

Model Based Analysis of the Indian Electricity system

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Motivation and Objective

Objectives:

- To check the sustainability of India's energy transition process
- To develop a 'first of a kind' model for the Indian electricity economy
- To emulate and evaluate several different scenarios

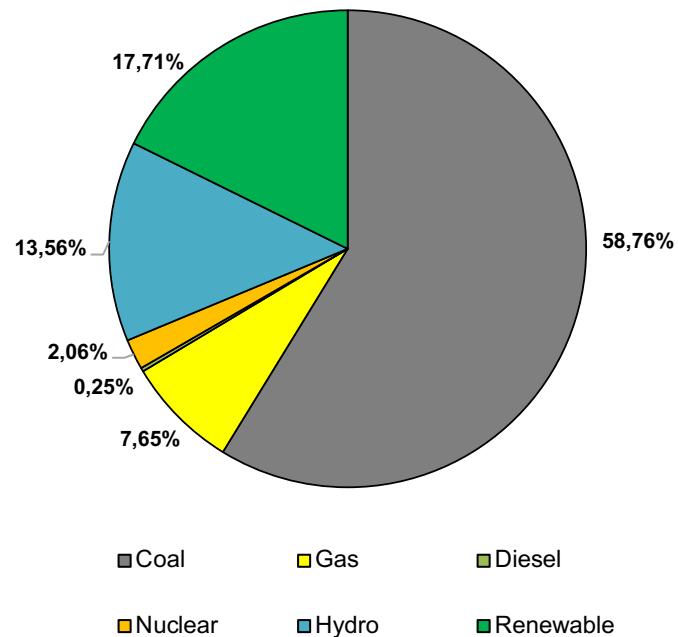
Motivation:

- 175 GW of Solar PV and Wind expansion in a decade
- Half of India's infrastructure is yet to be built
- Several existing problems in the Indian Power Sector

The Indian Electricity System

- Huge : Area and Capacity
- 5 power regions
- 330 GW of installed capacity
- 890 TWh of annual electricity consumption
- 145400 circuit kilometers of transmission lines
- ~60% is coal capacity
- 18% renewable
- 14% hydro

All India installed power plant capacity, 2017
330 GW in (%)



The Indian Electricity System

- Coal dependency : a threat for long-term sustainability
- COP 21, Paris Agreement : 30% reduction in carbon intensity pledge
- Demand – Supply gap : Not enough generating capacity
- Also, 88% energy access : Not enough transmission lines
- ‘Make in India’ initiative: Would increase the electricity demand
- Also, problems for Hydro power in India : Water sharing, and land issues
- Increase of ~200% renewable capacity since 2006
- Market partial liberalization in 2006 (electricity act, CEA)
- Financial hurdles: Domestic private sector

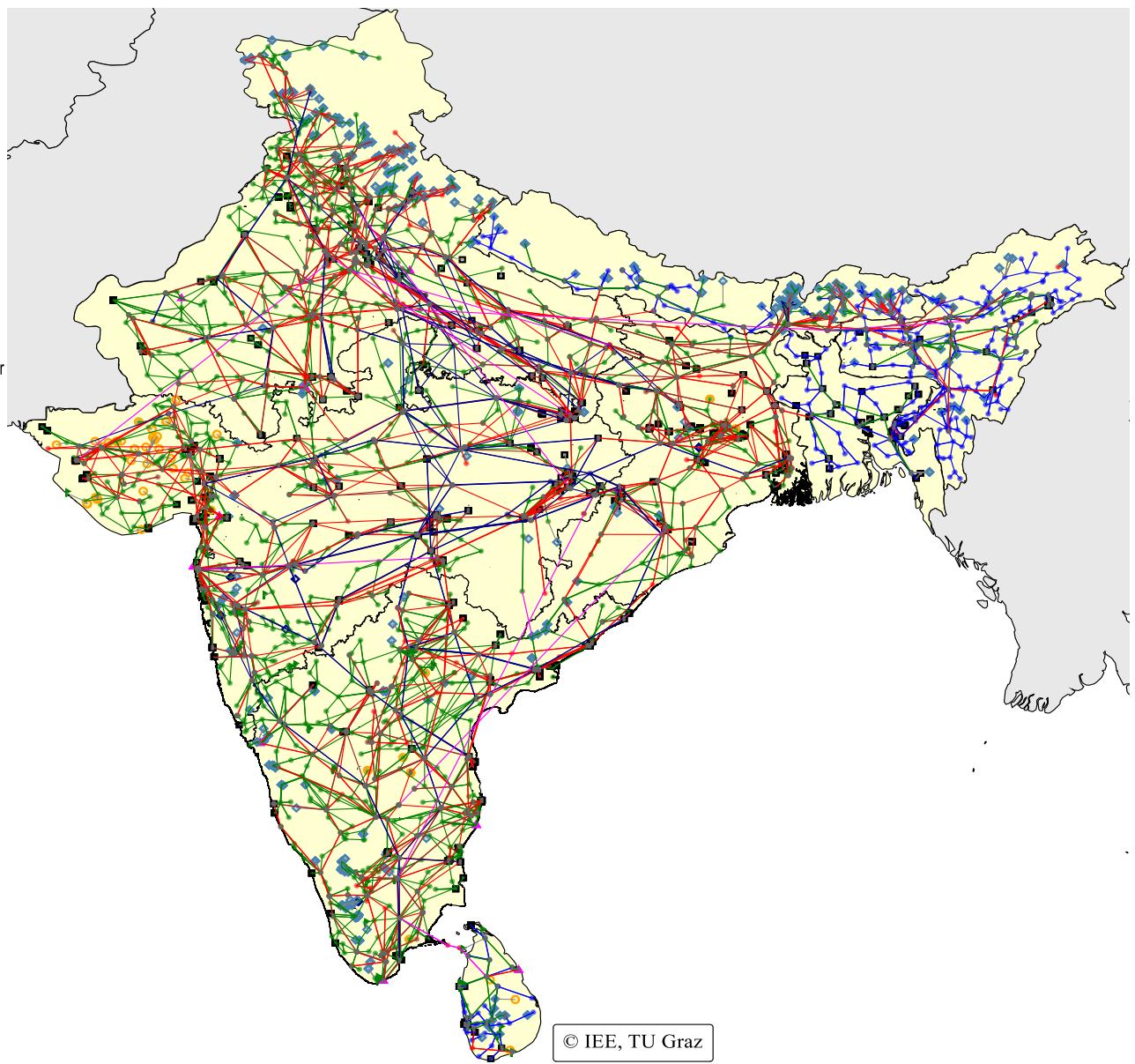
ATLANTIS_India

- Reference to the model ATLANTIS, IEE, TU graz
- Unique techno economic model developed at the IEE
- Over 3000 nodes covering India, Bangladesh, Bhutan, Nepal and Sri Lanka
- More than 6000 transmission lines with physical restrictions
- Over 3750 power plants (smaller PPs aggregated)
- Node-specific demand model
- Additional demand model for e-mobility and other factors
- Economic market model : Copper plate, Zonal Pricing and Redispatch
- Emulation of real-like scenarios

