

# Development of Sub-regional TIMES Energy system model for India

## TERI Pilot model

Aman Agrawal  
Research Associate  
TERI, India



# TIMES India sub-regional model

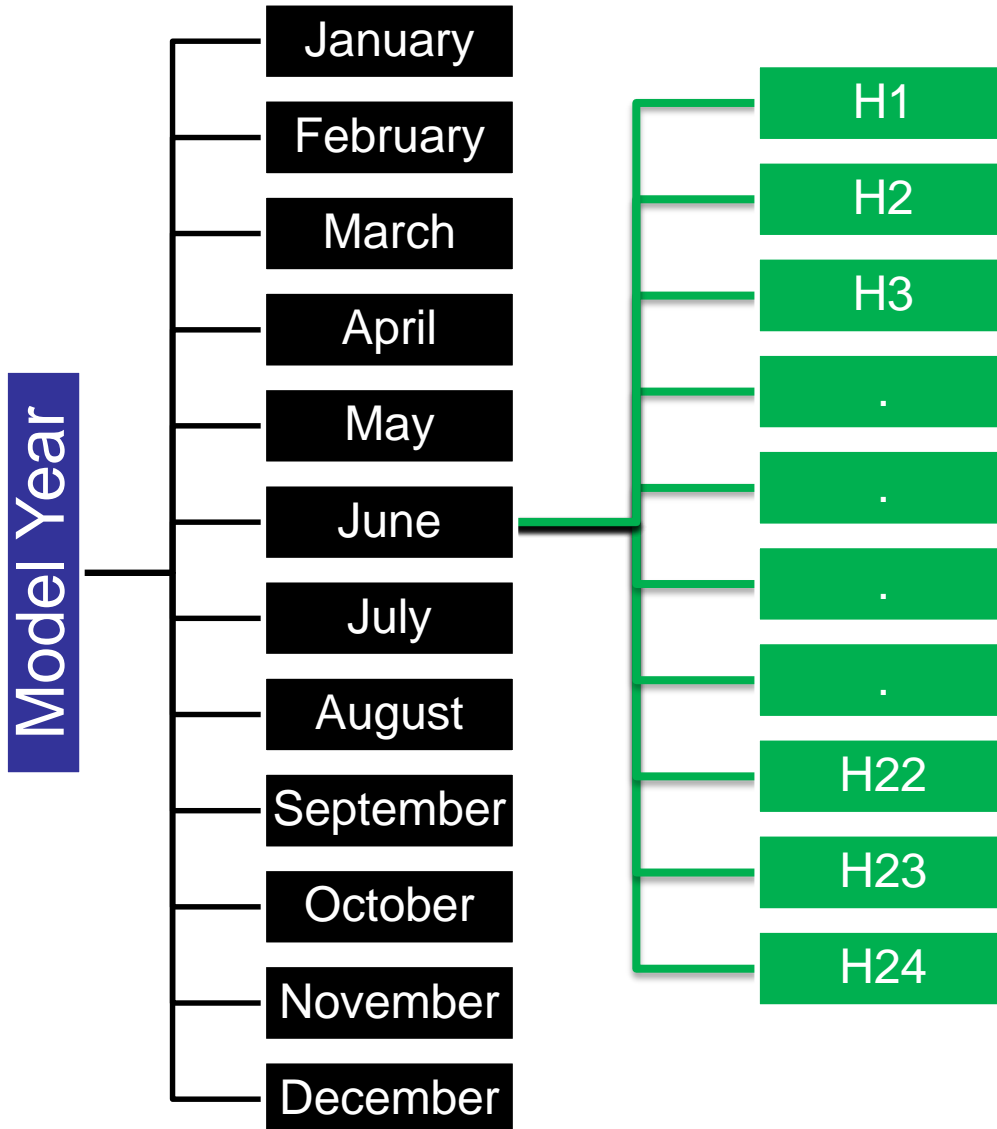
 Creating Innovative Solutions  
for a Sustainable Future

- Highlights of TIMES India sub-regional model
  - India in 5 sub-region
  - Detailed 288 time-slices
  - Base-year: 2011
  - Power sector focused model
  - Model Horizon is till 2050
  - Demand is sub classified in 5 sectors:  
Agriculture; Commercial; Industrial;  
Residential; Transport

