



## Economic Cost-Benefit Analysis of distribution modernization and smart grid introduction, Case Study Bangladesh

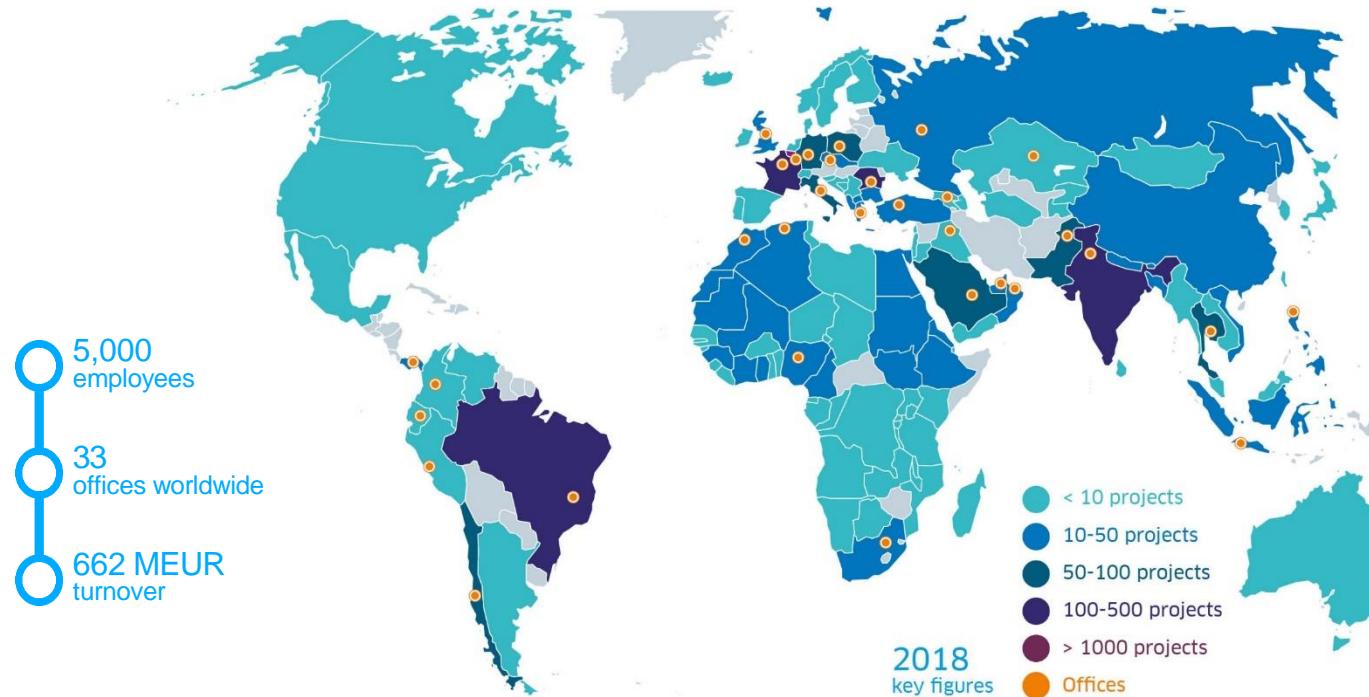
Johanna Geuppert  
Essen, November 2019

Feasibility Study

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- 2 Current Grid Situation
- 3 Implemented Technology
- 4 Advantages vs. Costs
- 5 Results and Conclusion

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# Introduction

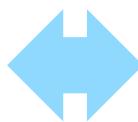
## Overview of the Project

- Project:
  - Modernizing substations
  - Grid expansions
  - Centralized grid observation
- Client developing country Bangladesh:
  - Distribution level Westzone area
  - Size: 1060 MW upgraded to 1500 MW
- Project sponsor KfW:
  - Greenhouse gas reduction
  - Social Welfare improvement

# Introduction

## Content of an Economic vs. Financial Analysis

Evaluation of an EA\* refers to the social welfare by an investment



Evaluation of a FA\*\* refers to the financial benefit of the project's sponsor

- The EA enables a holistic view to the country's economy itself → indirect und direct costs are included
- It includes quantitative und qualitative aspects

