Techno-economic evaluation of planned large hydropower expansions by India in Nepal and Bhutan

Karthik Bhat,
Institut für Elektrizitätswirtschaft und Energieinnovation

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„India to achieve COP 21 goals before deadline”

- The HINDU, Our Bureau New Delhi | Updated on January 09, 2018 Published on November 01, 2017

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Economy

India to achieve COP 21 goals before deadline

Our Bureau | New Delhi | Updated on January 09, 2018 Published on November 01, 2017

ADB India funding to focus on energy efficiency and distribution

India is likely to achieve the self declared Sustainable Development Goal of lowering fossil fuel share in the energy mix earlier than committed according to Secretary, Ministry of Power, Ajay Kumar Bhalla.

Speaking at the launch of a project partnership between Energy Efficiency Services Ltd and Global Environment Facility, Bhalla said, “India currently has 330 GW of power generation capacity. Of this, 220 GW is fossil fuels based. We are promoting a target of 40 per cent non-fossil fuel capacities by 2030. And we will be doing it much earlier than that.”

“We have a target of 175 GW of renewable energy sources by 2022. If we put hydro there and other non-fossil fuels, we will definitely be achieving the target much earlier than 2030,” he added.

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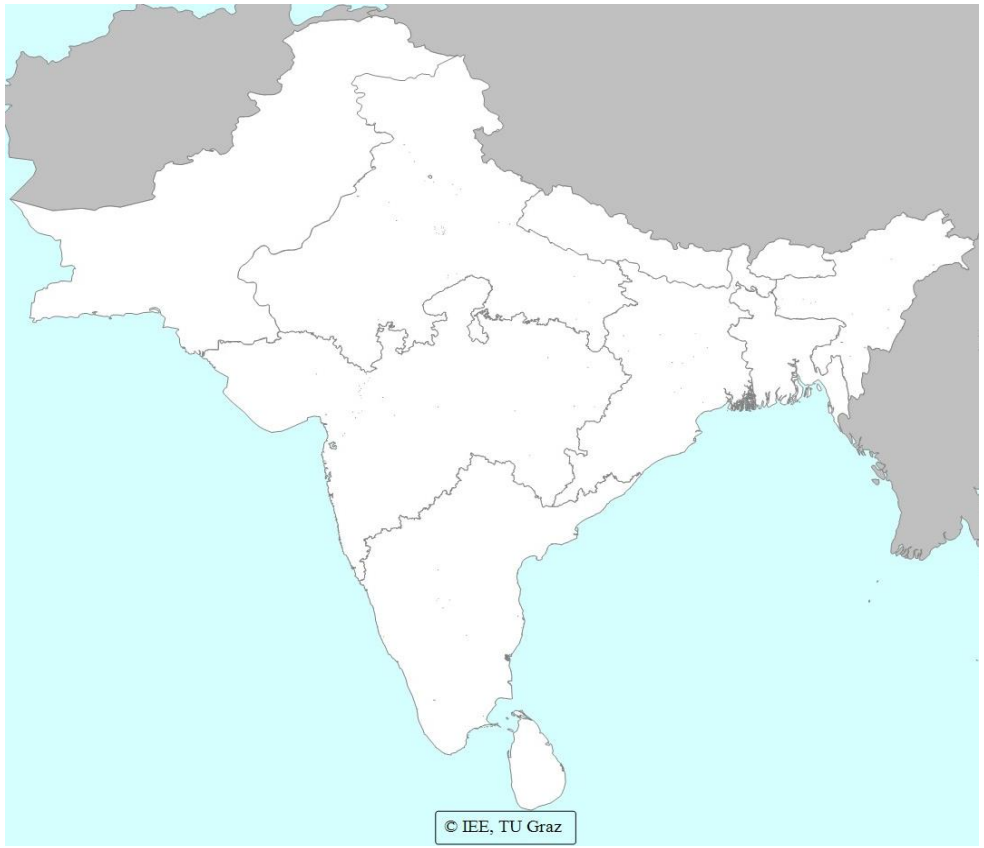
The Indian Subcontinent

Indian sub-continent :

- India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka
- Geographical area = 4,4 million sq. Kms
- Population = 1,710 billion, 2015
- Primary energy demand = 850 Mtoe (2015)

India:

- Electricity demand =897 TWh
- Electricity demand growth rate = 6,9% p.a.
- CO_2 Emissions = 2100 MtCO2



Energy Sector Challenges

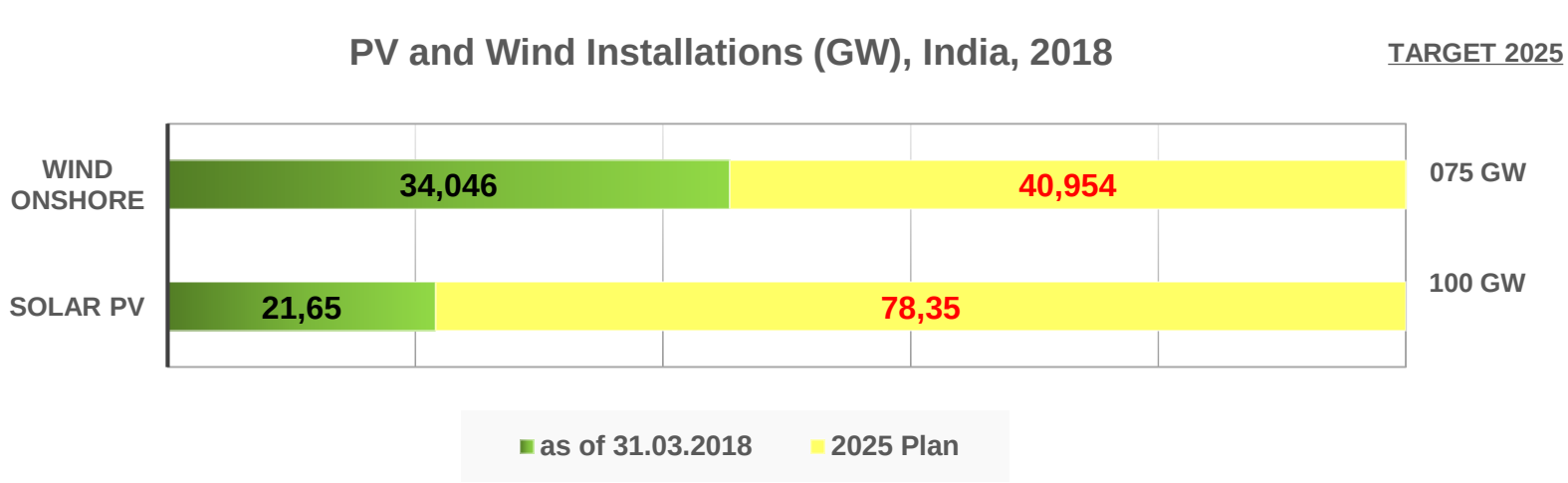
- Main challenges for the Indian Energy Sector:
  - Sustain economic growth along with energy transition (de-coupling of energy and GDP)
  - Transmission and Distribution losses minimization (~15 % overall in 2018)
  - Financial declination of the private sector
  - Coal import independence
  - Emissions reduction (36% of emissions come from the power sector)
  - Improve electricity access (8%, i.e. ~100 Mill. people without access)
  - Nuclear energy capacity expansions (~9 GW from 3 GW)