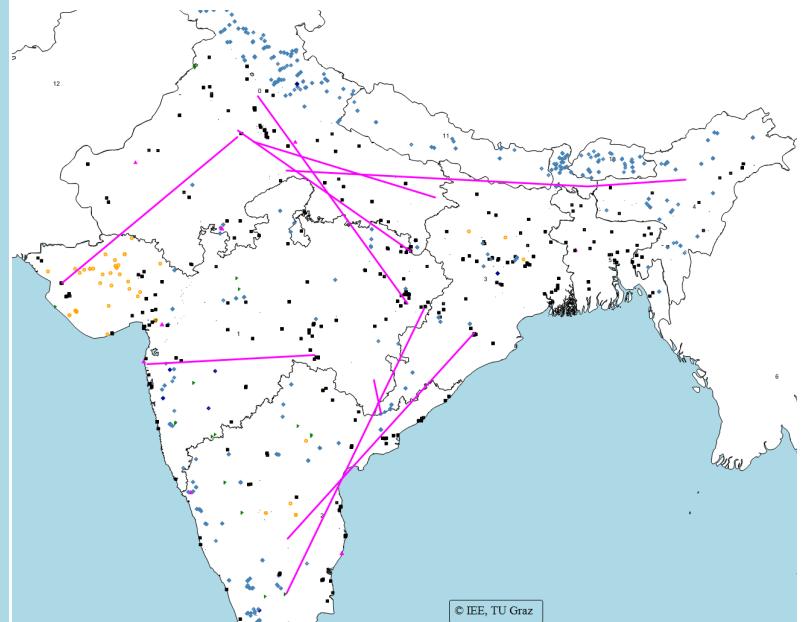
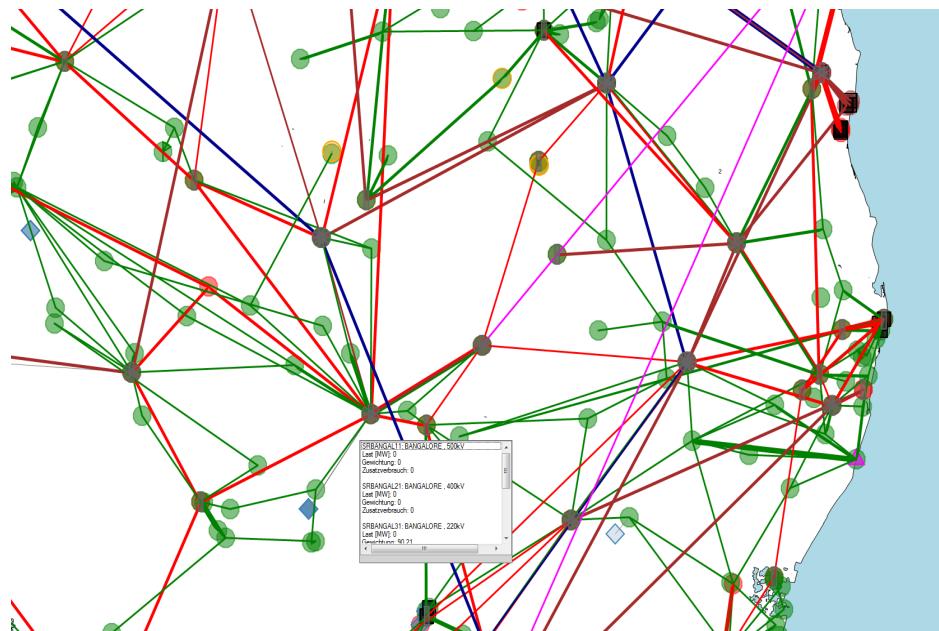
Transmission network model

- 4 voltage levels
 - 132 kV
 - 220 kV
 - 400 kV
 - 765 kV
- Each region carefully replicated
 - Number of lines
 - Physical restrictions/constraints
 - Voltage levels
- HVDC lines already under construction/ planned

- Transmission line 750kV
- Transmission line 500kV
- Transmission line 400kV
- Transmission line 330kV
- Transmission line 220kV
- Transmission line 132kV
- HVDC line
- Network elements
- Transformer | Phase shifter
- Bypass
- Nodes
- Node 750kV
- Node 500kV
- Node 400kV
- Node 330kV
- Node 220kV
- Node 132kV
- Power stations
- Runoff river|
- Storage | Pumpstorage
- Nuclear
- Wind (On-/Offshore)
- Solar | PV
- Biomass | Geothermal
- Thermal