# TimeSlices



Creating Innovative Solutions  
for a Sustainable Future



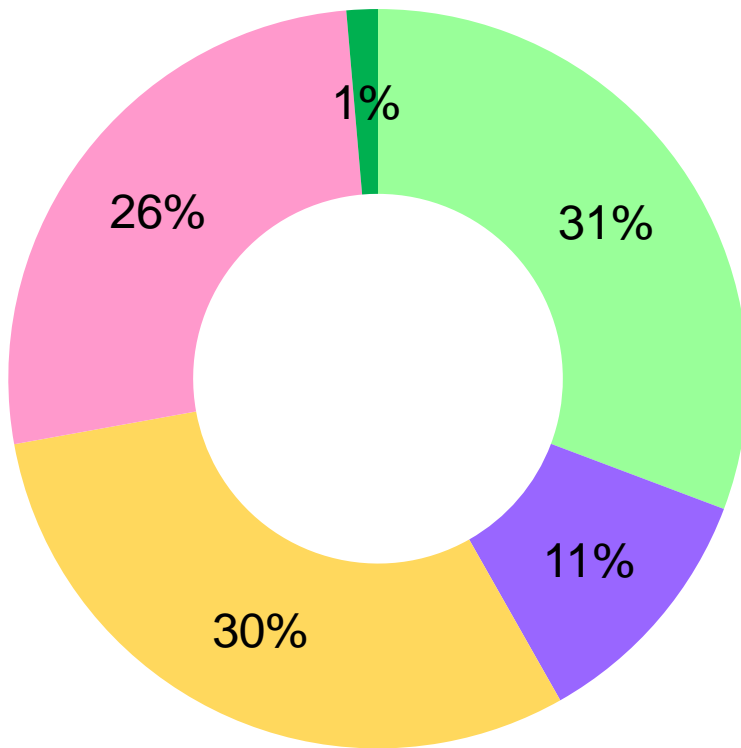
- Every Hour of the month is considered
- Existing demand pattern of electricity consumption will be provided to each timeslice
- Behaviour for future electricity demand will be analysed on all 288 timeslice

# Power Sector in India



Creating Innovative Solutions  
for a Sustainable Future

India's Electricity Demand Share (2015-16)