The results of the EIRR\*\*\* can be positive



The result of the IRR\*\*\*\* can be negative even for the same project

\*ÖA (Ökonomische Analyse); FA\*\* (Finanzielle Analyse); \*\*\*EIRR (Economic IRR); \*\*\*\*IRR (Internal Rate of Return)

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# Current Grid Situation

## Germany

- Integration of distributed and fluctuating renewables at distribution level
- Maintaining grid stability
- High expectation towards low SAIDI (13,91 minutes/year\*)
- Short supply interruption already leading to high economic costs
- Increasing comfort in handling various devices (eg: Smart Home)
- Increasing energy efficiency

\*[https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen\\_Institutionen/Versorgungssicherheit/Versorgungsunterbrechungen/Auswertung\\_Strom/Versorgungsunterbrech\\_Strom\\_node.html](https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Versorgungssicherheit/Versorgungsunterbrechungen/Auswertung_Strom/Versorgungsunterbrech_Strom_node.html)

# Current Grid Situation

## Bangladesh

- Blackouts durations of up to several hours
  - Reasons: No automatization, overload, old and vulnerable grid components
  - Solution: private energy generation by small diesel generators (more expensive and higher  $CO_2$  – factor)
- New consumer integration to the grid
  - Sharply increasing electrification rate
  - Highly densely populated country → Many connection points towards one substation
  - Pedelecs in conurbations
  - No distributed renewables integration

# Current Grid Situation

## Bangladesh – Condition in Conurbations



# Current Grid Situation

## Bangladesh – Condition of Substations



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# Implemented Technology

- Renovation works at middle voltage substations
  - 22 substations at 33kV level
  - Automated Meter Reading Systems integration
  - Replacement typical substation components (Switchgear, closing Lacks...)
- Grid Expansion
  - 300 km new overheadlines
  - 138 capacitors
- SCADA Systems (& corresponding telecommunication infrastructure)

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# Benefits vs. Costs

## Economic Benefits

- Reduction Losses
    - By renovation works at substations
    - By new overheadlines
    - By capacitors (Power Factor)
  - Reduction supply interruptions (SAIFI / SAIDI)
    - By renovation at substations and overheadlines
    - By capacity expansion
    - By the prevention of system's faults (SCADA)
- $CO_2$  –emission reduction (Social Cost of Carbon (SCC))
  - Reduction on energy not served (Cost of Unserved Energy)
  - $CO_2$  –emission reduction (SCC)
  - Economic growth (Energy Productivity)

