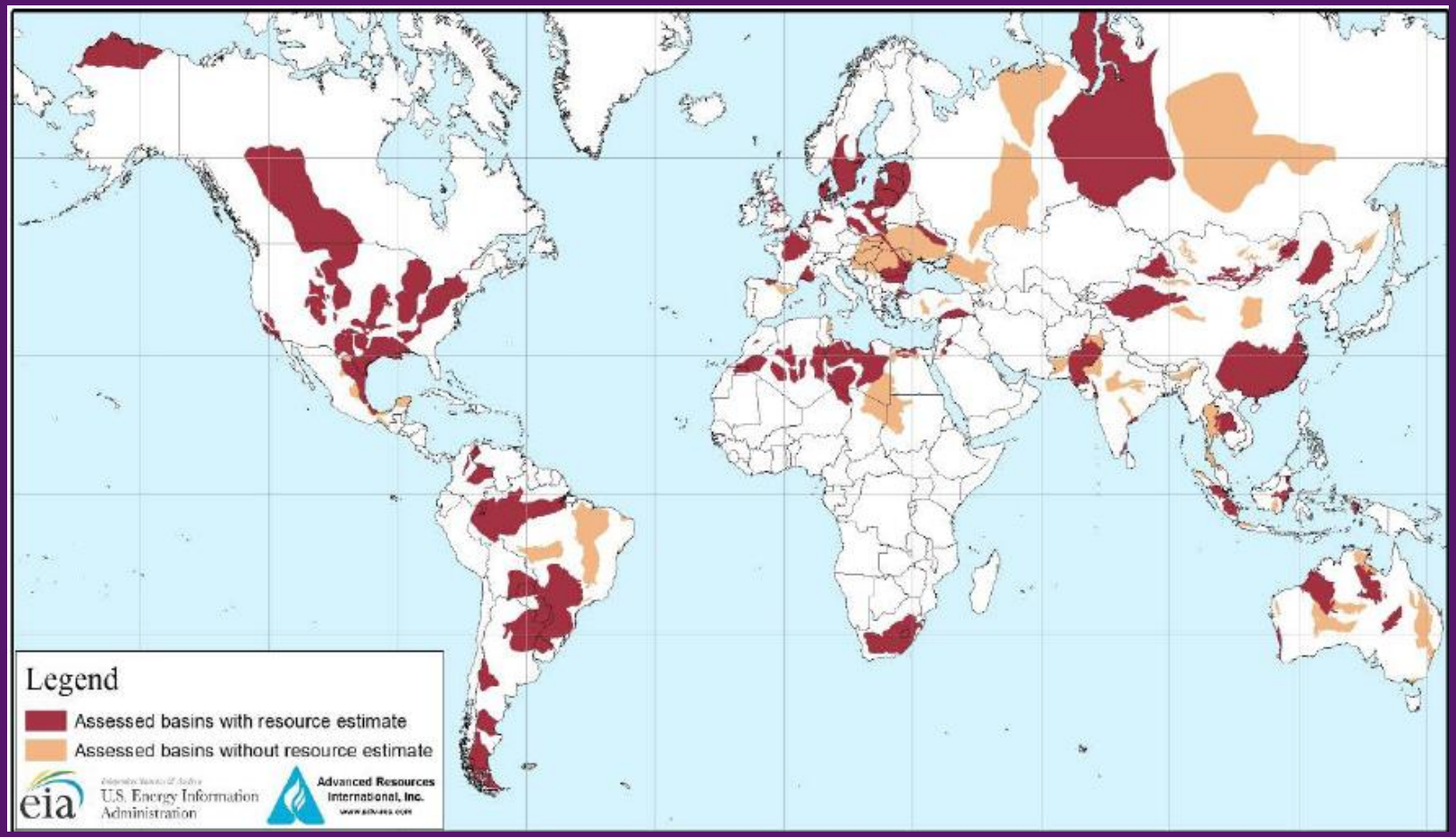
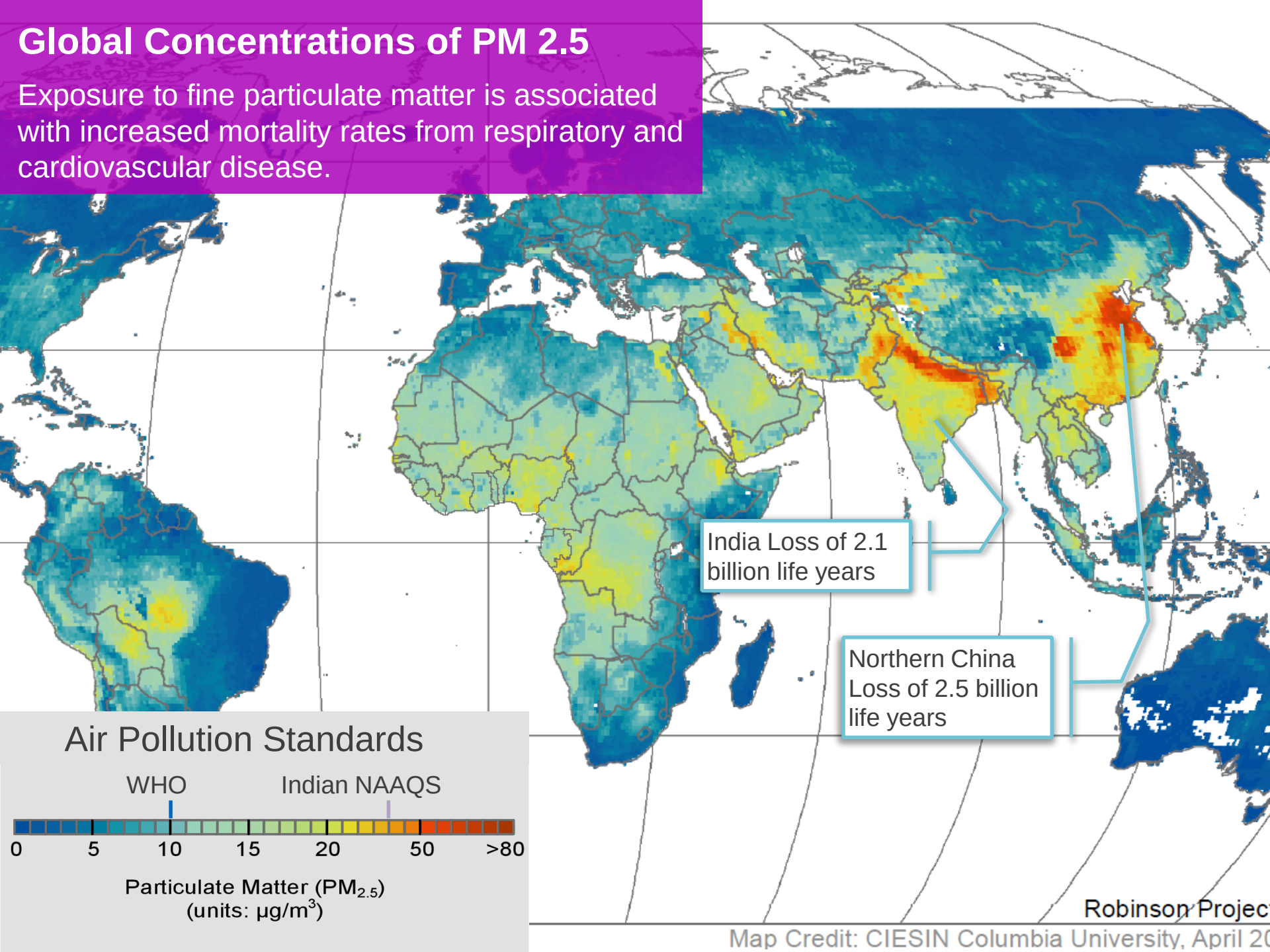
# Tremendous Innovation in Fossil Fuels in the Last 5-10 Years



# Global Concentrations of PM 2.5

Exposure to fine particulate matter is associated with increased mortality rates from respiratory and cardiovascular disease.