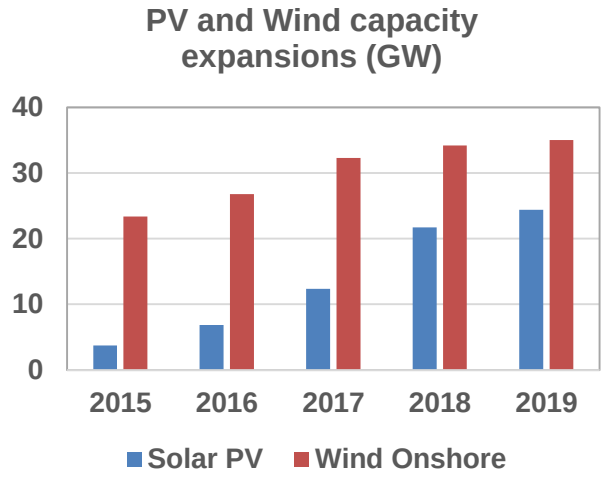
Source: Ministry of Power, GoI

India‘s commitment to the COP21

- **Agreed:**
  - Decrease up to 33% carbon intensity from 2005 levels.
  - 175 GW of Solar PV and Wind energy expansion planned.

- **Progress:**

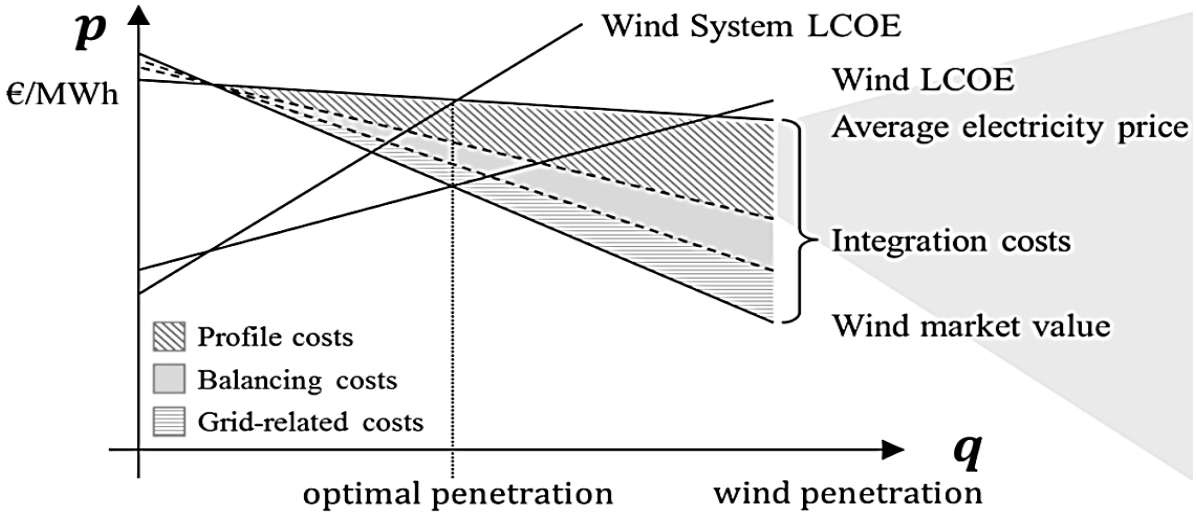




Source: MNRE, MoP, GoI

Hydropower and VRE

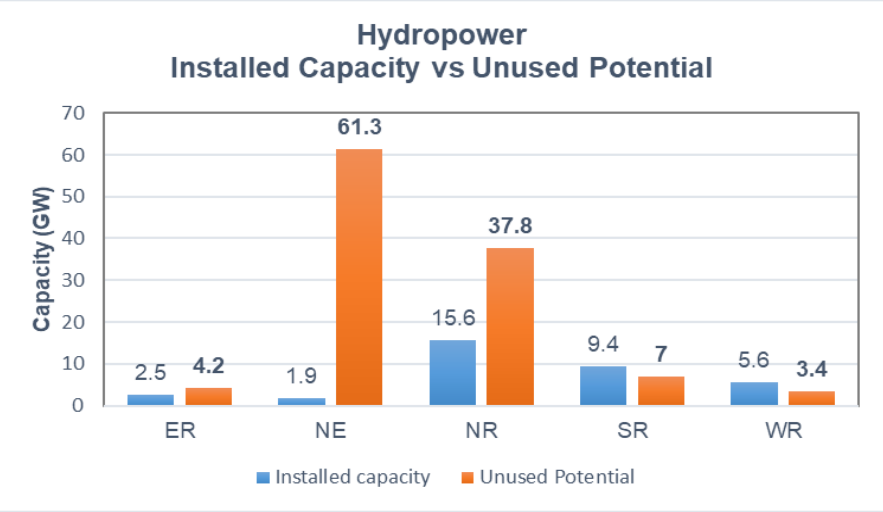
- Variability of VRE → increases complexity in energy system interactions
- Leads to ‚integration costs'
- Higher penetration of VRE → Higher integration costs
- Optimum penetration of VRE
- Coupling with dispatch-able RE
- Hydropower is the best possible option (ex. Brazil)

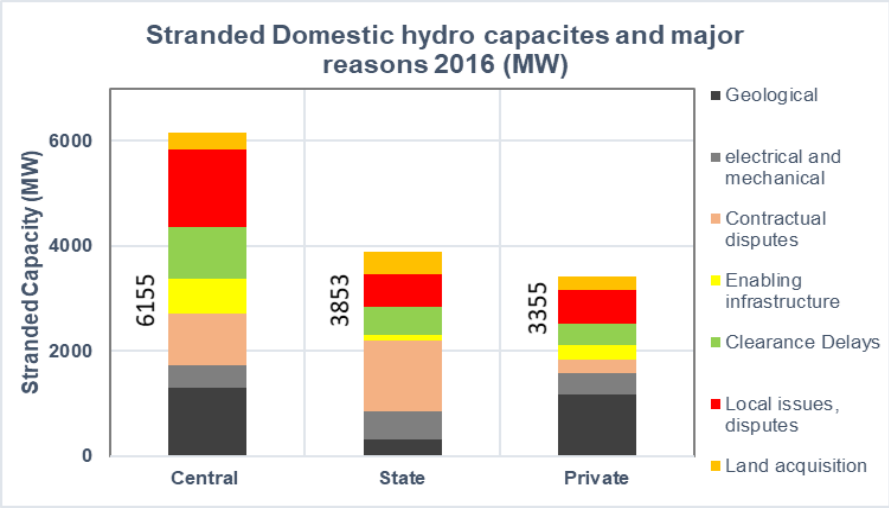


Source: Neon-energie

Challenges for Hydropower in India

- Roadblocks for Hydropower in India
  - Regional and International Water sharing issues
  - Migration of people afftected by construction of dams
  - Land ownership issues - interregional
  - Silt formation and Environmental issues