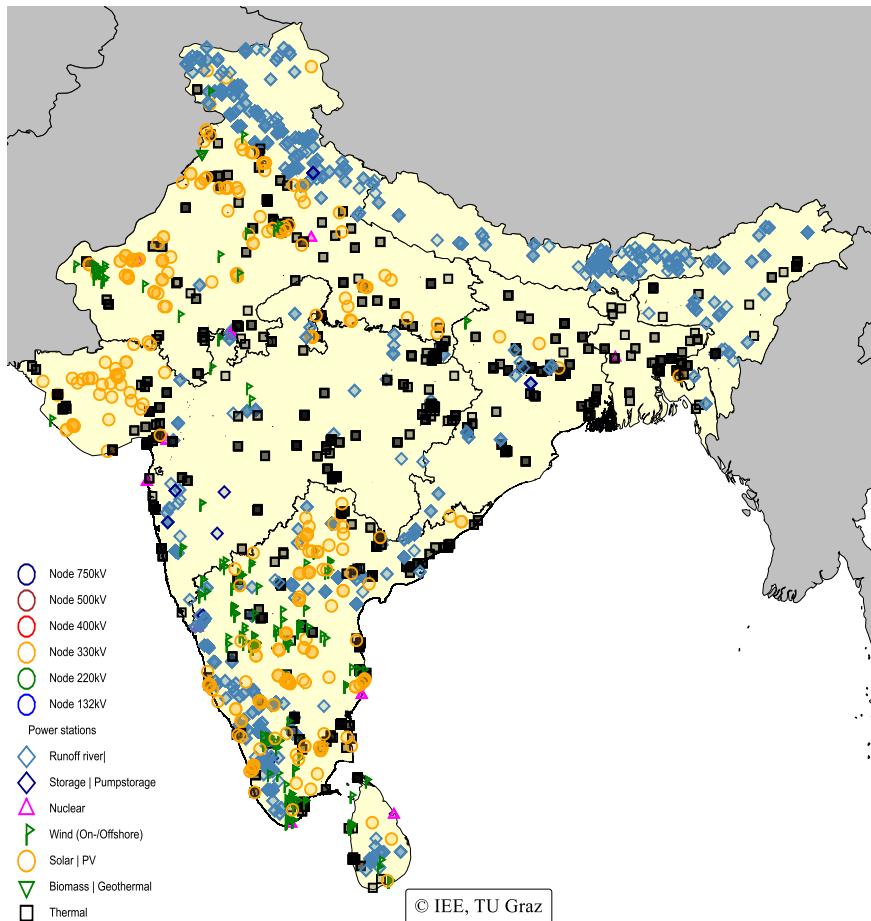


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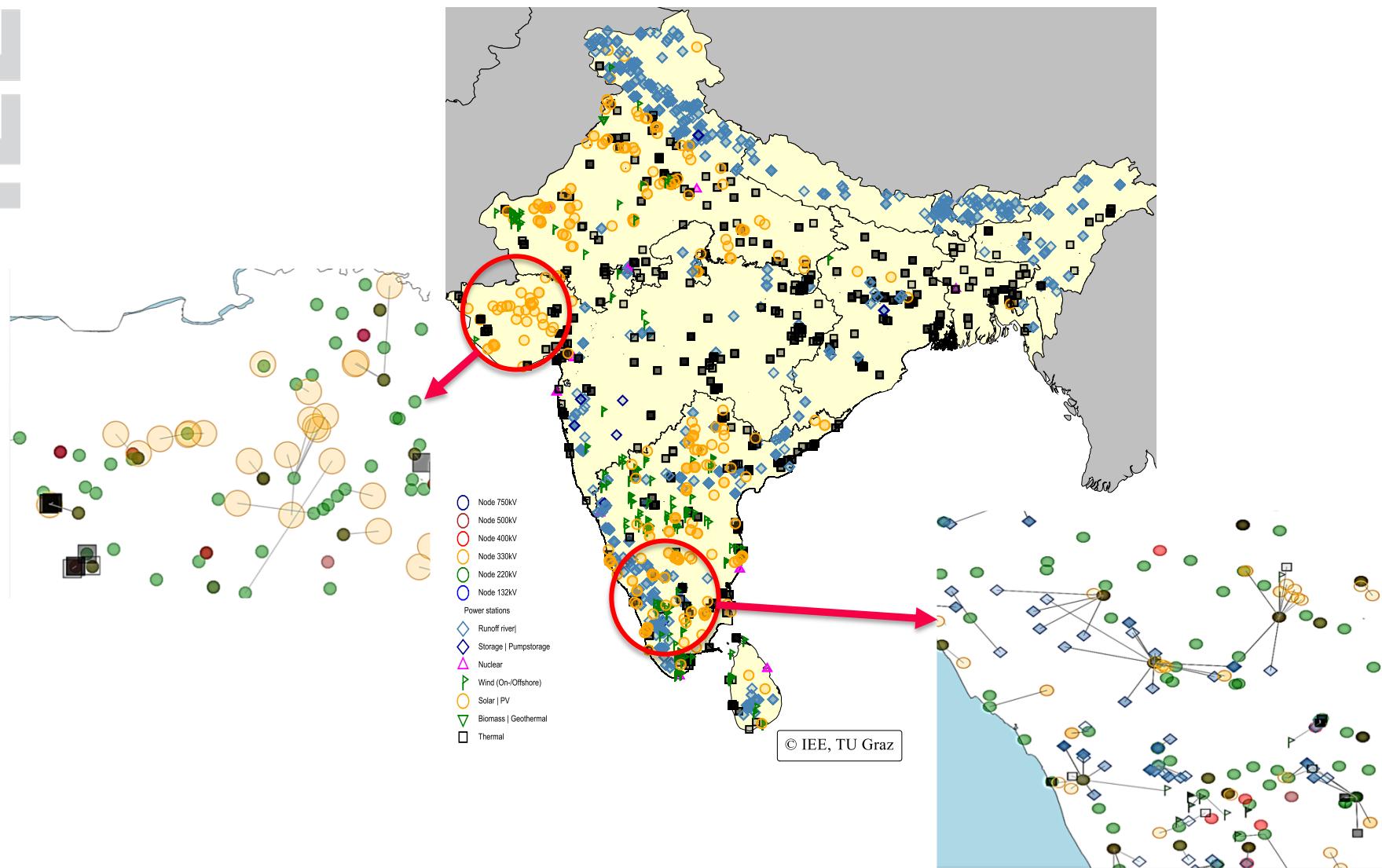


Power plant fleet

- 330 GW of capacity with over 3000 PPs
- Smaller PPs are aggregated into larger capacity PP
- Geographically specific: RES factors and feed in nodes
- Annual electricity generation and availability factors
- Start up year, technical and economic lifetimes and owner company data also included

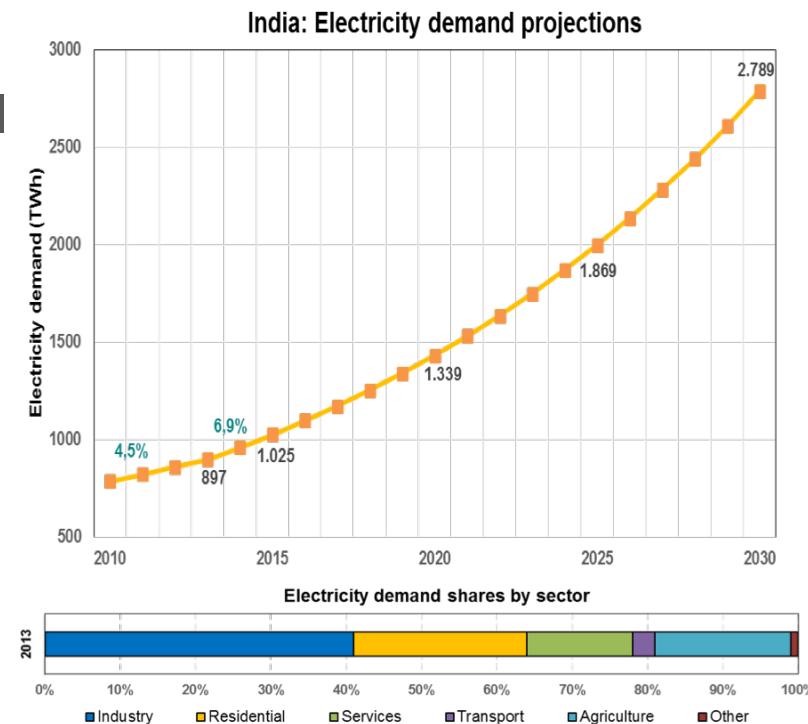


Power Plant Fleet



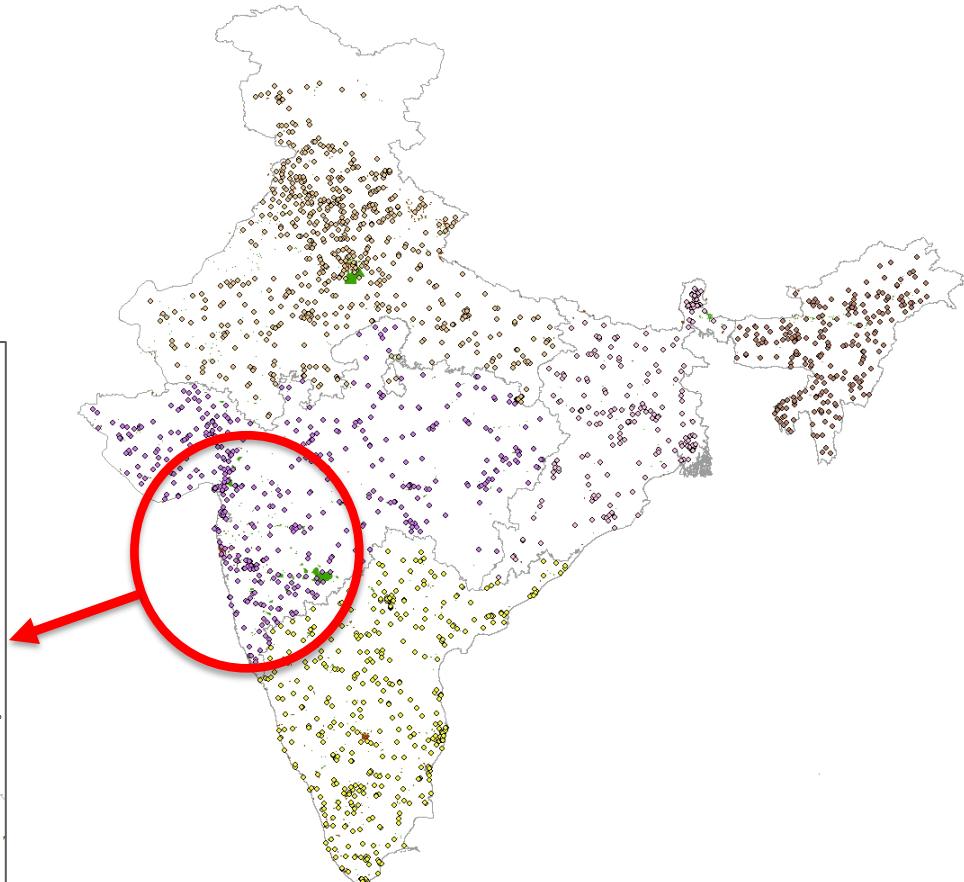
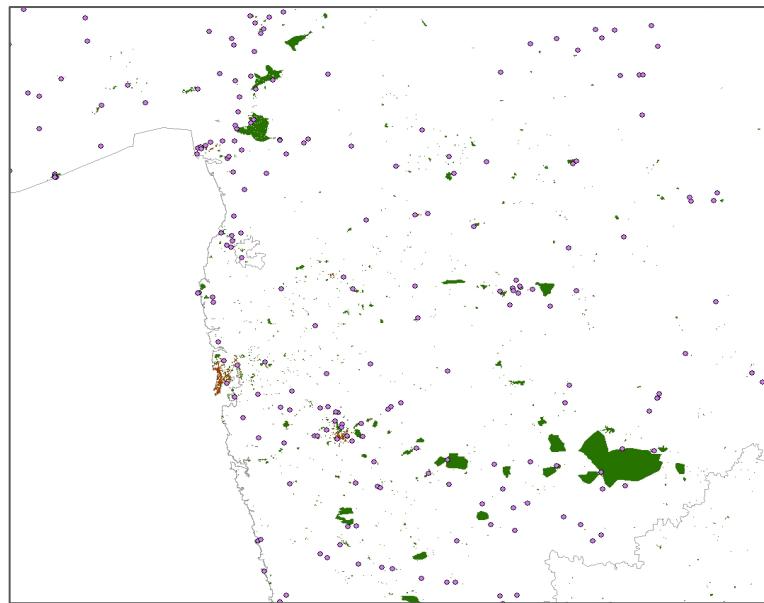
Electricity demand model