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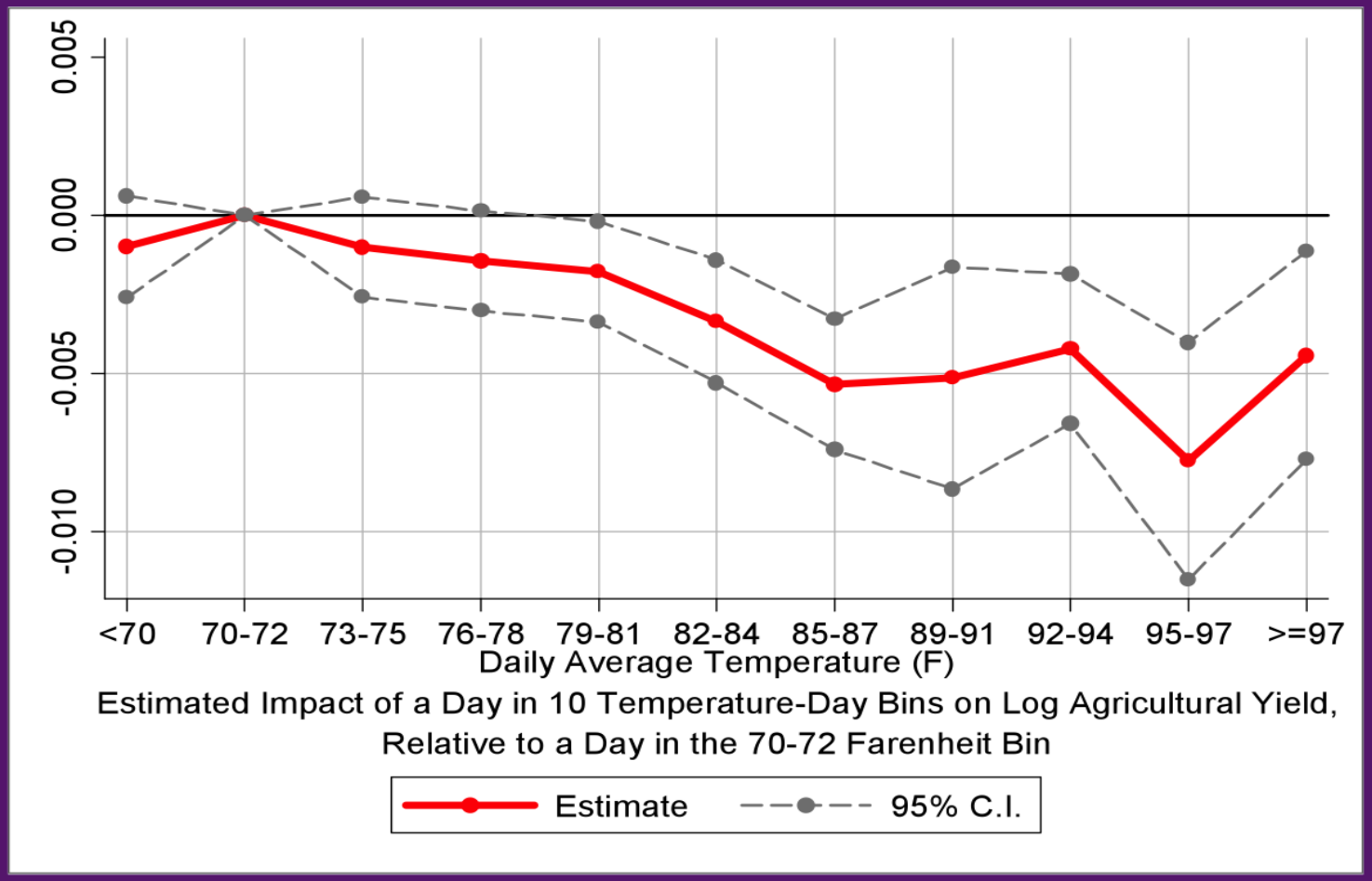
# Effect of Temperature Rise on Agricultural Yields in India



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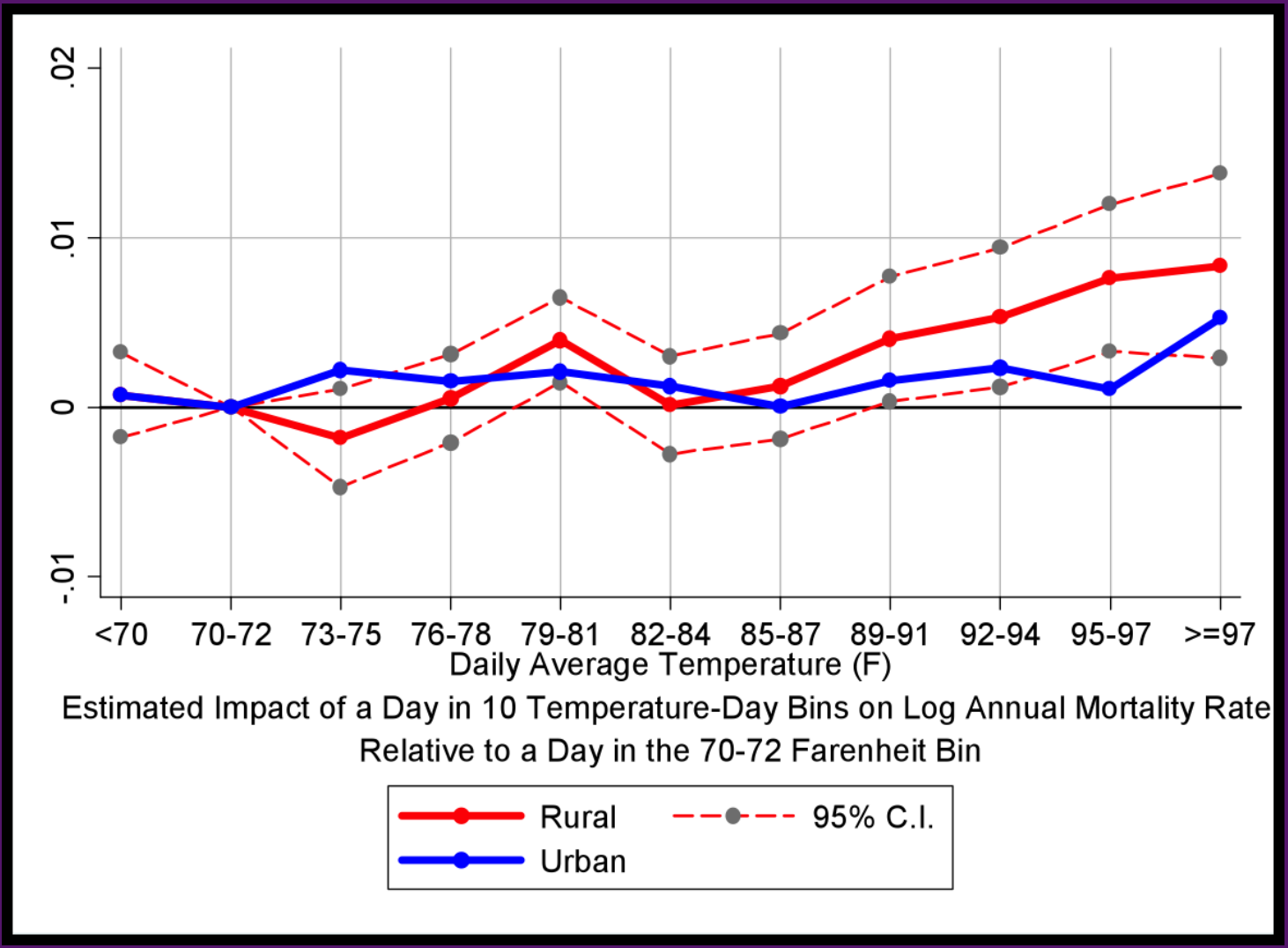
# Mortality Impact of Daily Temperature in Rural and Urban India



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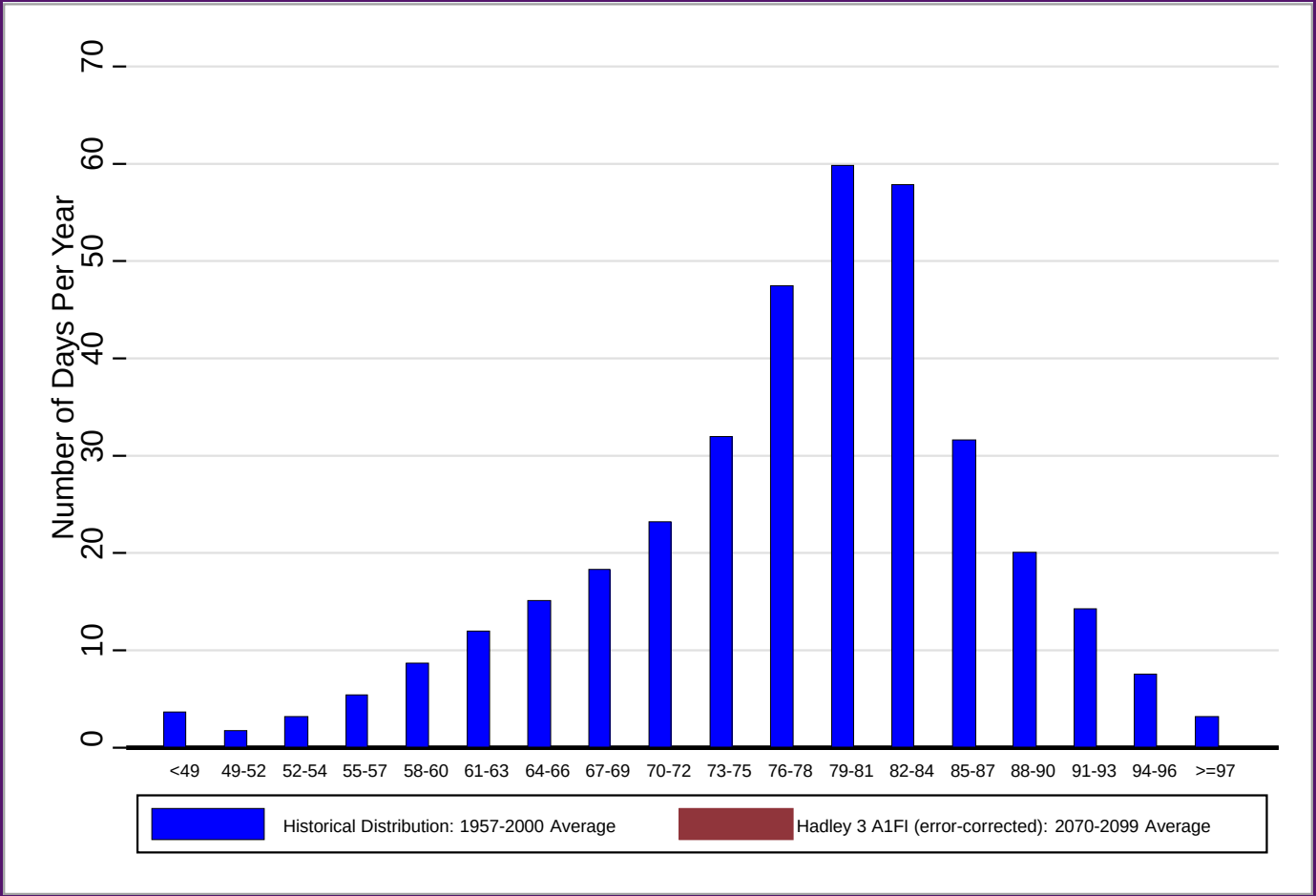
# Historical and Predicted Distribution of Daily Average Temperatures in India