Hydro power Challenges: Example

Tipaimukh Hydropower Project, North-East India

- **Location:** Manipur, NE region, River Barak
- **Planned Capacity:** 1,5 GW (250 MW X 6 Francis Turbines, ~4500 FLH)
- **Proposed:** Early 1990s
- **Planned Operation:** 2020 (after several delays)
- **Status :** Planning and Clearance
- **Reasons for the roadblock:**

  Water sharing issue with Bangladesh

  Population displacement issues

  Ecological issues, also seismic volatility

Source: International rivers blog,Six degrees, ejatlas.org

Bi-Lateral hydro power strategies

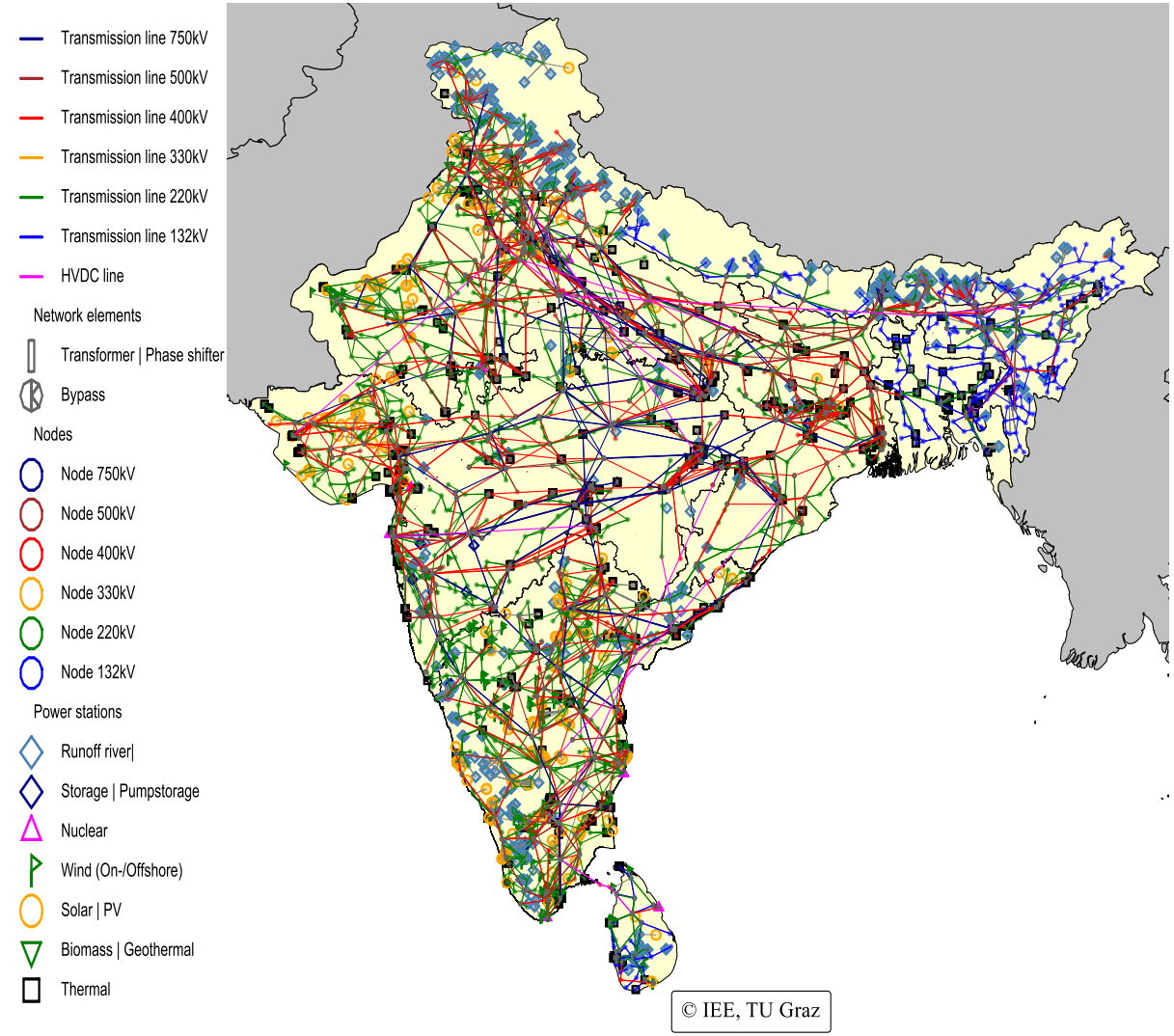
- **India - Nepal**
  - Improvement of Cross border transmission capacity : improve secondary peak support
  - Installation of hydropower plants in the North West Nepal – India Border
  - Development of the new 220 kV HV ‚Electrical Highway‘ in Nepal
  - Operation on 70% - 30% (IND-NEP) basis for over 50 years and complete handover
  - Bangladesh to import electricity from Nepal via Indian transmission network

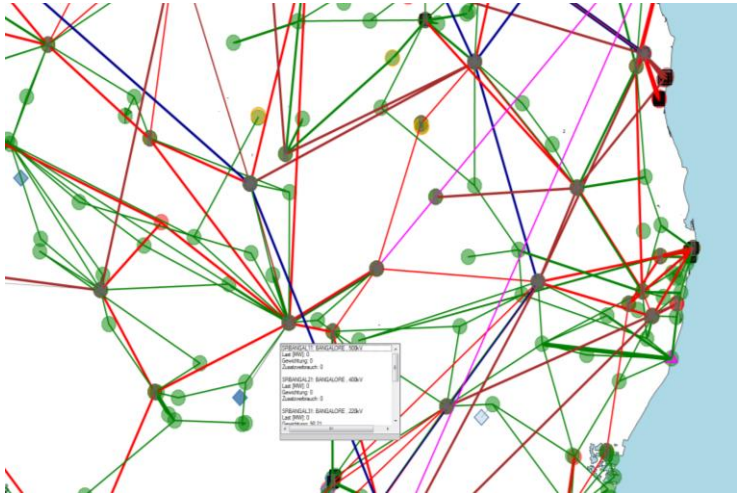
- **India – Bhutan**
  - 10 GW of HPP installations by 2030
  - Improvement of the Bhutanese transmission system
  - New Cross-border transmission lines between Bhutan, East and North East Indian regions
  - Operation on 80% - 20% (IND-BHU) basis for over 50 years and complete handover