- North Region
- West Region
- North-East Region
- East region
- South Region

Source: CEA, India



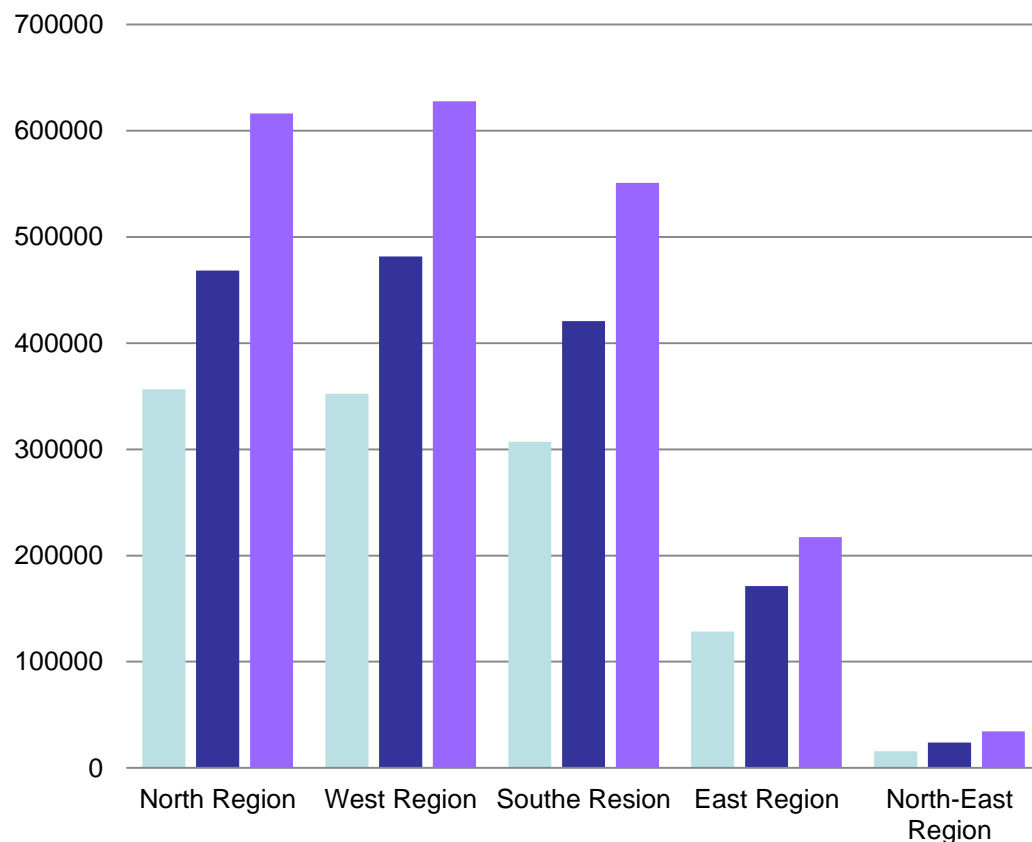
# Power Sector Growth



Creating Innovative Solutions  
for a Sustainable Future

- Rapid change in power demand
- Different drivers in different regional power demand growth:
  - Services growth
  - Industrialization
  - Energy access
  - Population growth
  - Energy transition

## India Power demand growth (MU)



■ India Power demand growth (MU) 2016-17  
■ India Power demand growth (MU) 2021-22  
■ India Power demand growth (MU) 2016-27

Source: CEA, India

# Energy carriers in TIMES-India

 Creating Innovative Solutions  
for a Sustainable Future

- Primary energy supply carriers for India are:
  - Coal (Maximum Share)
  - Oil (largely from Import >80%)
  - Gas (Economically not viable)
  - Renewable (Increasing)
  - Nuclear (Small share)
  - Biomass (highly Unregulated)
- Secondary:
  - Electricity
  - Petroleum products
  - Biofuels

# Energy Supply Analysis



Creating Innovative Solutions  
for a Sustainable Future

- All the primary energy commodities are analyzed at annual level, whereas electricity is analyzed at DAYNITE level (288).
- To capture the variable generation and power system flexibility, a total of 288 Timeslices are framed in a manner to capture hourly variation.



# Power sector analysis



Creating Innovative Solutions  
for a Sustainable Future

- To provide a detailed techno-economic characterization into the model, various aspects of the power system technicalities will be provided into the model
  - **Power system flexibility**
  - **Increasing penetration of renewable**
  - **Peaking power plants**
  - **Spinning reserves**
  - **Increasing efficiencies (power generation as well as end use demand technologies)**
  - **Changing load patterns**



# Current Electricity Generation sector



Creating Innovative Solutions  
for a Sustainable Future

- Based on various types of primary energy reserves availability, the power generation portfolio of India is very diverse.
- Within each type of fuel source various technologies are actively operating with their specific characteristics for providing electricity.
- Power generation categorization are primarily done on the basis of fuel type and technology

# Future Power system



Creating Innovative Solutions  
for a Sustainable Future

- Increasing power generation capacities and high penetration of Variable energy generating sources, flexibility of the system need to be evaluated.
- Impact of High renewable energy capacities on base-load power plants and their performance in conjunction requires attention.
- Economics and necessity of Electricity storage at grid level.
- Requirement and Evaluation of suitable flexible options to handle the variable power generation and it's competitiveness with energy storage

# Demand Drivers



Creating Innovative Solutions  
for a Sustainable Future

- Driver behind increasing energy demand of India:
  - High GDP
  - High population and Energy access
  - Penetration of new and advance technologies
  - Upgrading living standards
  - Urbanization

# Demand side



Creating Innovative Solutions  
for a Sustainable Future

- End-use energy demand is modeled to analyze the effect of new and efficient appliances.
- Considering several demand drivers, sector wise demand technologies and their utilization is captured in a detailed manner.
  - **Technologies using primary energy sources are analyzed annually**
  - **Technologies using Electricity are analyzed at hourly level**
- Behavioral analysis will be carried out to estimate the future electricity demand profile in various sectors