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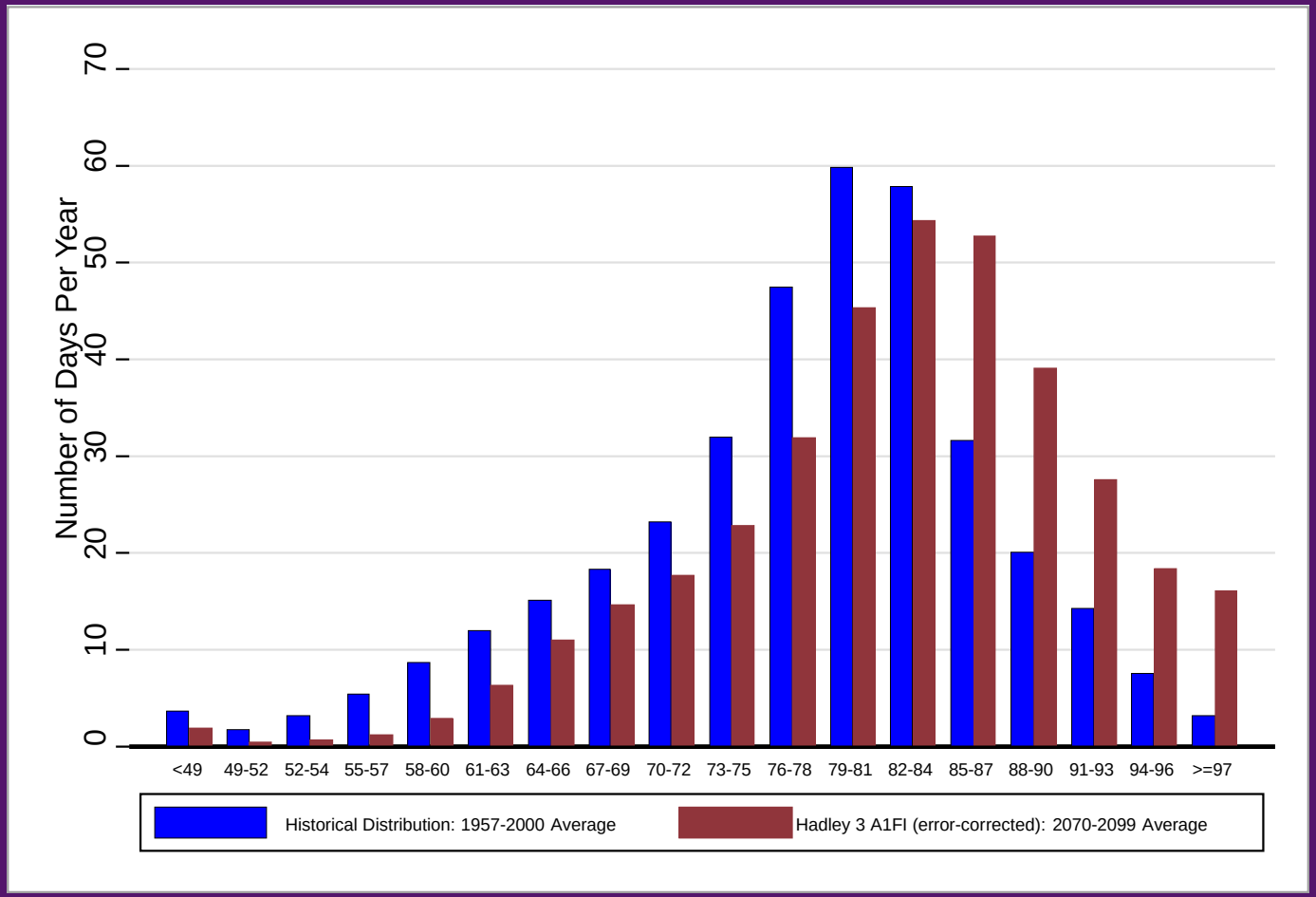

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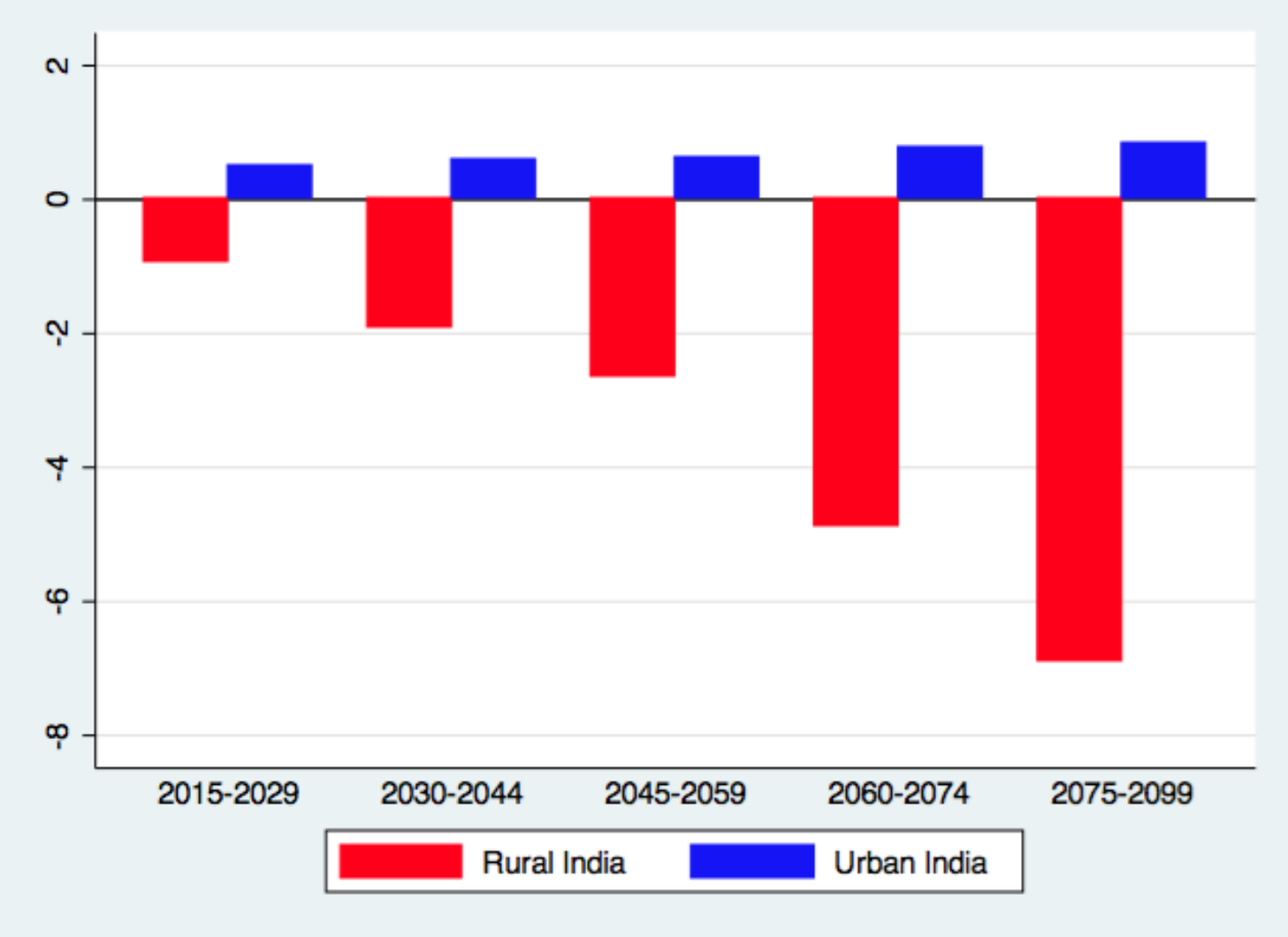
# Predicted Impact of Climate Change on Indian Life Expectancy at Birth, Based on Error-Corrected Hadley 3 A1FI Model: 2015-2099