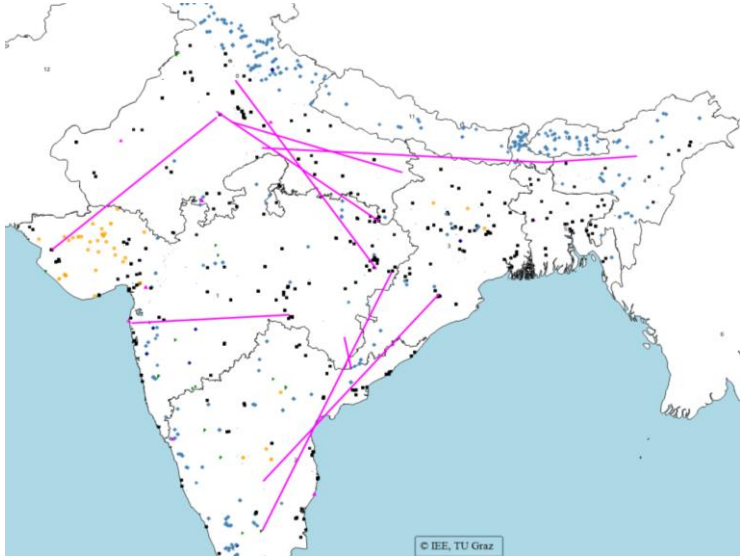
ATLANTIS_India

- 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

ATLANTIS_India vizualization







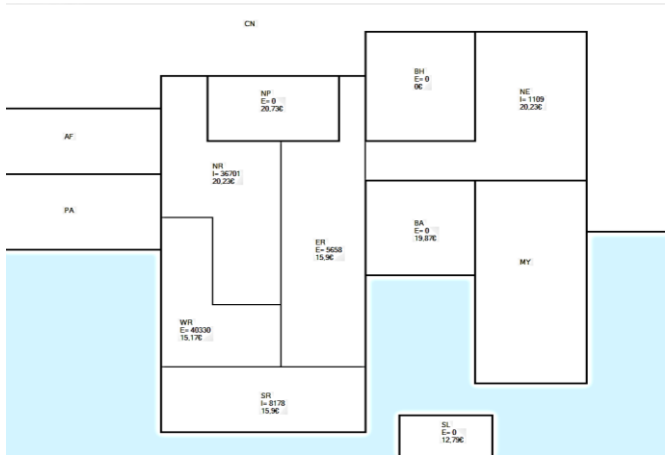
Market modeling

Four market models:

- Without load flow calculations

  a. Cu-Plate Market Model
  (No load flow, no NTCs)

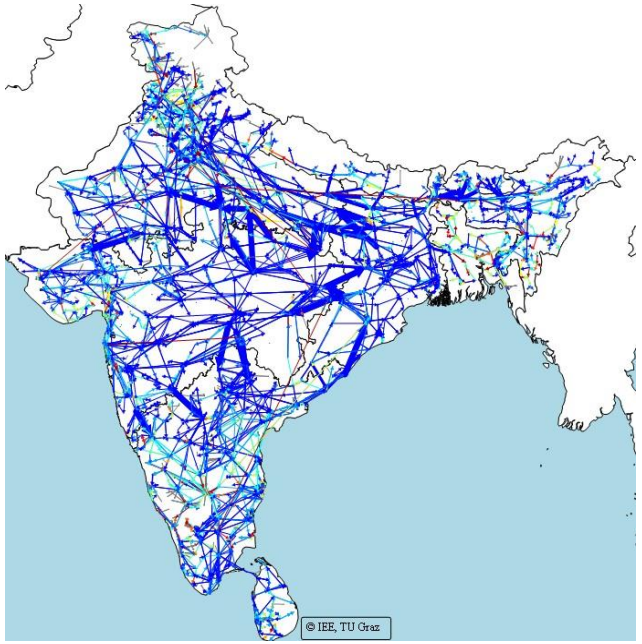
  b. Zonal Pricing model
  (NTC between Power regions)



- With load flow calculations

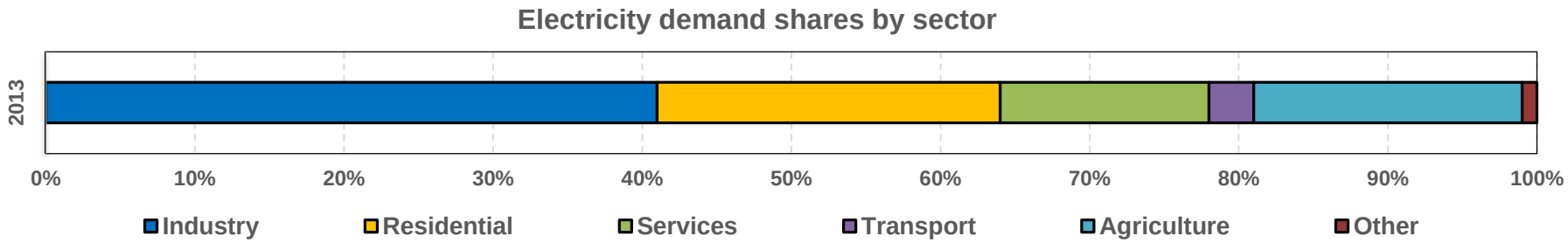
  c. Overall Market Model
  (Only load flows, no NTCs)

  d. Redispatch Model
  (Load flows with NTCs)



Demand modeling

- Node specific demand weightage
  - Weighted w.r.t. overall annual demand of specific power region
  - Three sectors: Residential, Industrial and Agricultural
  - Residential: population concentration
  - Industrial: Industrial zones, GIS map
  - Agricultural: Rural population and Agricultural land, GIS map