# Issues of Modeling interest



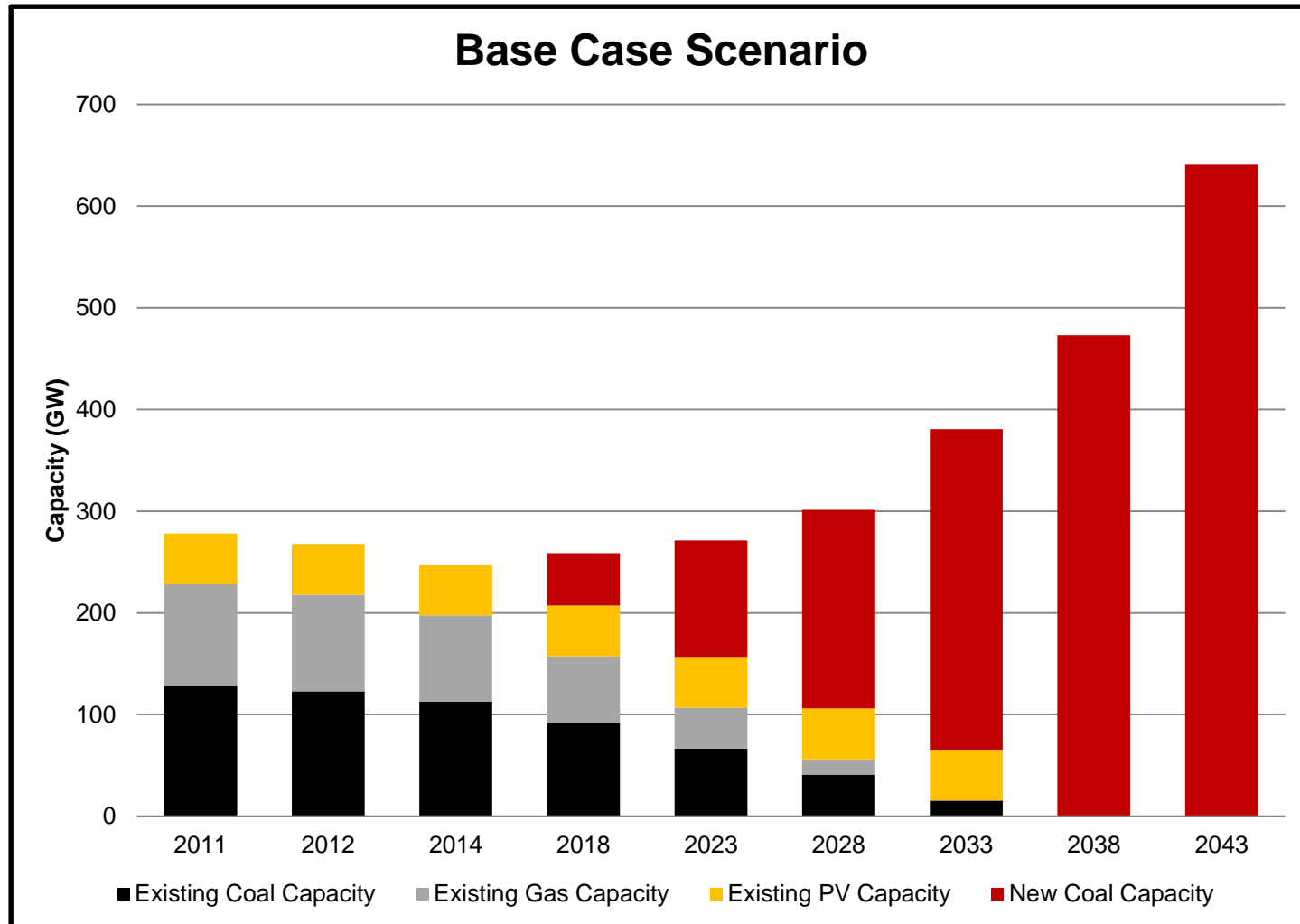
Creating Innovative Solutions  
for a Sustainable Future

- Modeling energy demand behavior in terms of Time of use & it's effect on load curve
- Modeling of energy conservation processes
  - **Upgrading building envelop**
  - **Introducing Car pooling**
  - **Upgrading to efficient appliances**
- Implication of changes in efficiency gains on power generation technologies & options across regions
- Identification of power sharing needs between regions based on future demands and supply of resources
- Implications of emerging demands such as electric cook-stoves, Energy access or charging of e-vehicles at certain times of the day on generation capacities & costs
- Short-term and long-term impact of energy transition and introduction of new energy carriers in Indian energy sector