# Energy is Mispriced

1) Low Repayment Rates Limit Supply

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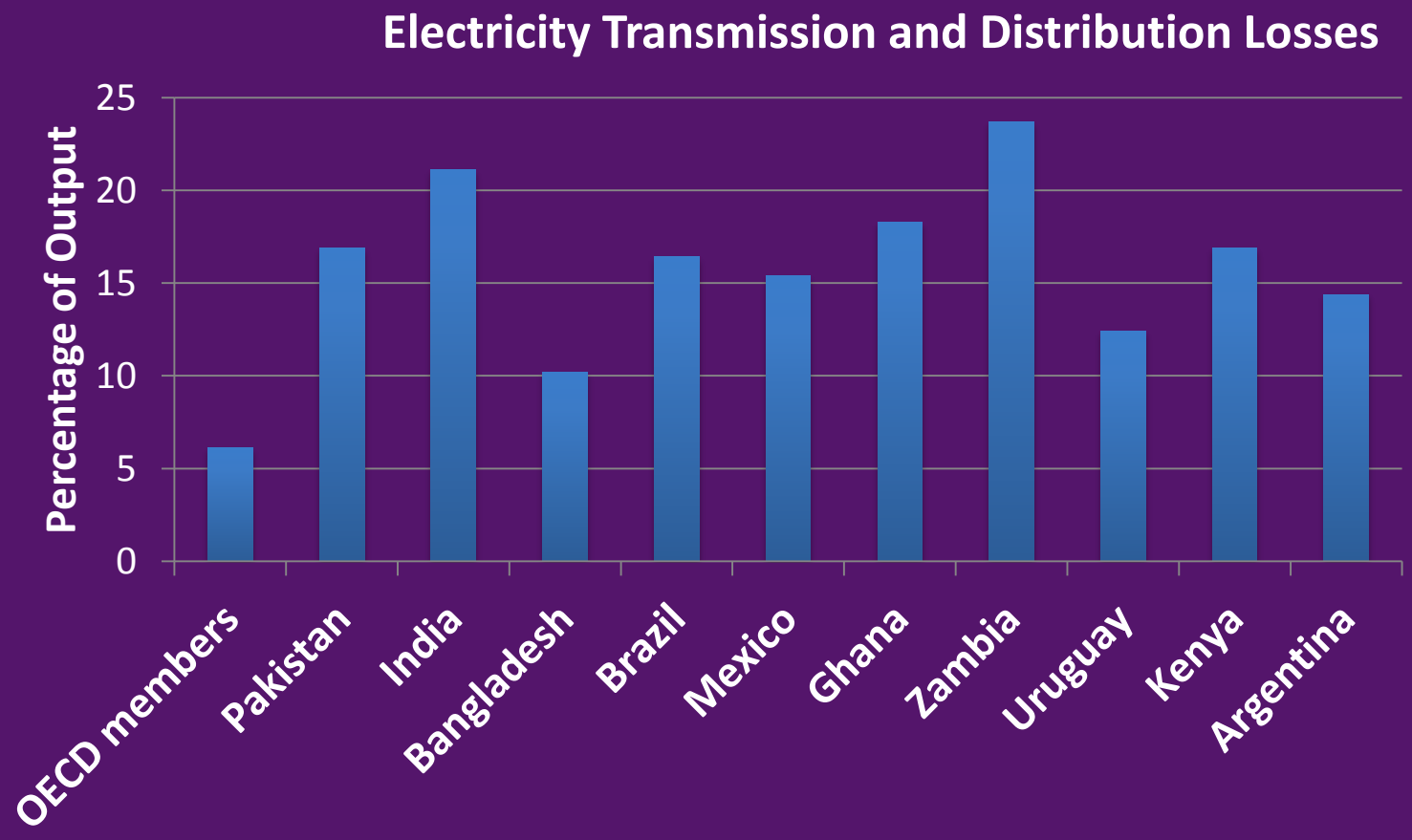
# Repayment Rates are Low in Developing Countries, Leading to "Circular Debt"



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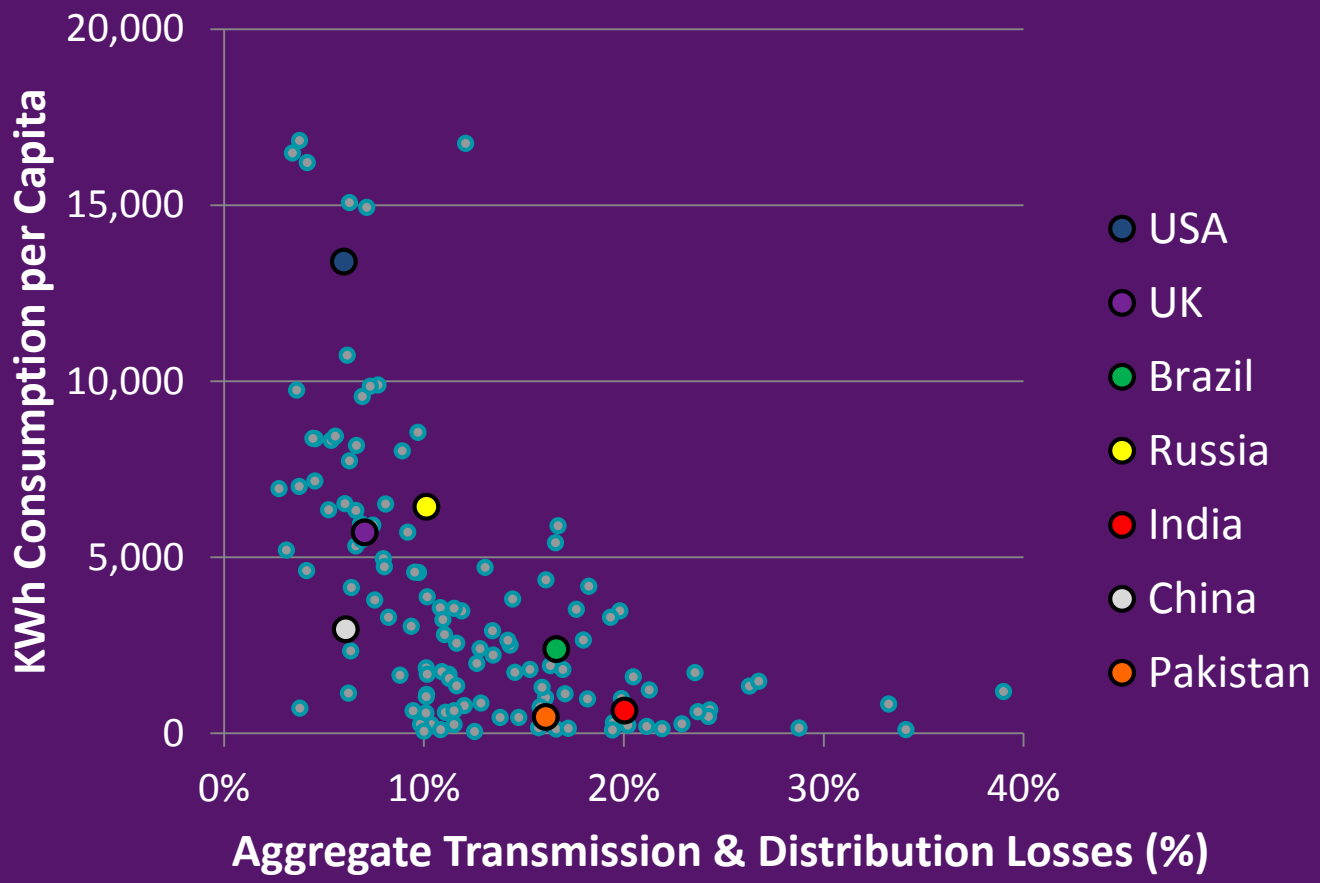
# Electricity Consumption and Distribution Losses are Linked