Quelle: WEO2015, IEA

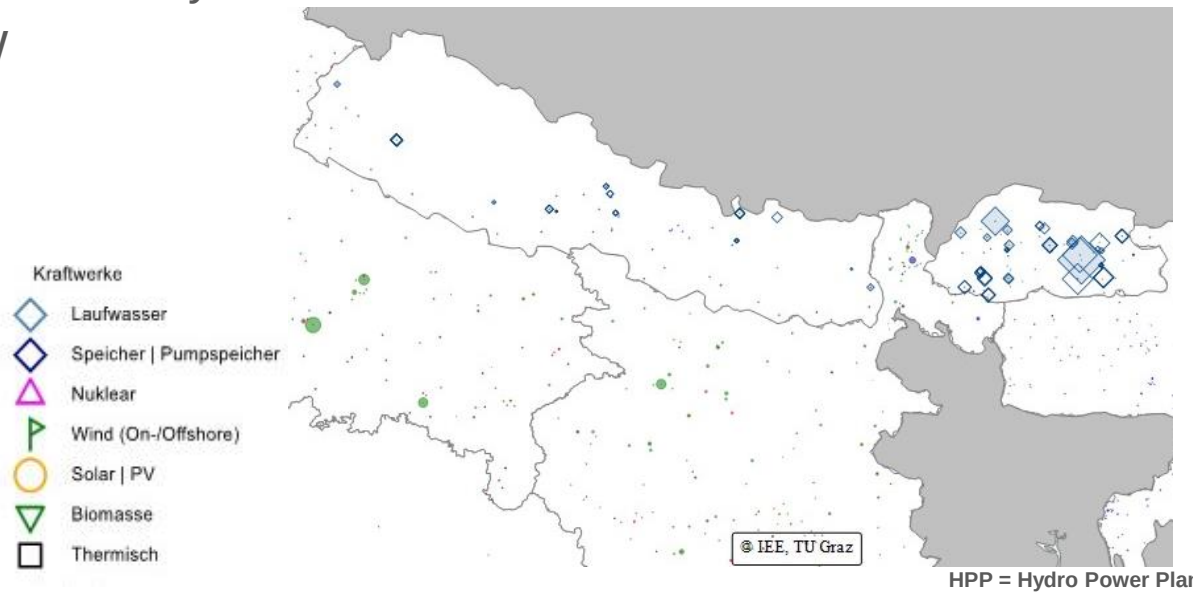
Scenario definition

- Varying input data : Powerplant data, Transmission data
- Hydro power capacity
  - By ignoring around half of large hydro planned capacity expansions
  - By varying annual expected energy generation
- Cross-border transmission capacity
  - By decreasing the thermal capacity of planned cross border lines
  - X 0,5 Thermal capacity of cross border lines

Scenario 1 : Extreme Case

Delayed HPP installations and minimum Cross Border transmission

- Only around half of planned capacities successfully start operation by 2030
- Cross-border transmission capacity less than expected
  - Mostly HPPs in the northern regions of Nepal and Bhutan ignored
  - Overall Hydro power capacity expansion withheld/delayed: 5.5 GW
  - Cross Border transmission capacity: 12.8 GW

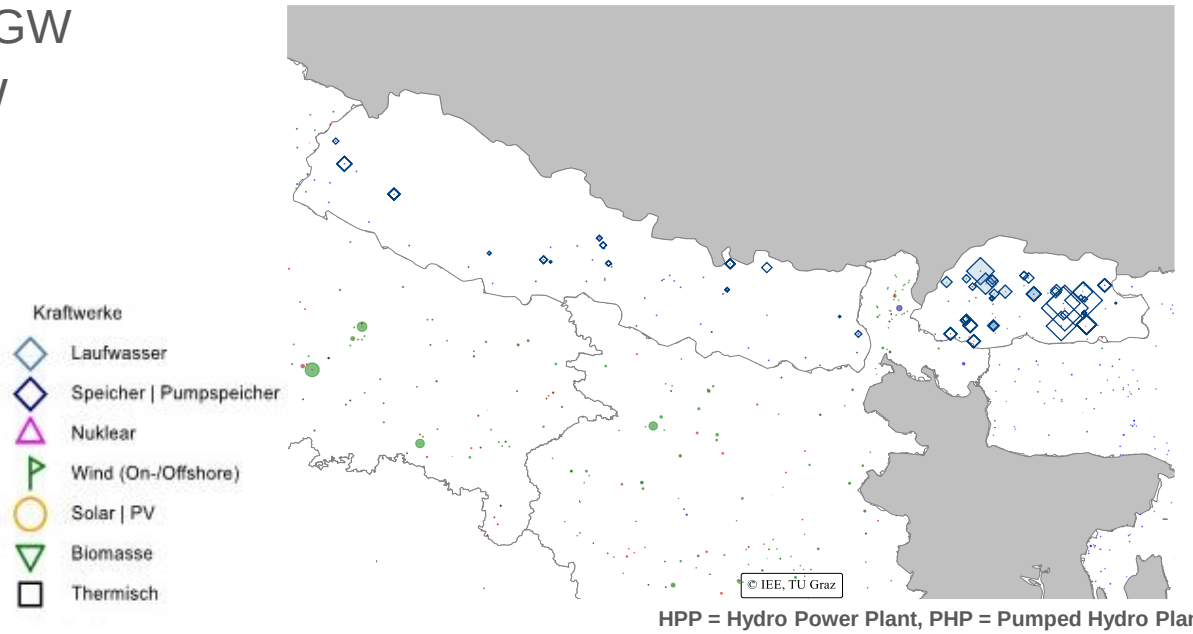


HPP = Hydro Power Plant

Scenario 2 : Best case

- All of planned capacities successfully start operation by 2030
- Several HPPs at high altitude regions treated as PHPs
- Cross-border transmission capacity as planned

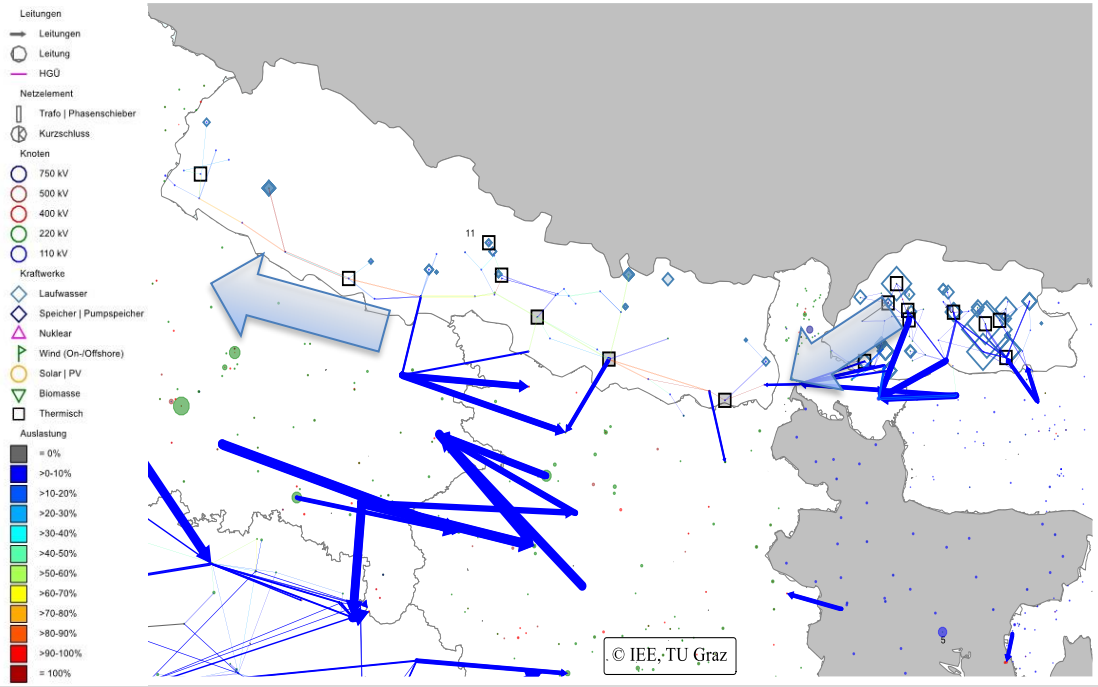
  - Mostly hydro power plants in the northern regions of Nepal and Bhutan treated as PHPs
  - Overall Hydro power capacity expansion: 10 GW
  - Cross Border transmission capacity: 17.3 GW