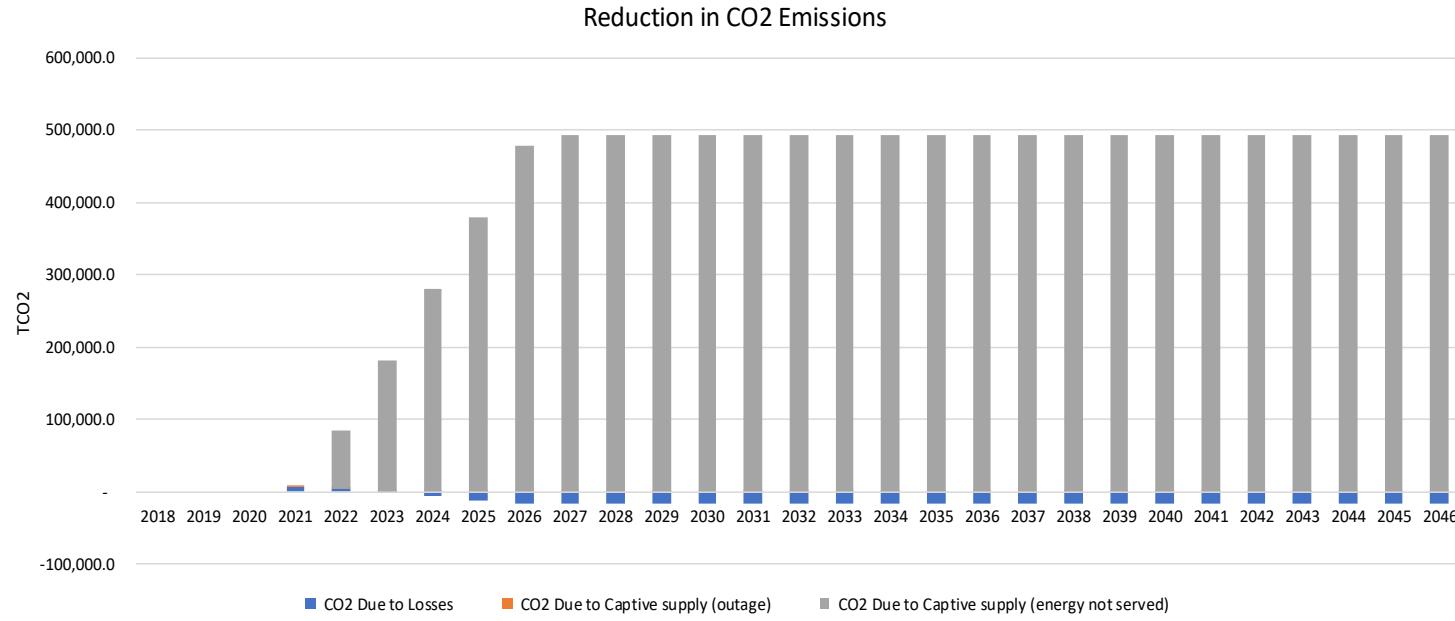
# Benefits vs. Costs

## Economic Benefits

- Reduction operation costs
  - By substation automation
- Reduction maintenance costs
  - By implementation of new grid components

# Benefits vs. Costs

## Greenhouse Gas Emission Reduction



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# Results and Conclusion

## IRR / NPV / GHG Emissions (CO2 equivalents)

### Economic Scenario Results

Indicator	Demand	Results in numbers
Economic IRR		292%
Economic NPV	High Growth	2,483,094
Reduced CO2 Emissions		10,902,844
Economic IRR		160%
Economic NPV	Medium Growth	2,236,013
Reduced CO2 Emissions		10,551,545
Economic IRR		97%
Economic NPV	Low Growth	1,923,739
Reduced CO2 Emissions		10,004,816

# Results and Conclusion

## Main Findings in the difference of value adding

- First Priority is enabling a stable energy supply for basic application (lights, cooking, heating, ...)
- Power consumption will increase by modernization works → increases economical real activity
- Despite increasing power consumption energy efficiency increases as well
- Modernizing and Automatization necessary for current improvement and future investments in case of increasing distributed renewables

**Many thanks to your attention!**

# Einführung

## Ziele

- Einführung Energiesektor Entwicklungsland
- Erläuterung des Nutzens für die Bevölkerung eines Entwicklungslandes durch Modernisierungsprojekte
- Ausarbeitung der ökonomischen: Entwicklungslandes vs. Industrieland

# Einführung

## Projekt Übersicht

- Kunde Entwicklungsland Bangladesch:
  - Verteilungsebene
  - Westzone
  - Größe: 1060 MW zu 1500 MW Spitzenlast
  - Anlagen frühe 80er
  - Manueller Betrieb der Netze