- Demand increase and distribution
- Demand weightage at each node
- Further classified : Industrial, Urban and Agriculture
- Industrial areas: identified by special economic zones
- Urban areas : By population density
- Agriculture : Land-use density
- Demand variation: can be node-specific
- Annual increase in demand growth : emulated as per reports



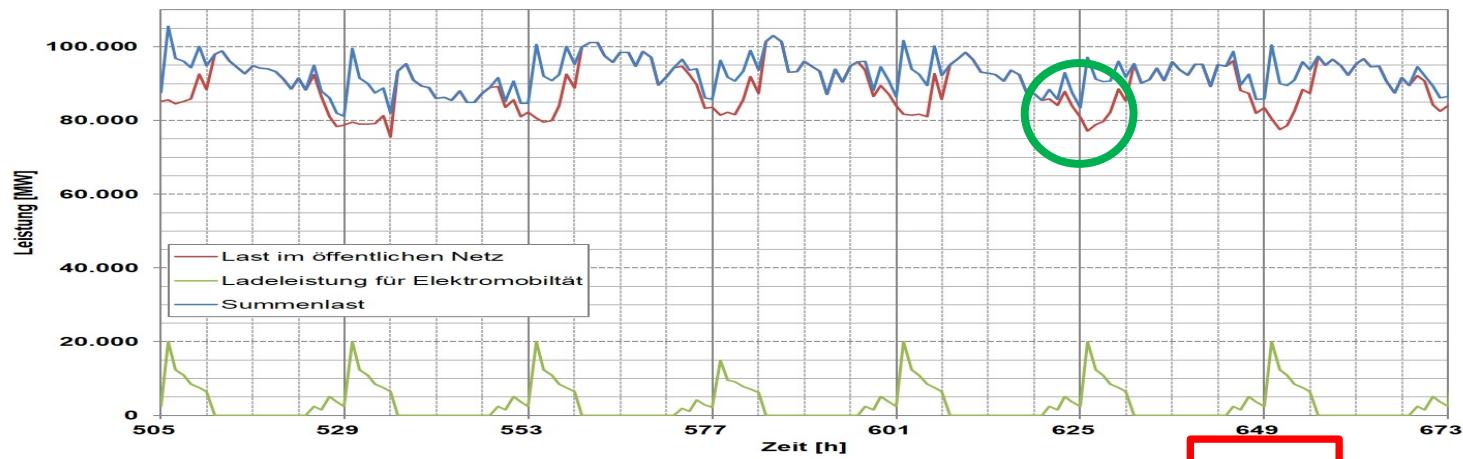
Quelle: WEO2015, IEA, MoP

Electricity Demand distribution



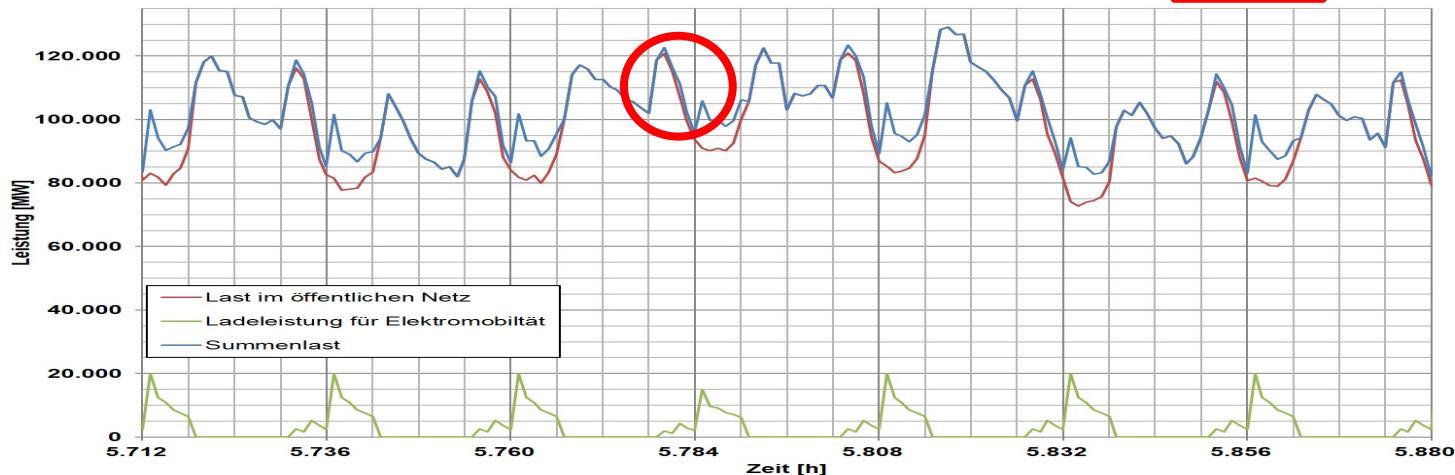
Additional demand (E-mobility)