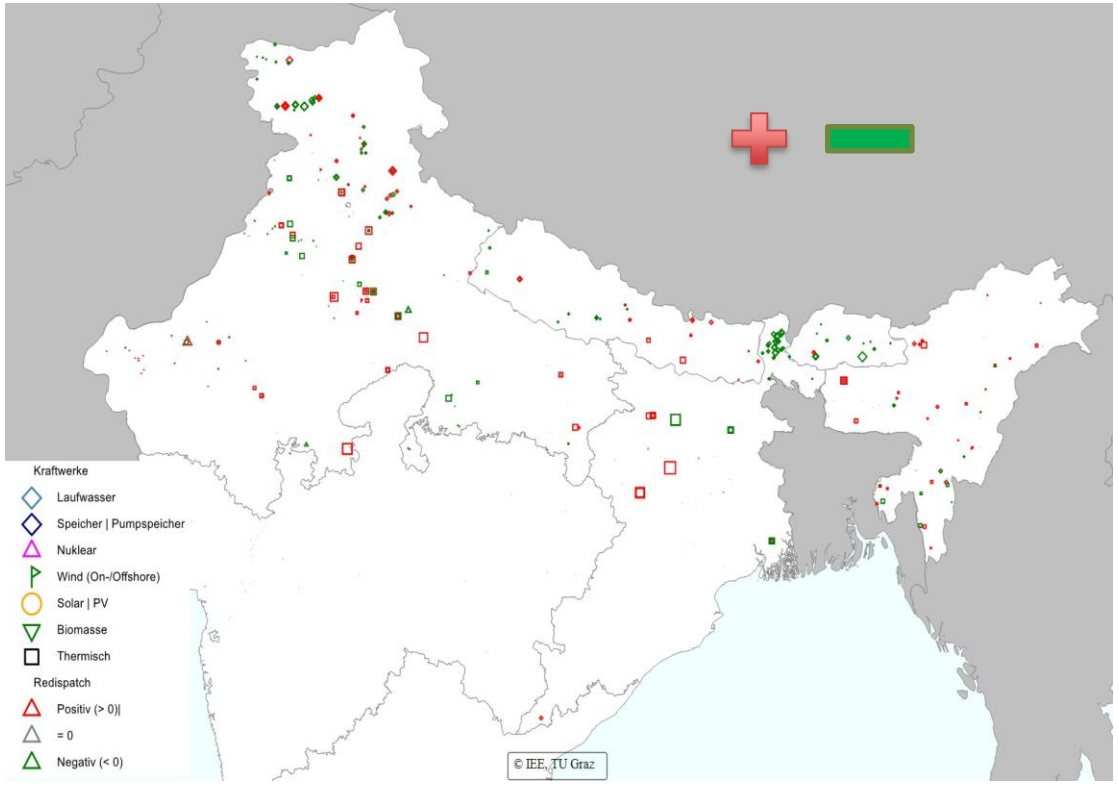


HPP = Hydro Power Plant, PHP = Pumped Hydro Plant

Results: Scenario 1

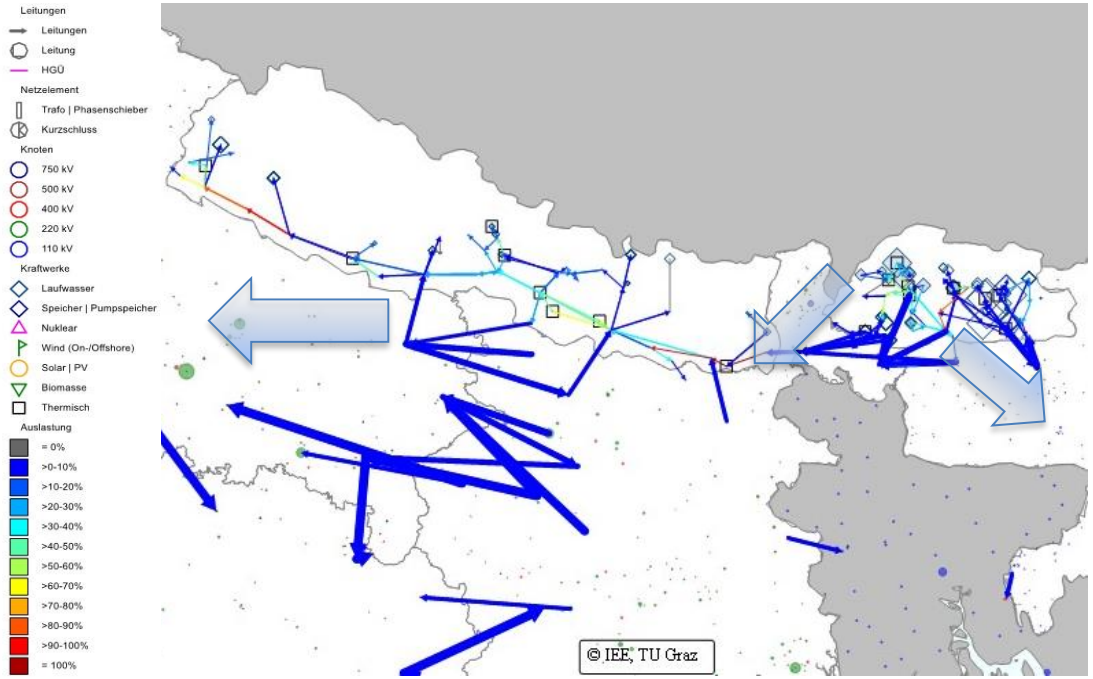
- Extreme case Scenario :
  - Load flow towards the region NR
  - Severe loading of the Nepalese transmission network
  - CB lines bottlenecks