# Introduction

## Difference of an Economic and Financial Analysis

### Ökonomische Analyse

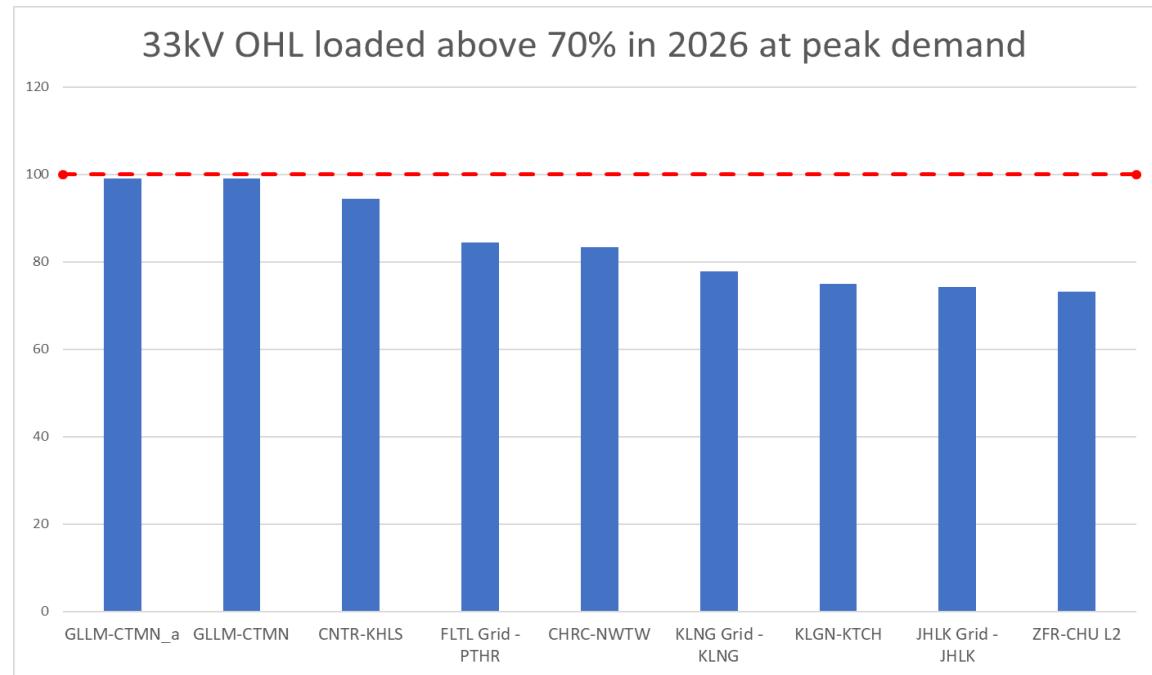
- Bewertet auf Basis des größtmöglichen Nutzens der Ressourcen eines Landes
  - Führt die Analyse aus Sichtpunkt der nationalen Ökonomie weshalb
    - Inflation,
    - Steuern,
    - Zölle
- Und weitere Faktoren welche die Marktbewertung verzerren **nicht beachtet werden**

### Financial Analysis

- Bewertung der finanziellen Durchführbarkeit und der finanziellen Attraktivität des Investments. Die Analyse wird aus Sicht der Projektponsoren unter Berücksichtigung der Erwartungen der Schuldner, Aktionäre usw. durchgeführt.
  - Inflation,
  - Steuern,
  - Finanzierungskosten,  
etc. **werden beachtet**