# Energy is Mispriced

1) Low Repayment Rates Limit Supply

2) **Energy Subsidies are Huge and Fail to Target the Poor**

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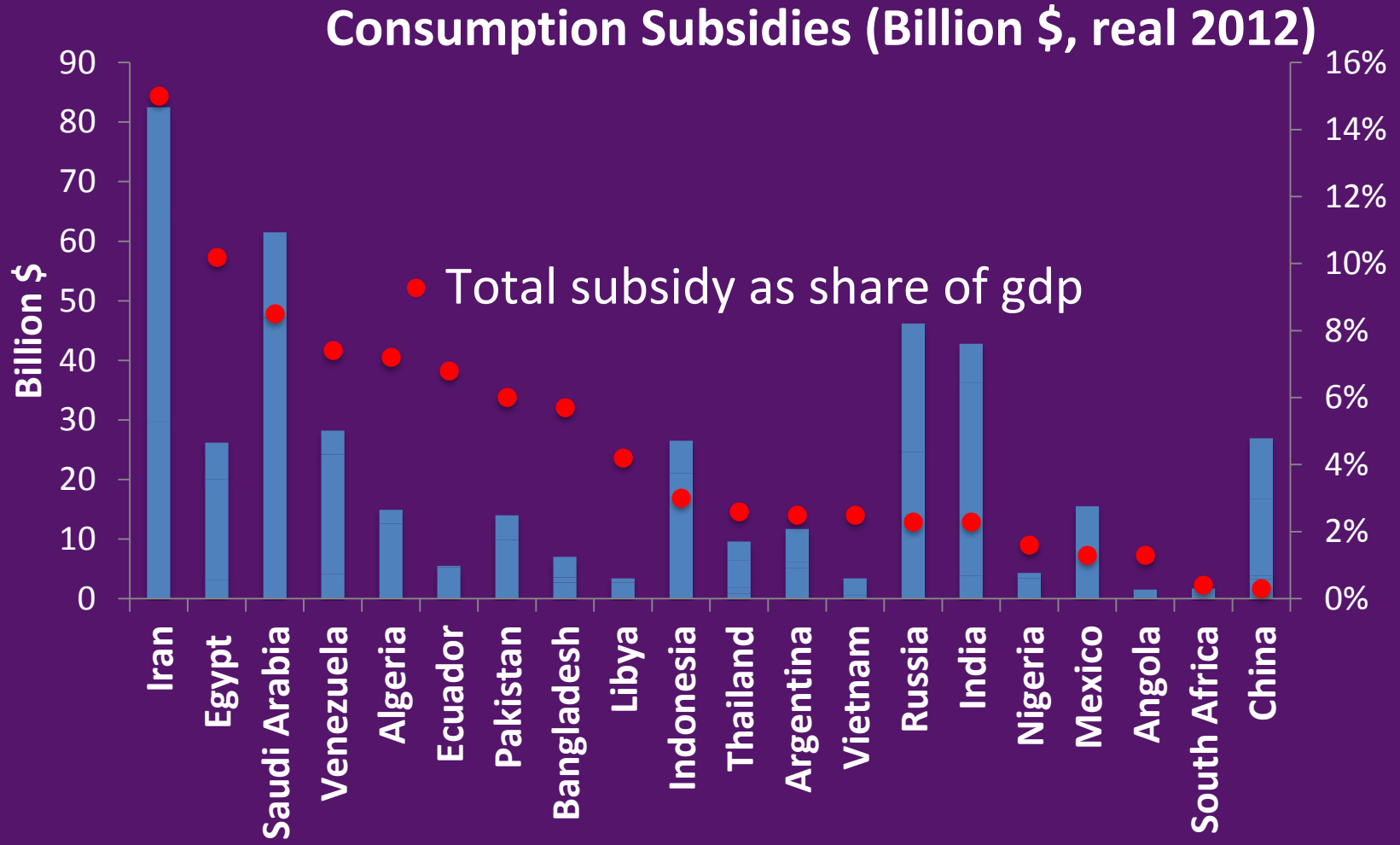
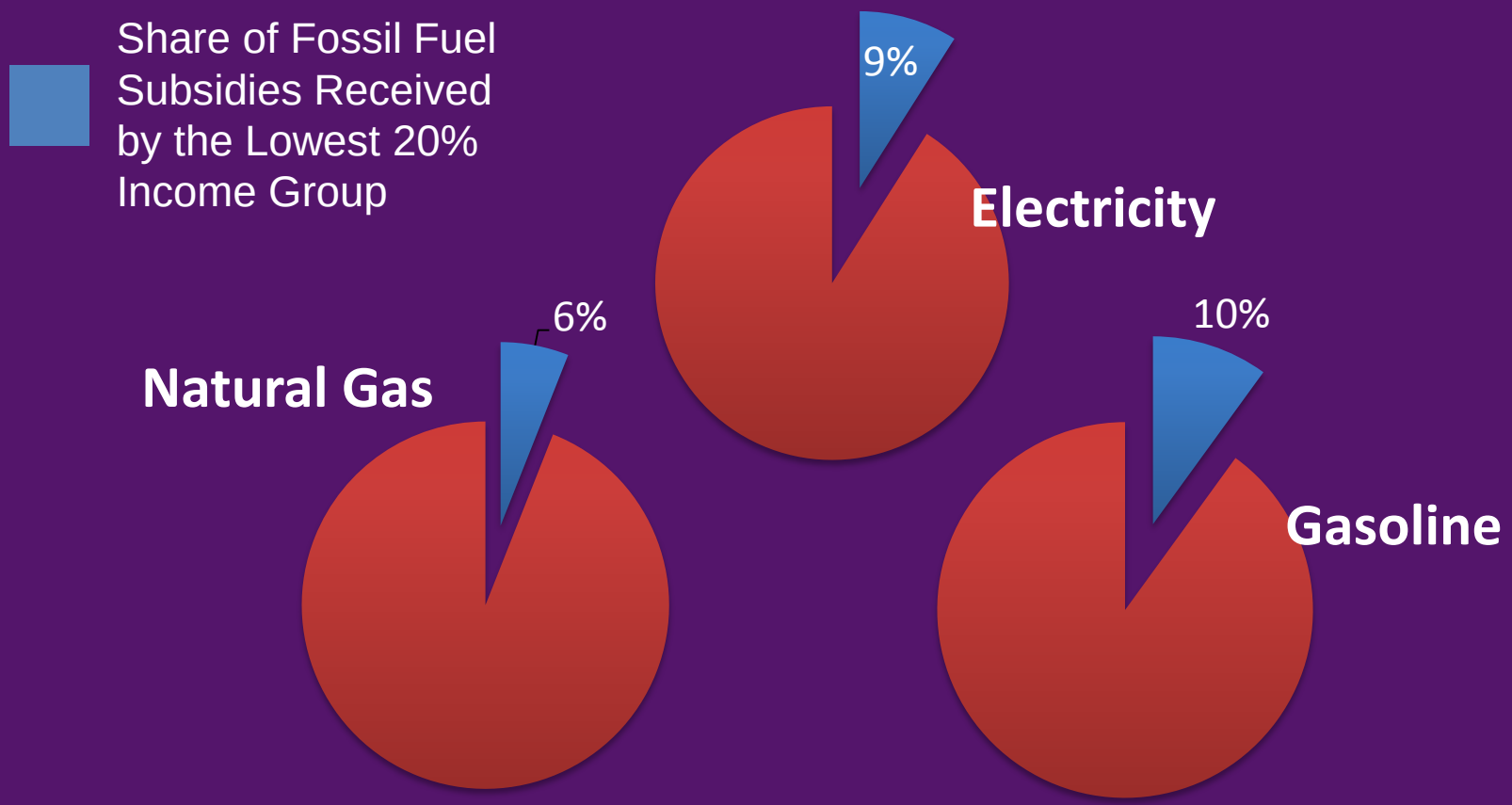
# End User Energy Consumption Remains Heavily Subsidised



# Energy Subsidies Benefit the Wealthy, not the Poor



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# Energy is Mispriced

1) Low Repayment Rates Limit Supply

2) Energy Subsidies are Huge and Fail to Target the Poor

**3) Mispricing Energy Favors Fossil Fuels**

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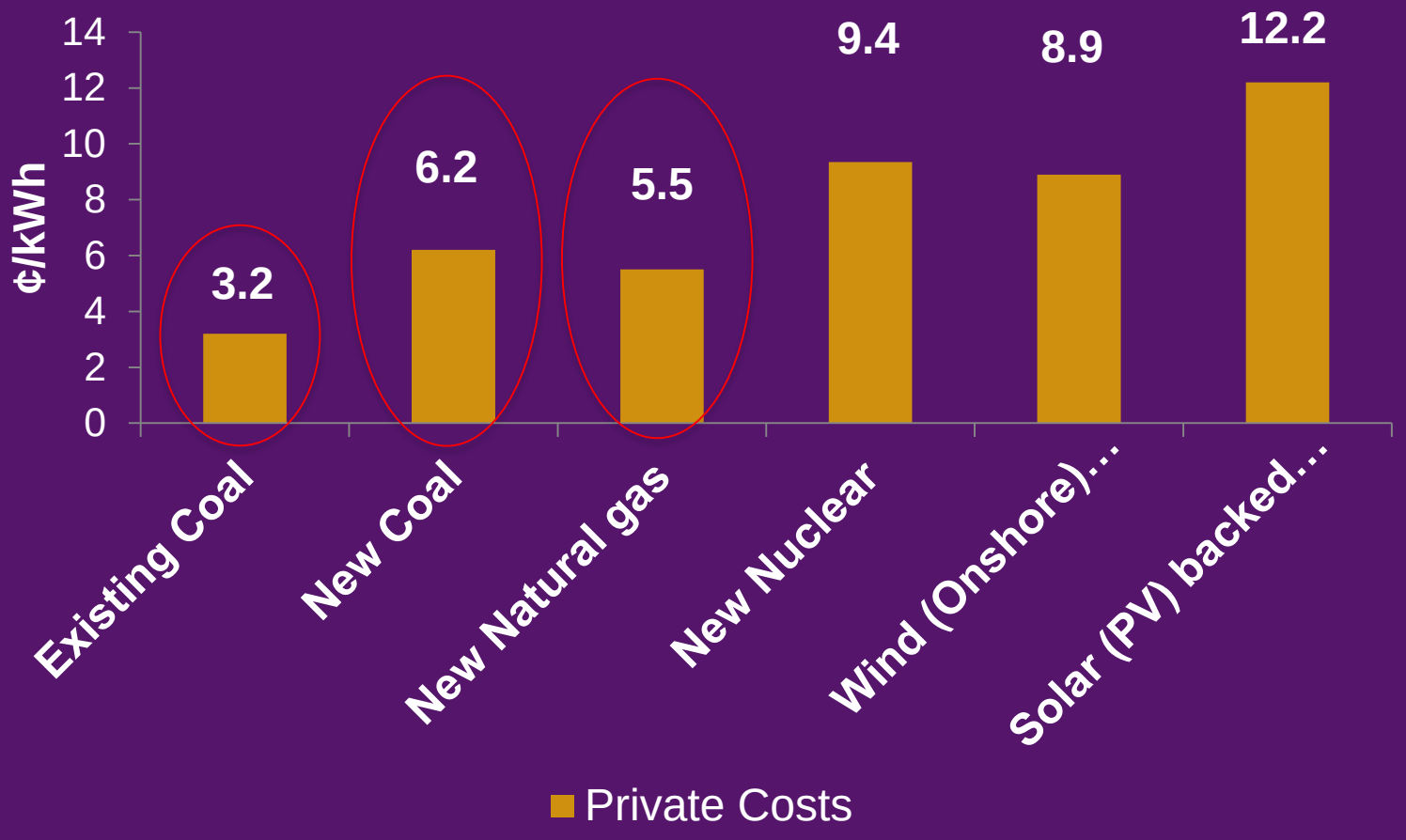
# Production Costs of Fossil Fuel-Based Electricity are Low (USA)