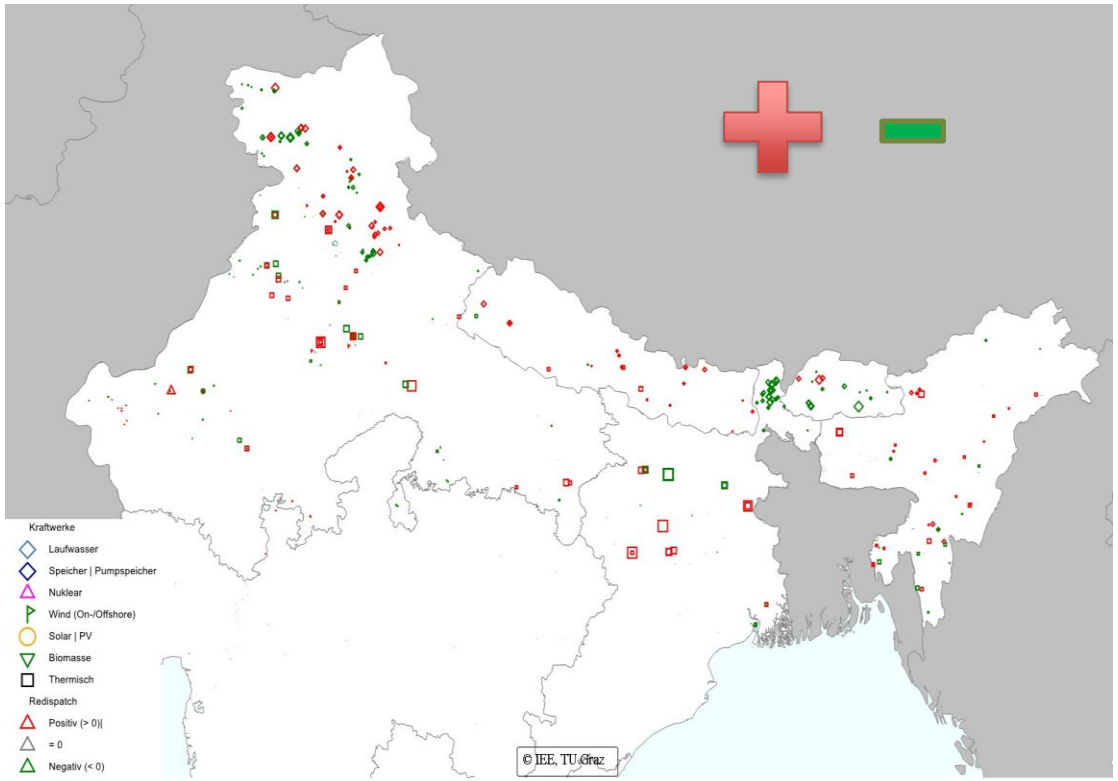




Results: Scenario 2

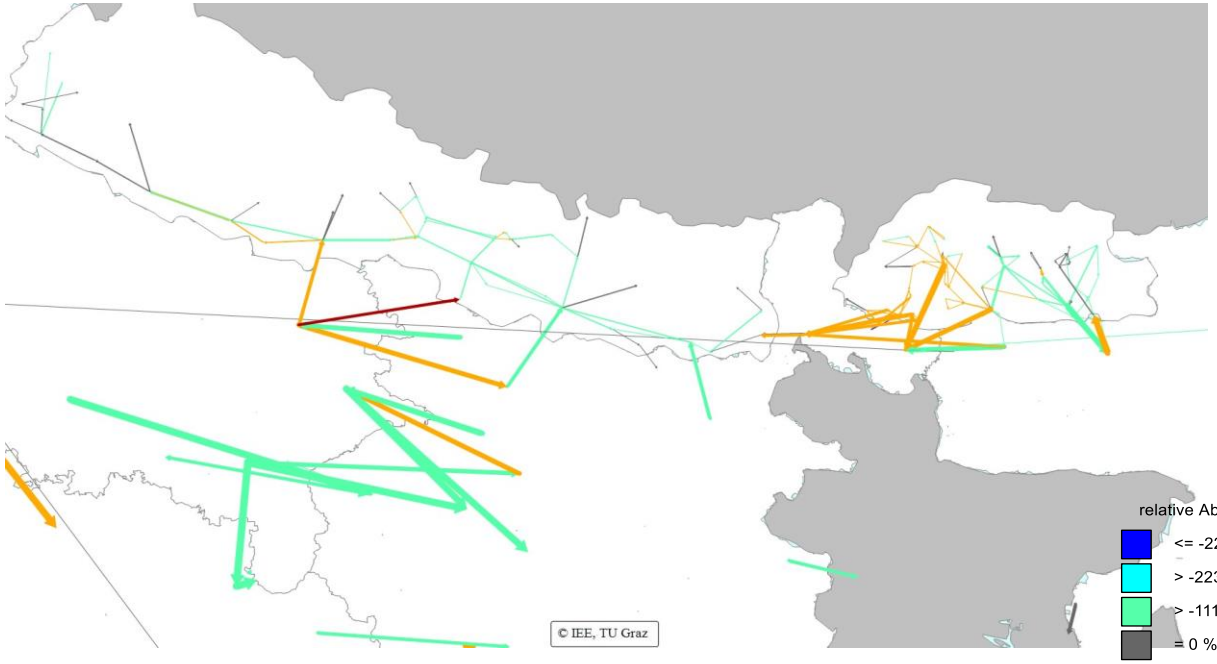
- Best Case Scenario:
  - Load flow evenly distributed
  - Few bottlenecks – new 220 kV transmission highway
  - CB lines – No bottlenecks