# Representative Results



Creating Innovative Solutions  
for a Sustainable Future

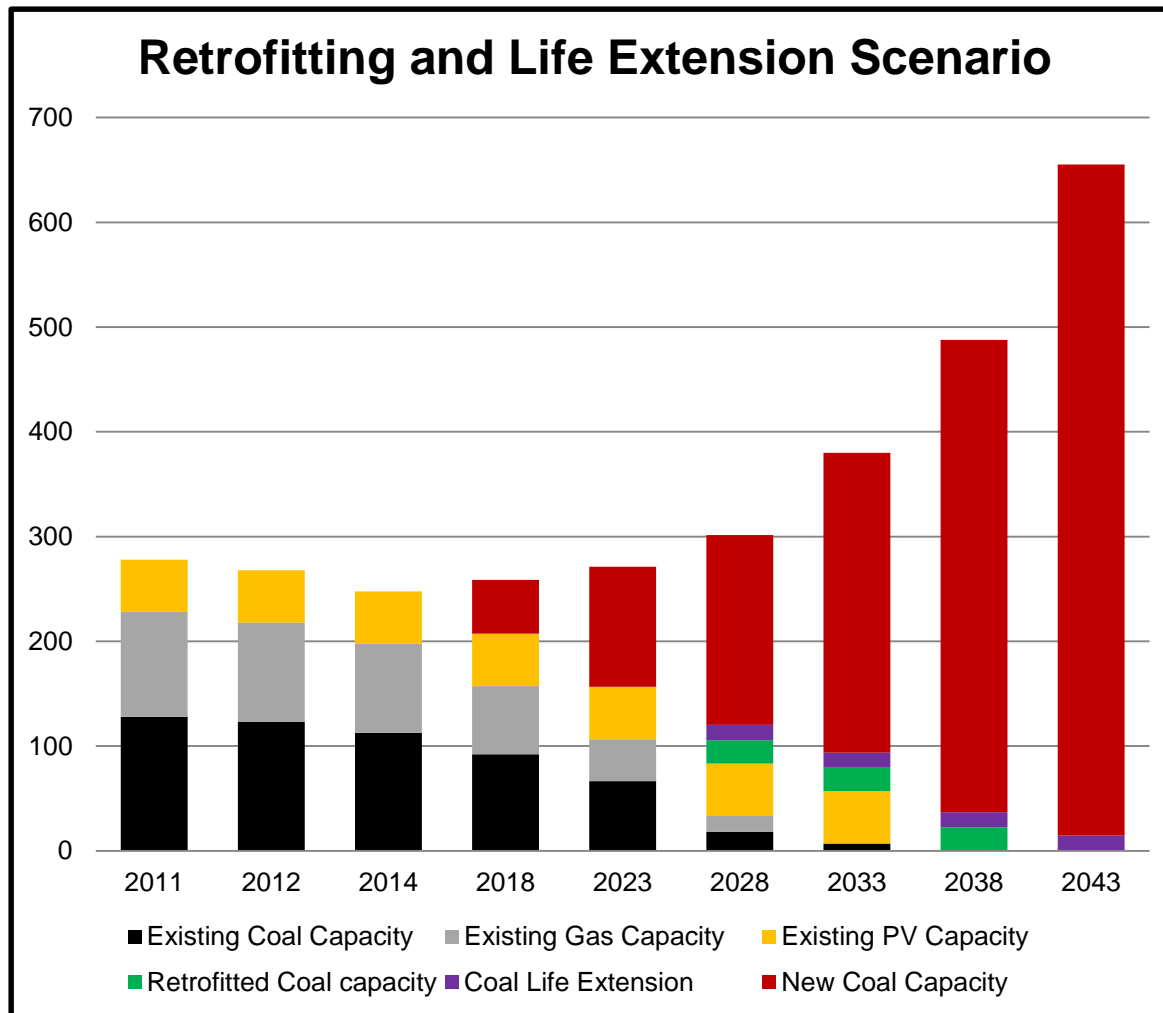


All the results and analysed  
based on Dummy numbers

# Representative Results



Creating Innovative Solutions  
for a Sustainable Future



- Retrofitting of coal based power plants with Biomass
- Life extension of existing thermal power plants
- Without any condition, Only thermal capacity is observed

All the results and analysed based on Dummy numbers



# **BETTER WAYS TO STRUCTURE THE MODEL !!**



Creating Innovative Solutions  
for a Sustainable Future

# THANK YOU FOR YOUR ATTENTION !

Aman Agrawal

Research Associate

The Energy and Resource Institute, New Delhi, India

E-Mail: [Aman.agarwal@teri.res.in](mailto:Aman.agarwal@teri.res.in)

Phone: +91-952-956-7455