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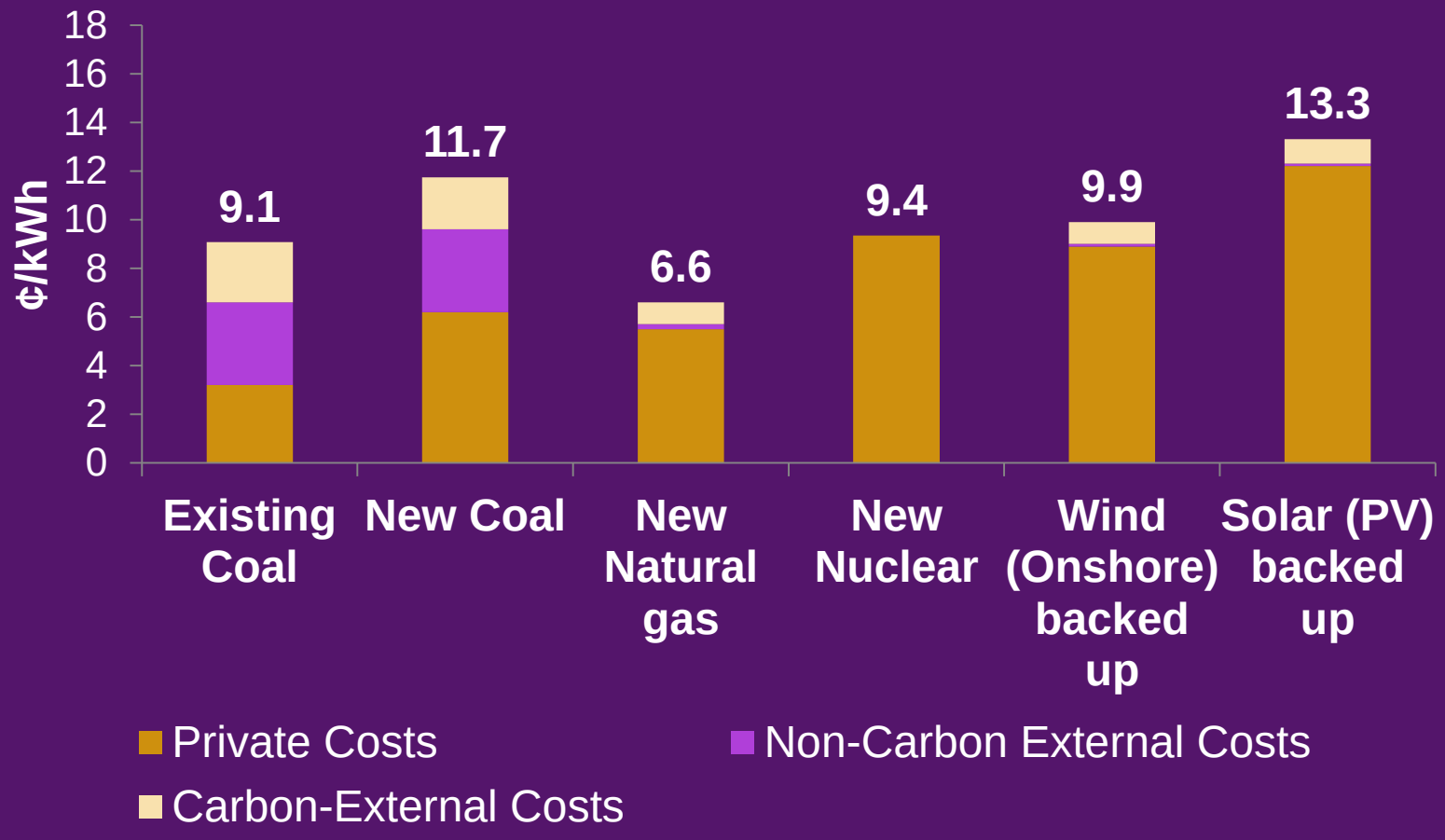
# Fossil Fuels Greatly Benefit from Failure to Price Pollution and Climate Damages



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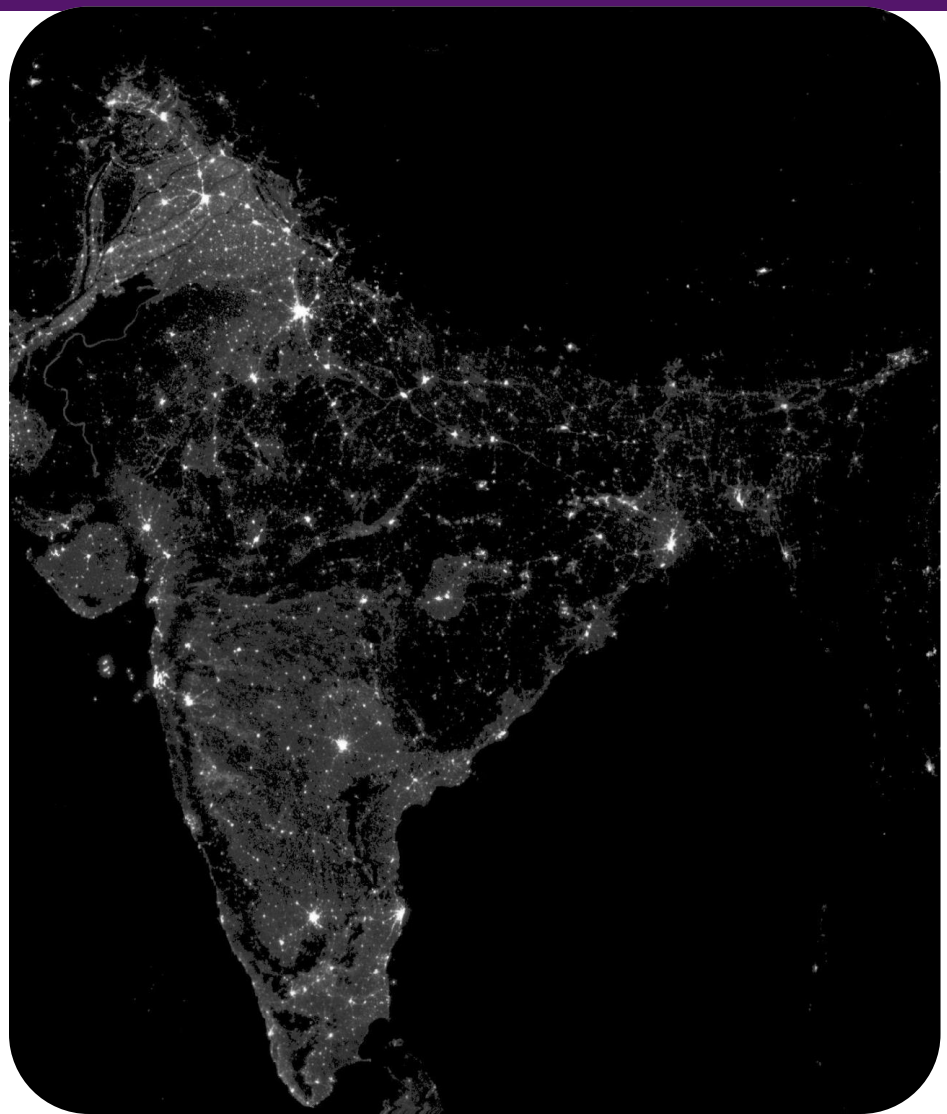
# Lighting up Bihar

# Extremely Uneven Consumption Across India



Average Per Capita Consumption:

**India – 626 kWh**

**USA – 13,325 kWh**

**Bihar – 122 kWh**

*Source: CIA World Factbook (200); Govt. of Bihar*

# Structure of the Bihar Electricity Sector

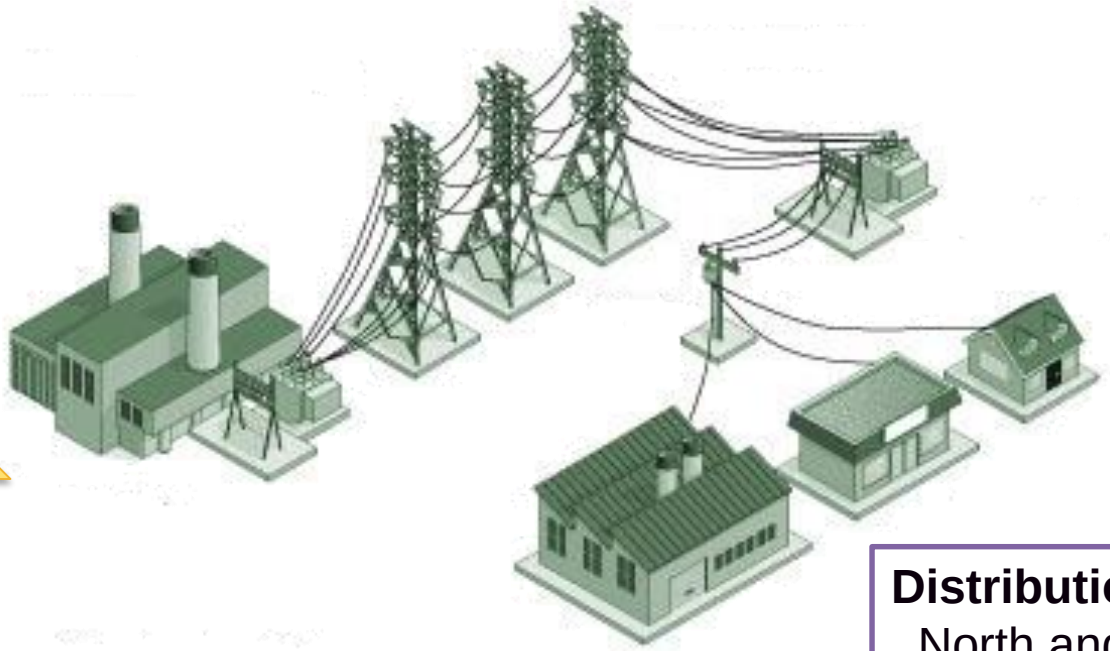
**Bihar State Power Holding Company Limited**