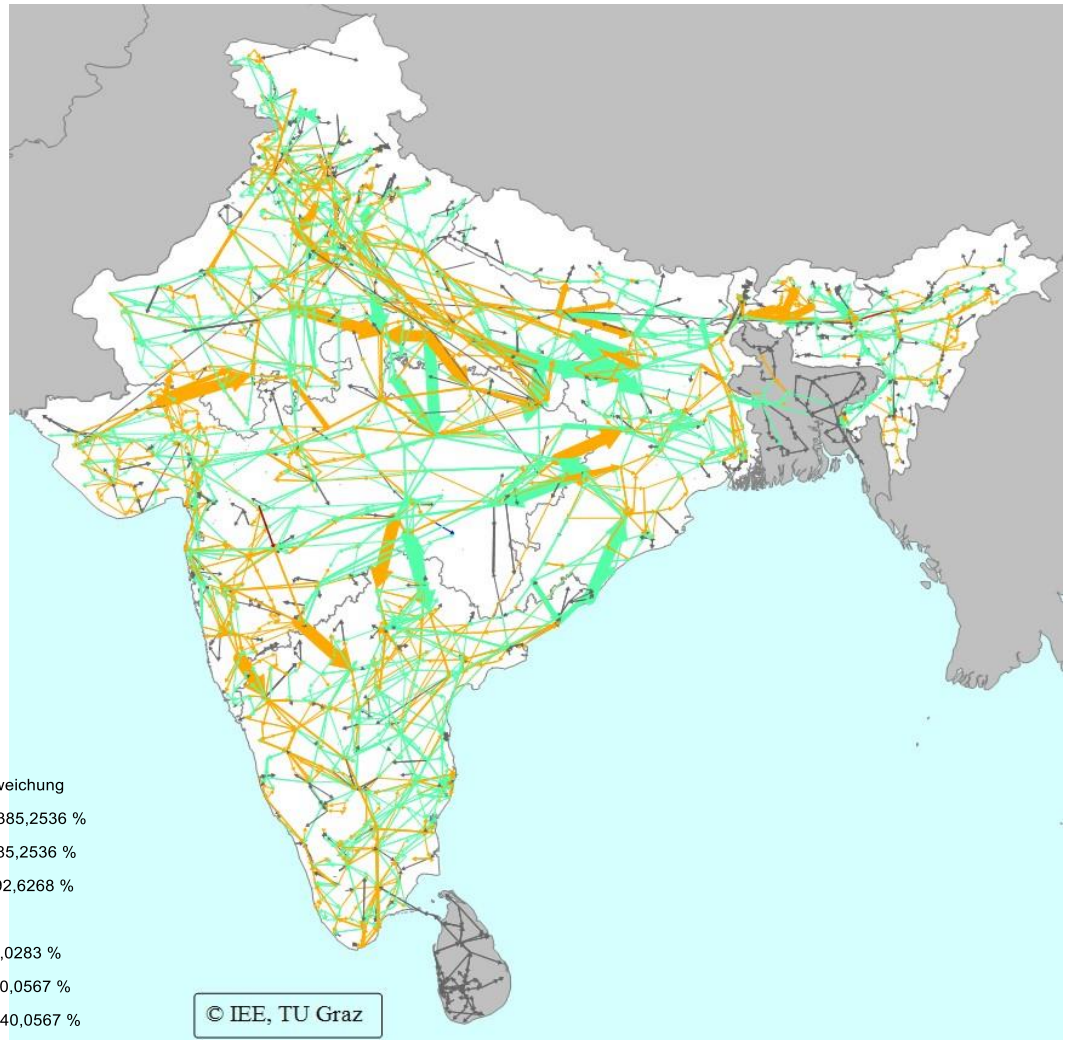




Extreme case vs Best case

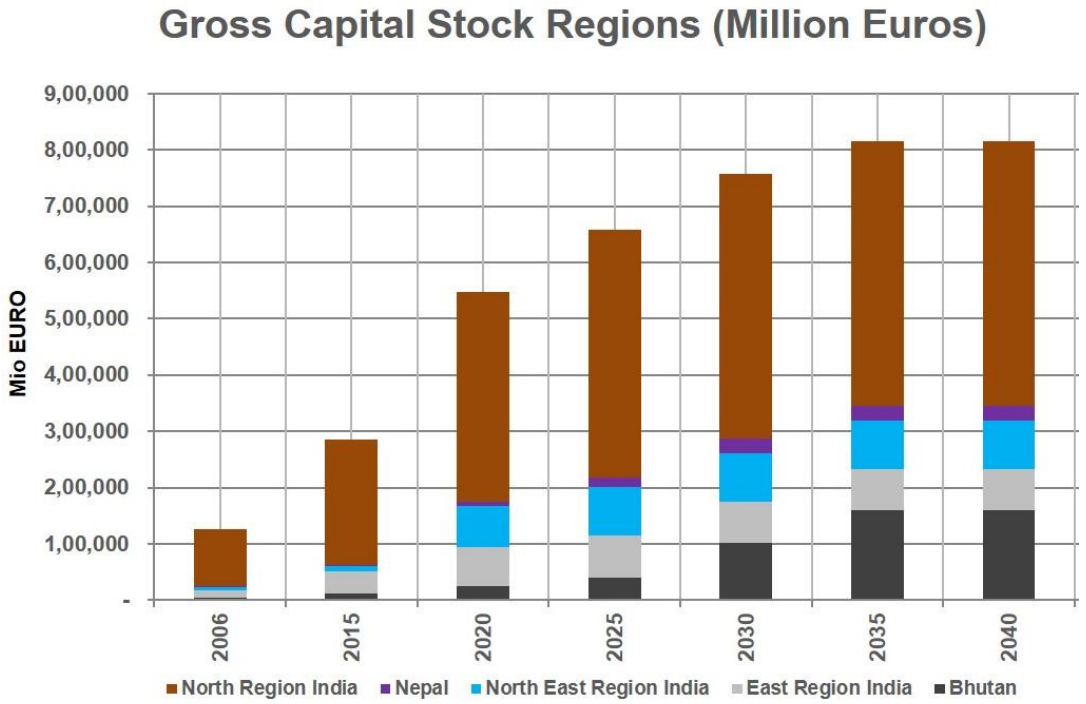
Load flow differences:

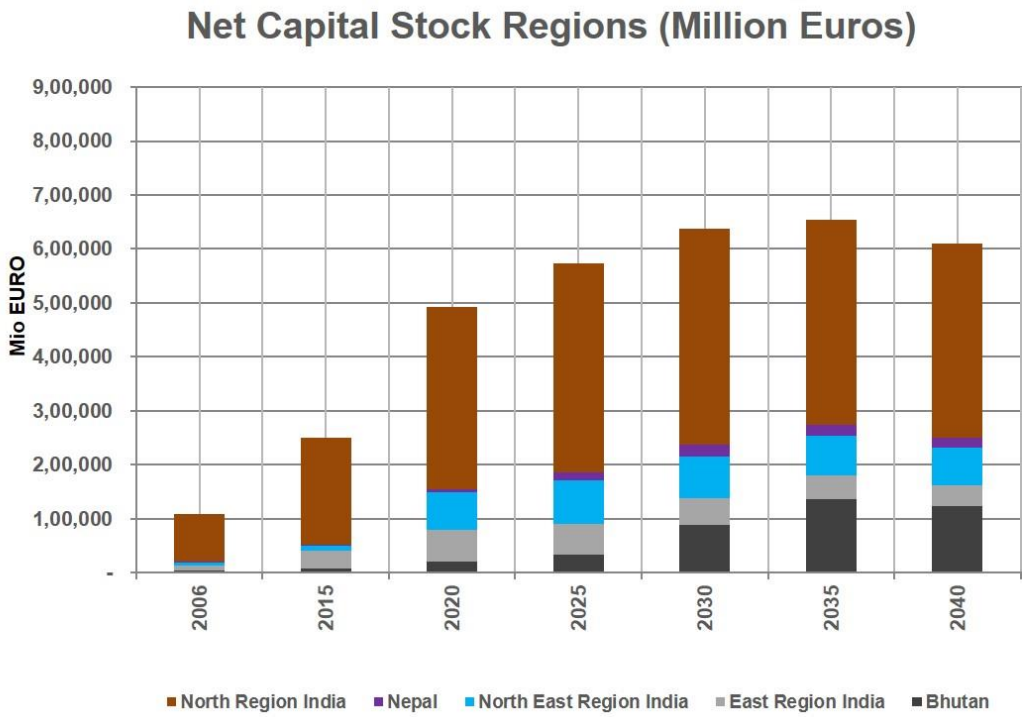




Economic Benefits : Capital Stock calculations

- Capital Stock : ‚Wealth' of the power system (for generations to come)
- Overall increase in capital stock of the regional power sectors:
  - Bhutanese and Nepalese power sectors benefit





Conclusions

- Hydropower installations in Nepal and Bhutan : Positive Impact
- Large influence : load flows in the overall transmission network
- Nepal : proposed 220kV ‚Electrical Highway' is critical
- CB transmission capacity increase : Definitely alleviates congestion
- PHP possibilities : definitely approachable strategy
- Gross and Net Capital Stock : Nepal and Bhutan get a huge improvement

Danke für Ihre Aufmerksamkeit!

M.Sc. **Karthik Bhat**

Technische Universität Graz
Institut für Elektrizitätswirtschaft und Energieinnovation
Inffeldgasse 18
8010 Graz

Tel.: +43 316 873 7908
Fax: +43 316 873 107908

Email: karthik.bhat@tugraz.at
Web: iee.tugraz.at