Winter week, NR



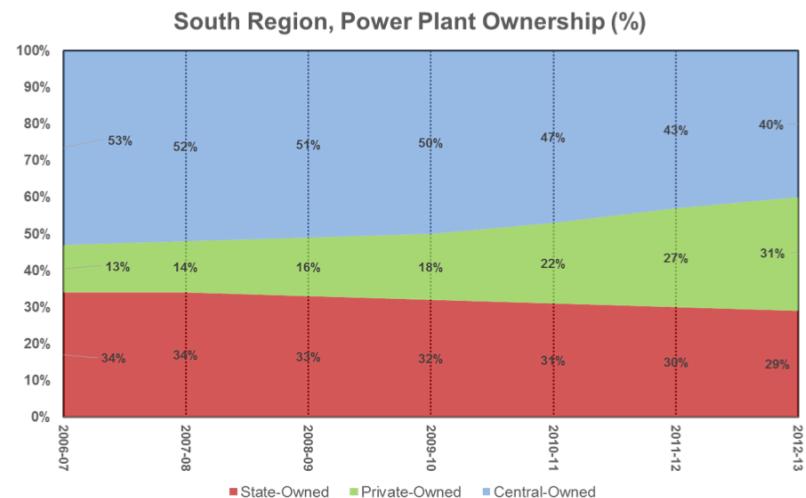
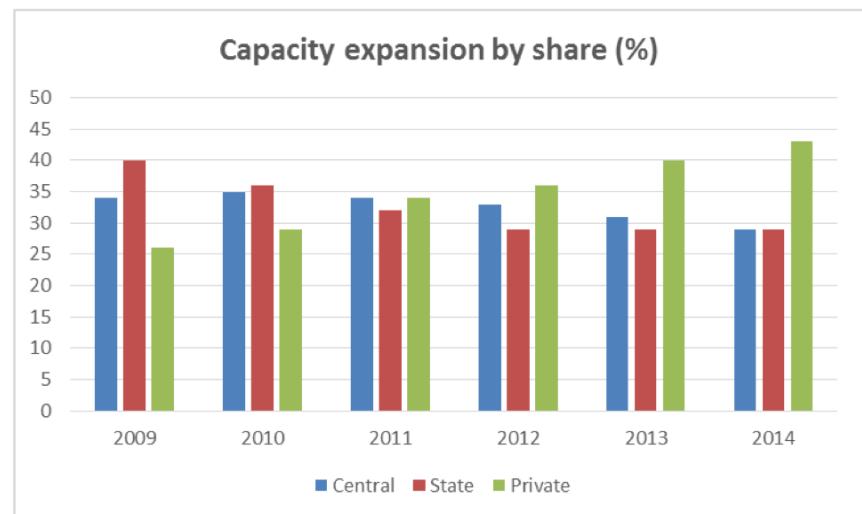
Summer week, NR

13%



Economic model

- Business model (GuV)
- 170 companies overall
- Only large capacity shares
- 14 centrally owned companies
- 27 state owned companies
- 129 Private companies
- Indian investments in neighbouring countries
- Ex. NHPCL (central) has hydro power investments in Nepal and Bhutan



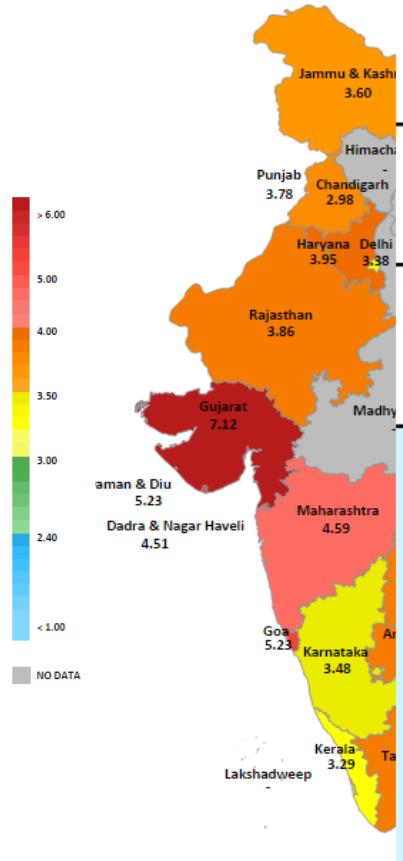
Economic model : Market

- A mix of traditional and liberalized market
- In the middle of a transition
- Due to increased share of private participants and to keep a fair competition
- Private utilities either make contracts or participate (now)
- Marginal pricing, and Weighted average pricing
- Zonal pricing model is to be adopted
 - Considers Export and import between regions
 - Allows investigations further on Re-Dispatch possibilities

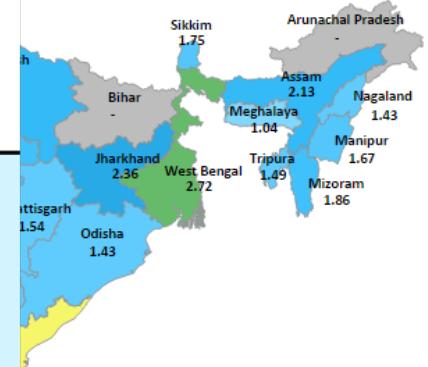
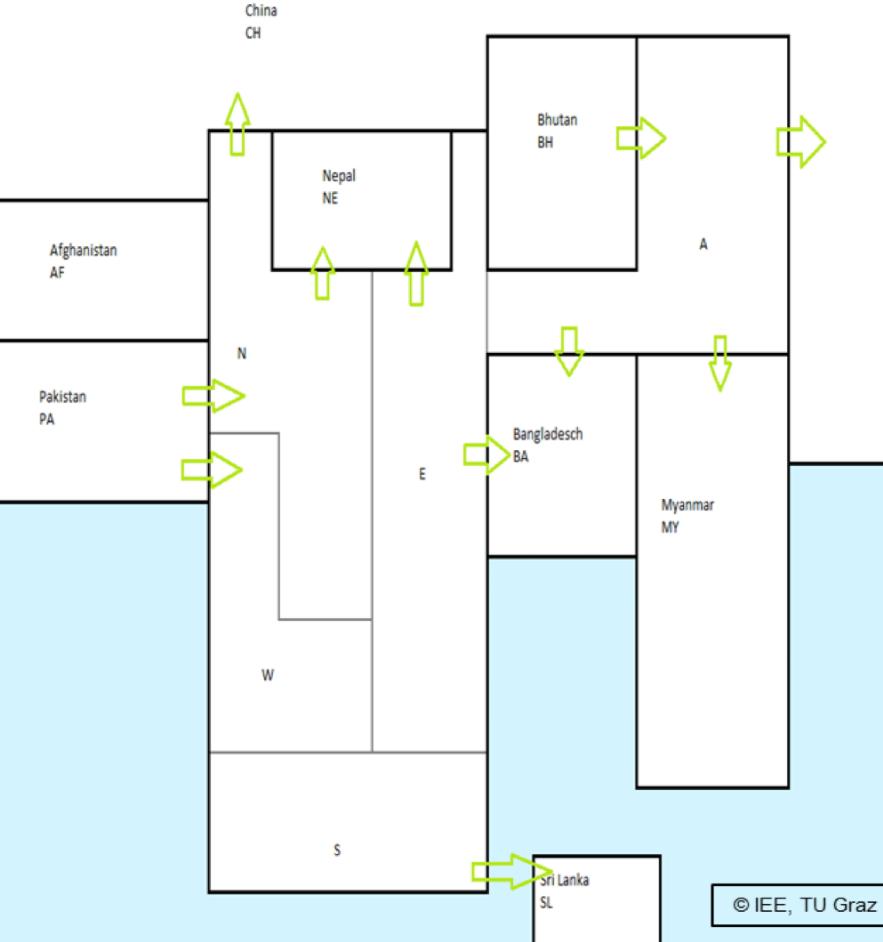
Market Model

MARKET MODELING : Zonal Pricing

Margin:



Cost



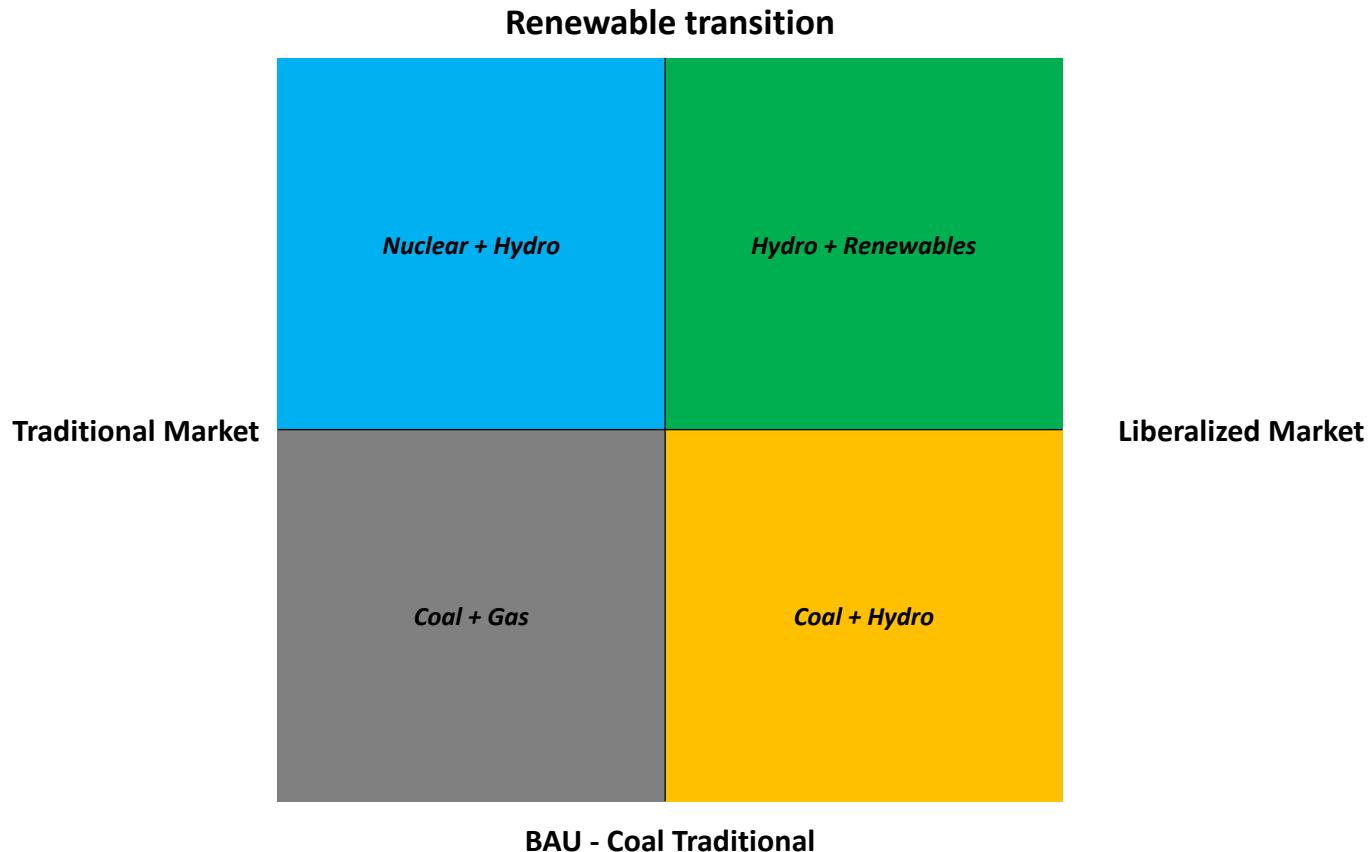
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Quelle: Merit India, IEX

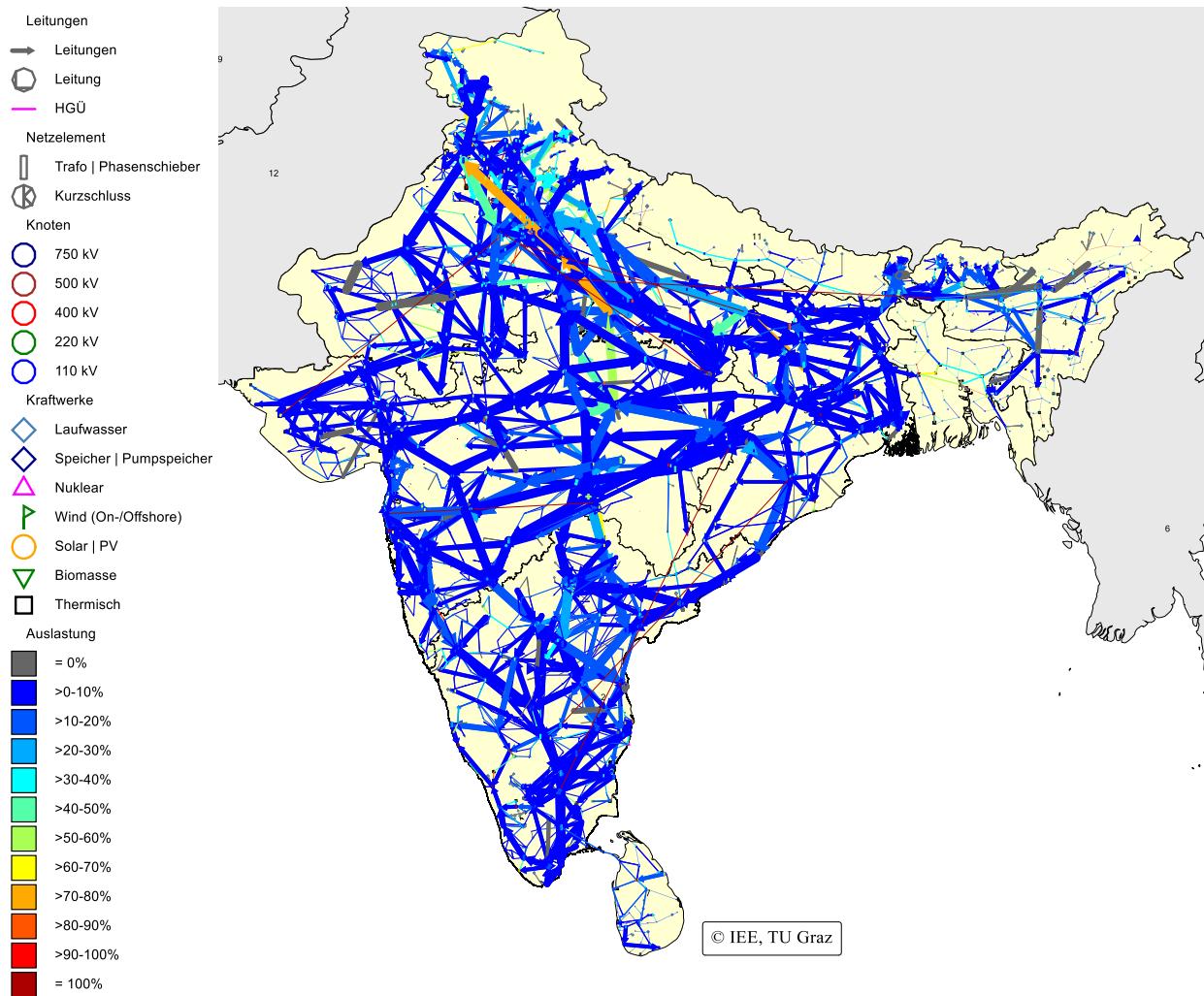
Market simulation modules

- Börsenmodell (Copper Plate Model) : demand-supply calculations
- Gesamtmarktmodell : With transmission lines
- Zonenpreismodell : With NTCs between each region
- Redistpatchmodell : With Physical restrictions within each region