**Generation**
Bihar State Power Generation Company

Revenue

**Transmission**
Bihar State Power Transmission Company

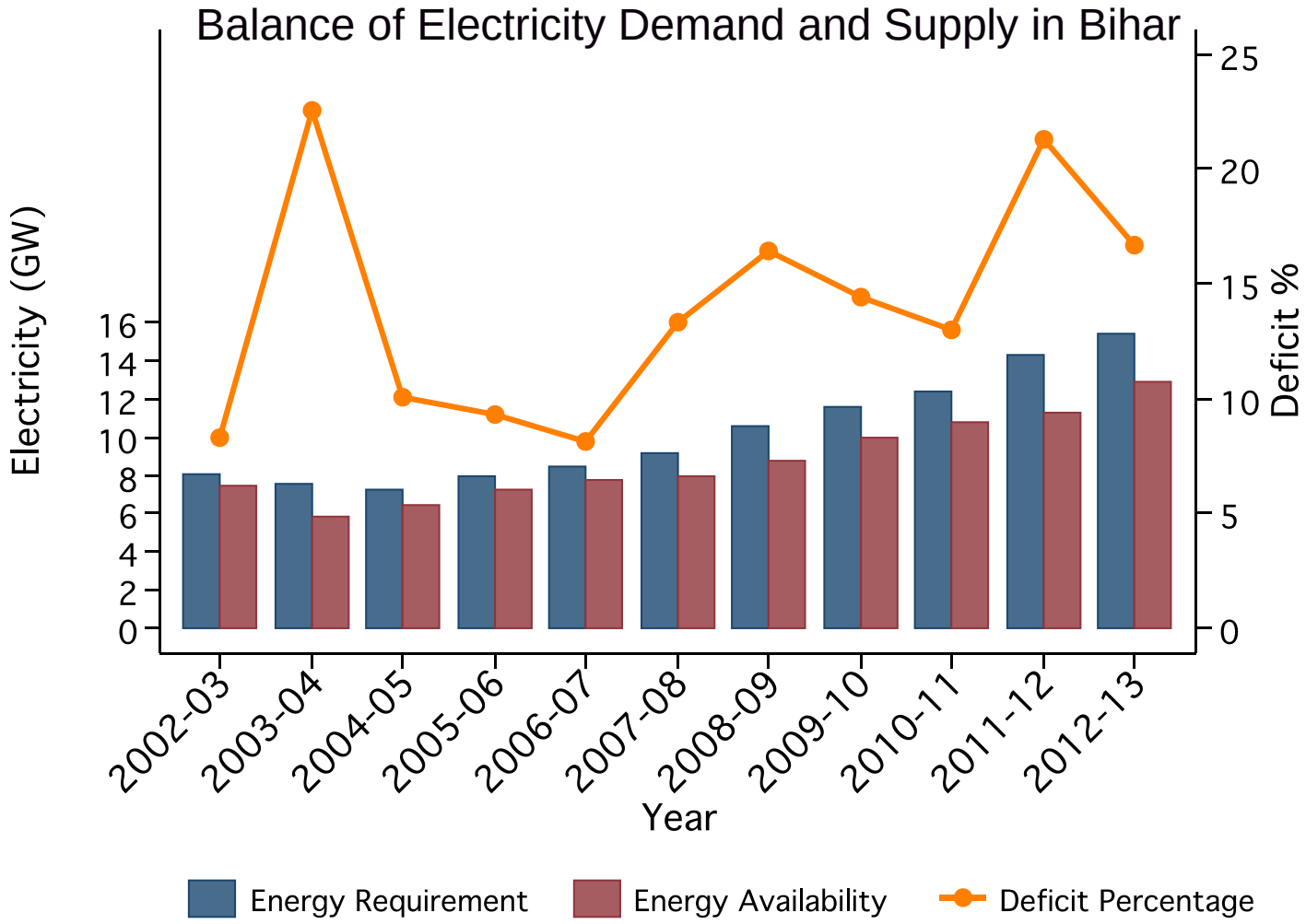
Revenue



**Distribution**
North and South Bihar Power Distribution Companies

Revenue

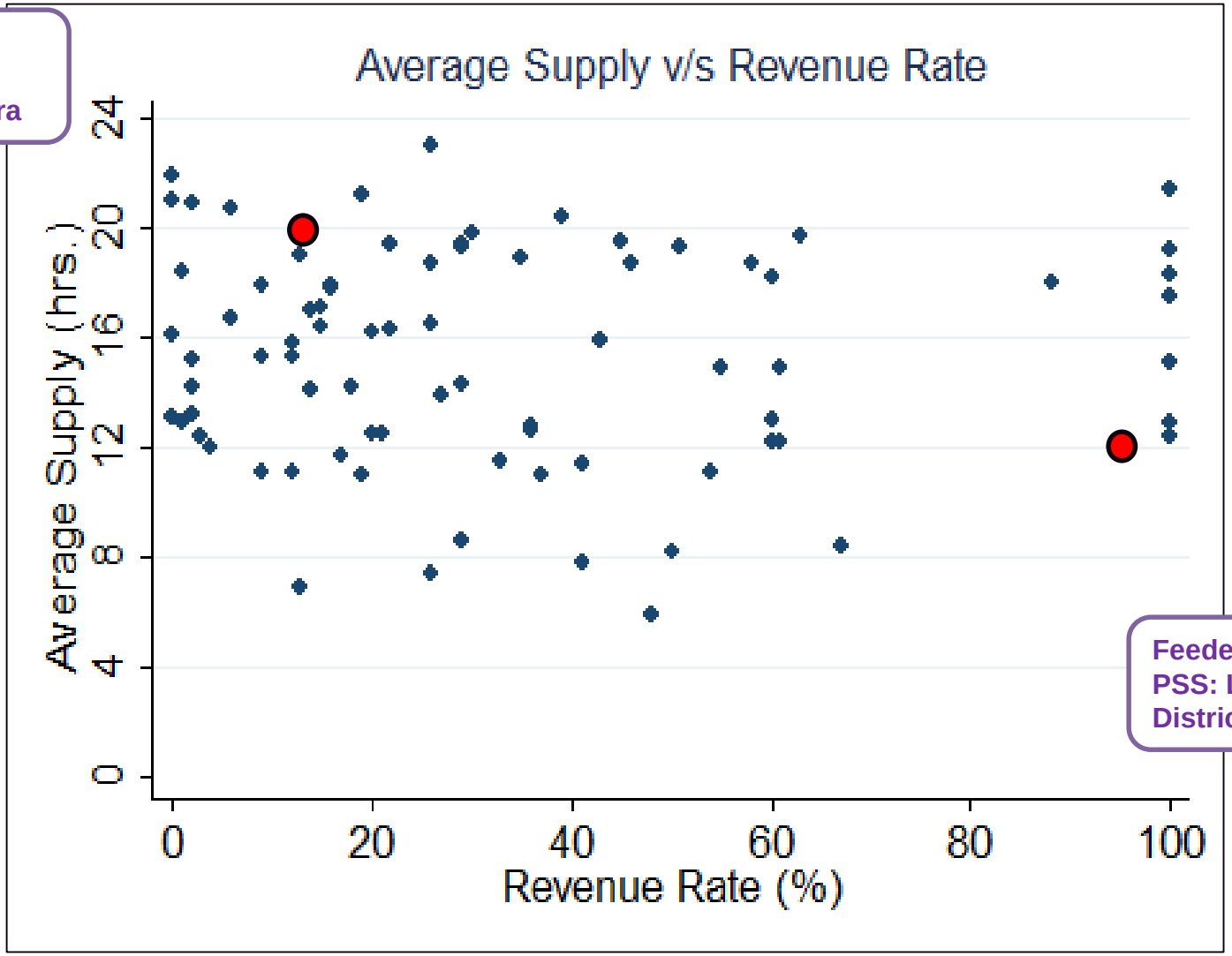
# Bihar Has a Substantial Energy Deficit




Source: CEA; Planning Commission

# Areas with high payment not rewarded with high supply

Feeder: Mela
PSS: Sonpur
District: Chapra




Feeder: Basahi
PSS: Lahlladpur
District: Chapra

# Bihar Transforming its Power Sector

**Bihar has undergone transformations in law-and-order, roads and access to education over the last decade**

**Power sector reform is now a focus, with recent increase in consumption**

**But expanding power supply is difficult**

- Losses and lack of revenue problems
- Electricity is a network good; many areas in a bad equilibrium of low payments and low or no supply

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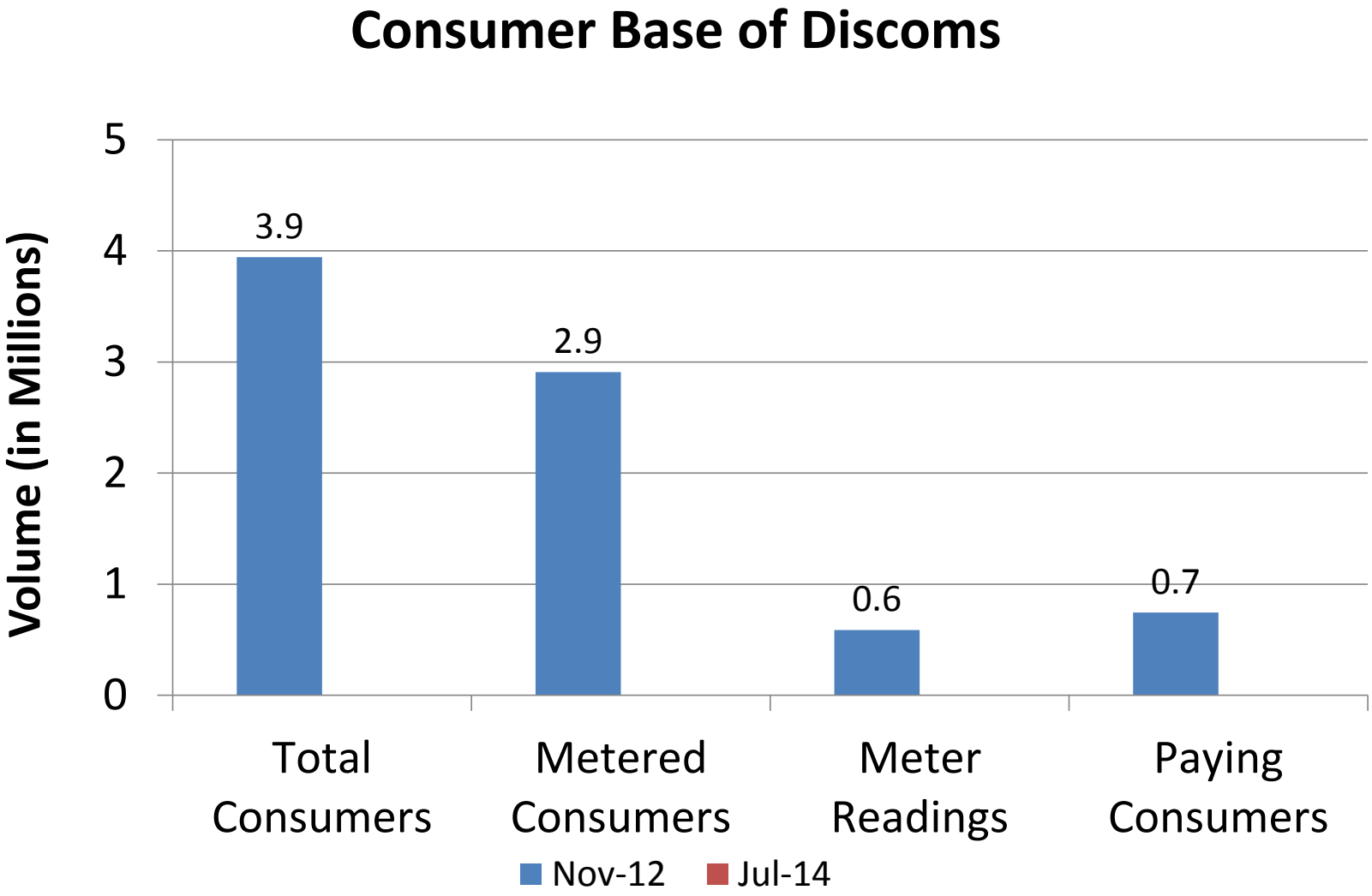
# Few Consumers are Paying Their Bills