Scenario Development



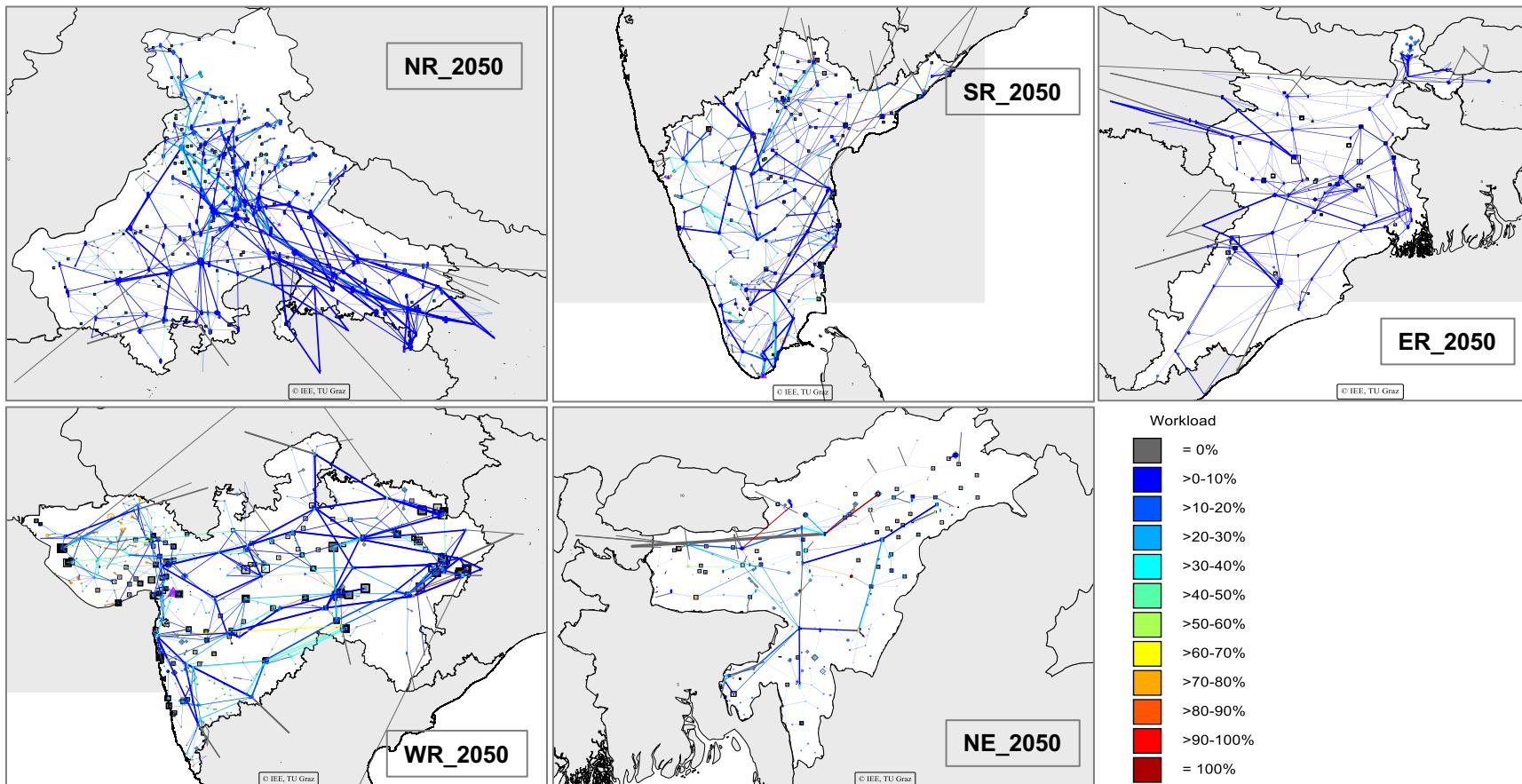
Results BAU, 2050



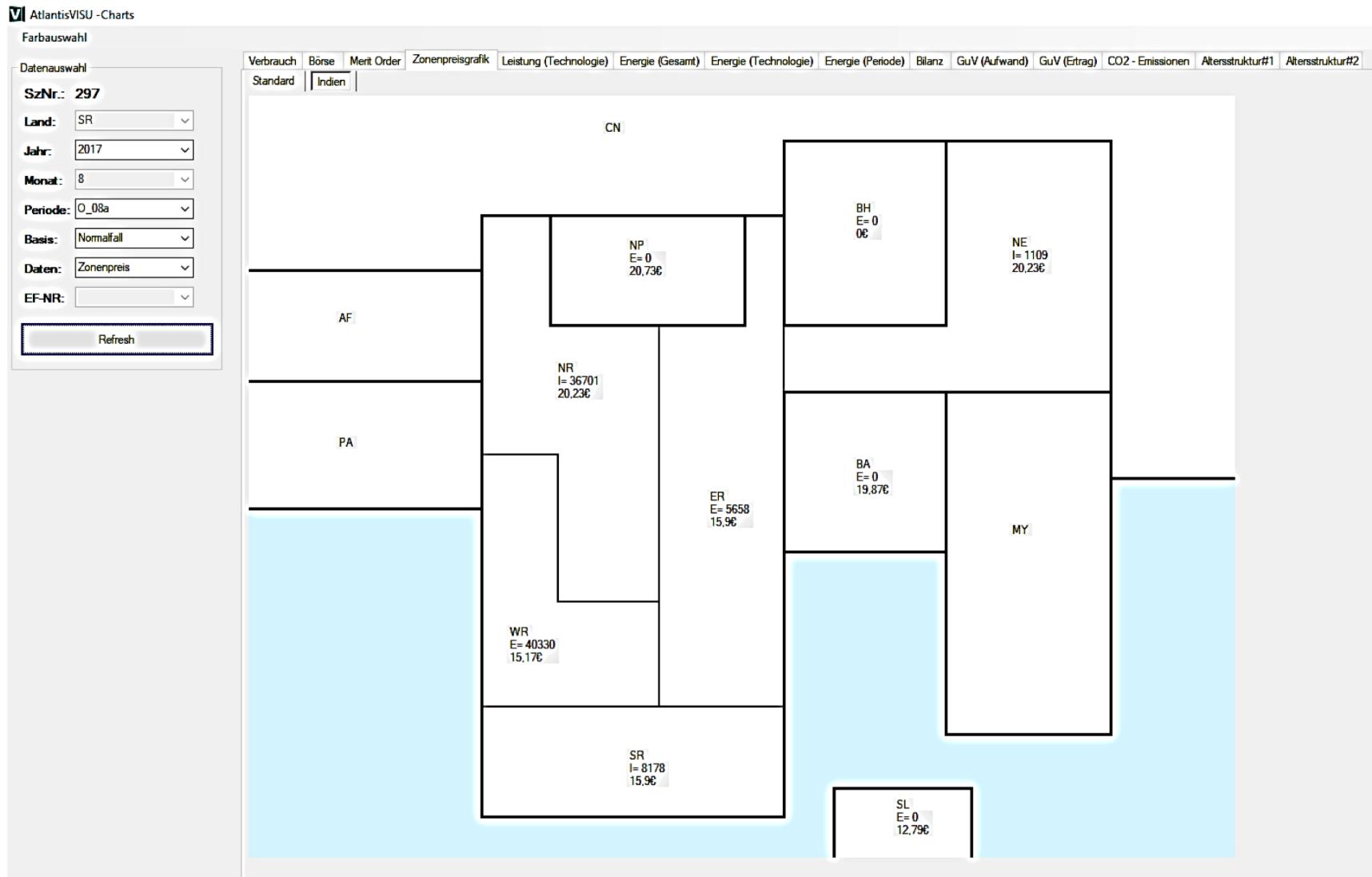
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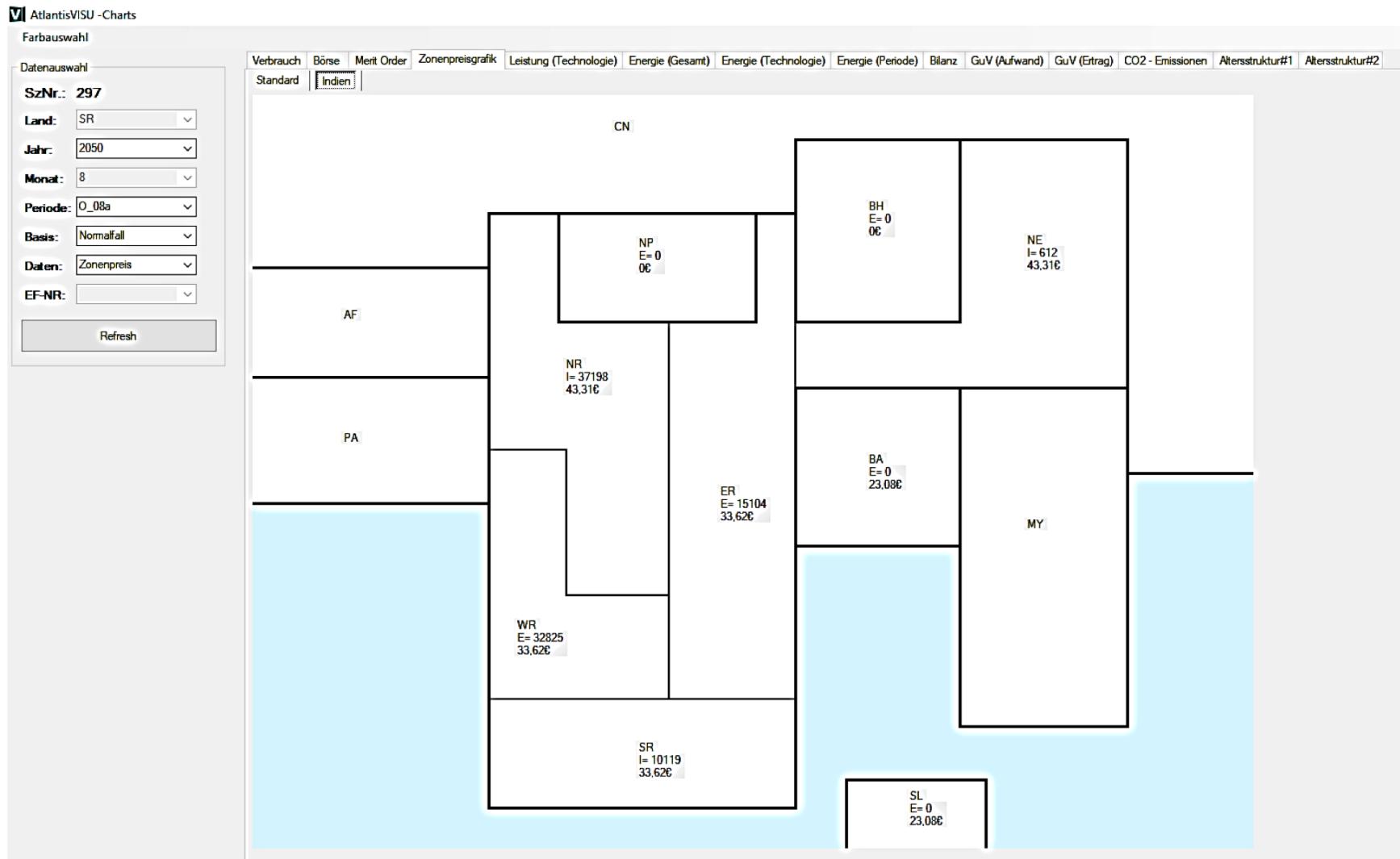
Result example BAU