# Potential Solution: You Get What You Pay for

## Bihar is attempting to address the problem of low payments

- In collaboration with Government of Bihar, the research team is randomizing repayment incentives across feeders
- Co-generation model: IGC working with Bihar energy department and distribution companies to increase payments
- **Key idea: communities incentivized to pay for electricity in return for more hours**

# Feeder Level Power Supply Scheduling

Feeders represent last high voltage node in distribution network and will soon be fully metered in Bihar (feeder = ~2000 households, 27 manufacturing and service sector firms)

**Research team focused on:**

- Linking feeder power supply to feeder level collection losses
- Group-level incentive to reduce theft and increase collections

# New scheme: You get what you pay for

## Rural Feeder Allocation

| Group | Revenue Rate (%) | Hours / Day |
|---|---|---|
| 1 | 0-10 | 10 |
| 2 | 10-20 | 12 |
| 3 | 20-30 | 14 |
| 4 | 30-40 | 16 |
| 5 | > 40 | 18 |

## Urban/Mixed Feeder Allocation

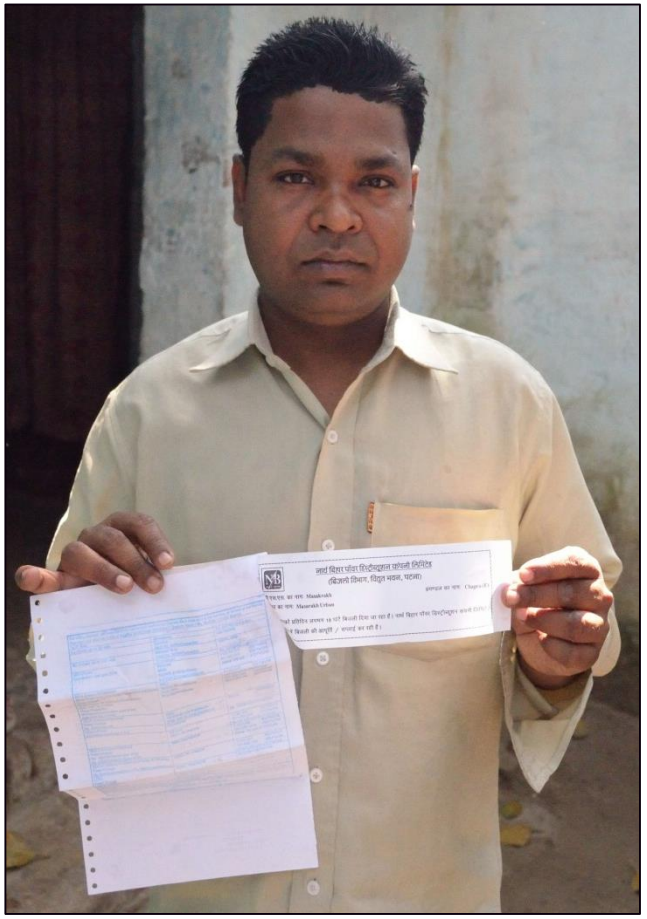
| Group | Revenue Rate (%) | Hours / Day |
|---|---|---|
| 1 | 0-15 | 12 |
| 2 | 15-30 | 15 |
| 3 | 30-45 | 18 |
| 4 | 45-60 | 21 |
| 5 | > 60 | 24 |

## Benefits of the scheme:

I. Reward better paying areas with more supply
II. Provide an incentive to increase payment rates
III. Reduce utility losses

# Bill Inserts were distributed to more than 1 lakh consumers

Inserts being attached to bills



Consumer receiving bill

# Mass-Marketing is Essential for Maximum Outreach

SMS Notification

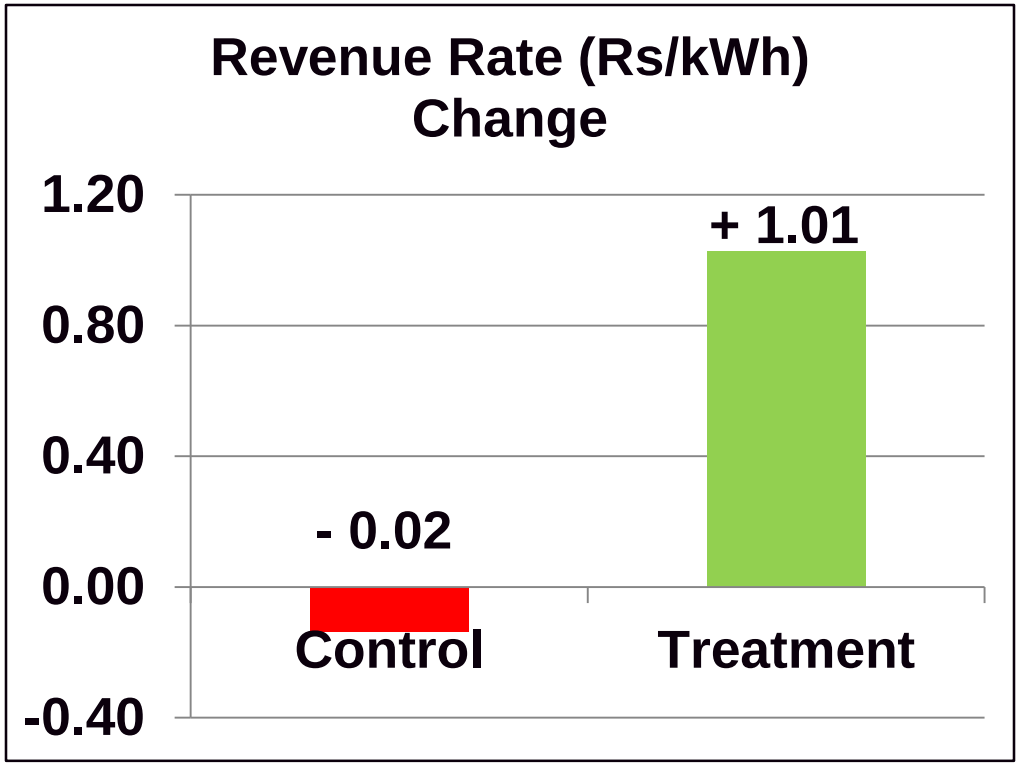
Public Announcement

- Mobile Number Database to send monthly SMS notifications
- Posters informing consumers about the scheme
- Feeder-wise route maps to make public announcements in villages

# The Scheme was Piloted in Chapra and Siwan

**39 Feeders randomly assigned into two groups:**

- **Treatment:** Supply based on revenue performance
- **Control:** Supply is uniform




**Revenue improves drastically in a short period**

Treatment feeders show increase of Rs. 1.01 on base of Rs. 0.95 within just two months

# Preliminary Conclusions

**Non-payment for electricity a global problem**

- Severely limits supply
- Low-cost and low-supply equilibrium in developing countries

- Bihar scheme is one way to break this deadlock
- May serve as model for supplying electricity in other developing countries

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# IGC Energy Research Agenda

# IGC's Energy Agenda

**Key focal areas: (directed by Michael Greenstone [Chicago] and Nicholas Ryan [Yale])**

**→ Trying to break out of low cost, low quality equilibrium**

1. Improving the Reliability of Grid Services
2. Rural Electrification
3. Energy Efficiency
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# Questions

***1) How to improve energy quality?***

- What is the demand for better electricity?
- How much will people pay for better quality electricity?
- What is the role for data and new technologies (pre-paid cards, privatization, etc.)?
- How to prevent electricity theft?

# Questions

***2) How to expand energy access?***

- How best to roll out expansion of the grid?
- How to encourage electricity uptake once connected?
- What are the best solutions for difficult geographies (i.e. poorer areas, population density, higher costs)?
- What is the role for minigrids, solar panels, etc. and how can these support longer-term solutions?

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# Questions

***3) How to encourage investments in energy efficiency?***

- What are the barriers to investment and their relative importance e.g.
  - Slow technology diffusion
  - Imperfect information
  - Price uncertainty
  - Costs of purchase/adoption
  - Different potential vs. real world returns
- What are the private vs. social costs of these investments?

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# Questions

***4) How to minimize the external costs of energy consumption?***

- What are the effects of energy use on:
  - Health
  - Welfare
  - Pollution
  - Climate Change
- Who is willing to pay to reduce these effects?

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- Energy is critical for growth & development
- Off-grid has potential but grids are critical to support firms' energy needs
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