Load flow validations and bottleneck identification

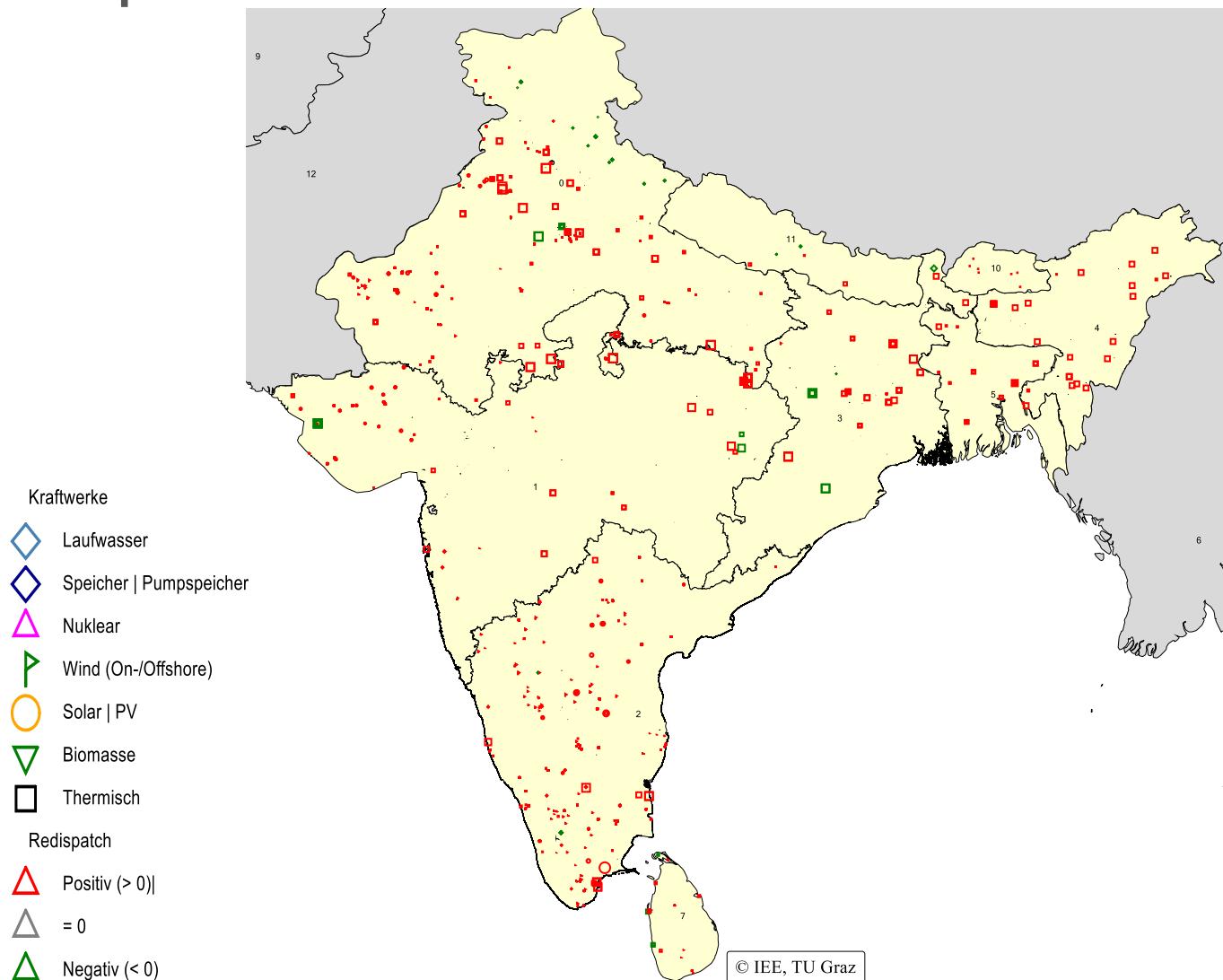


Result example BAU





Redispatch BAU



Conclusions

- Need for a techno economic model : High
- Optimized Energy planning : Possible
- Carbon free generation technologies : effective investments
- Technical model : Identifies the bottlenecks in transmission system
- Market model : Provides an insight on electricity pricing
- Business model: Company investments optimized

Danke für Ihre Aufmerksamkeit!

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