# Eingesetzte Technologie Netzbelastung vor Projektimplementierung

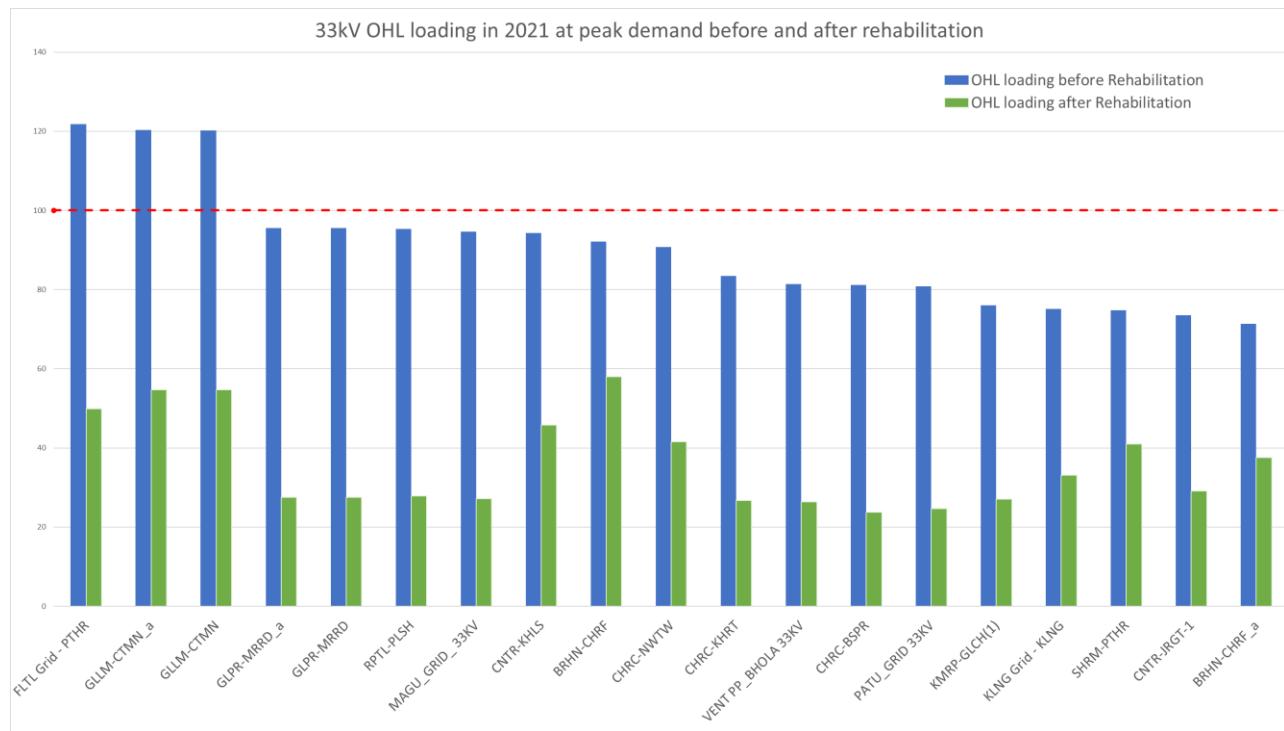
Reduktion der  
Freileitungsbelastung



# Eingesetzte Technologie

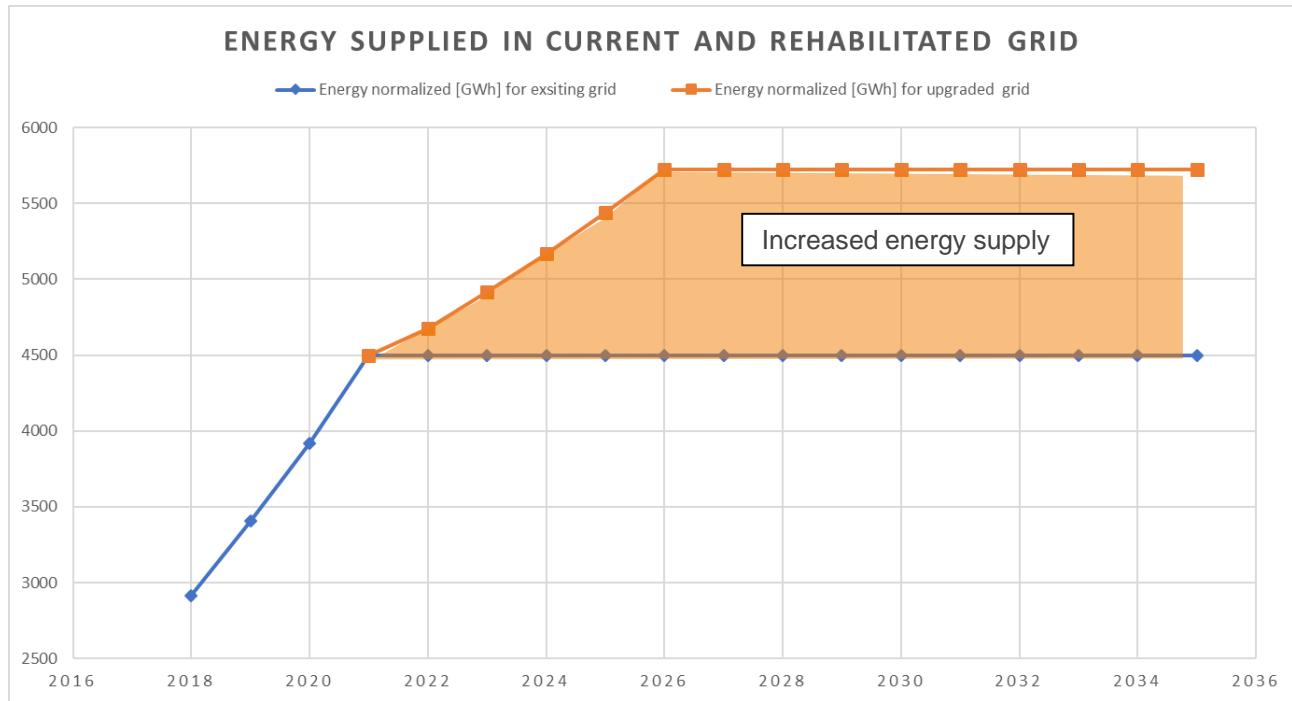
## Netzbelastung nach Projektimplementierung

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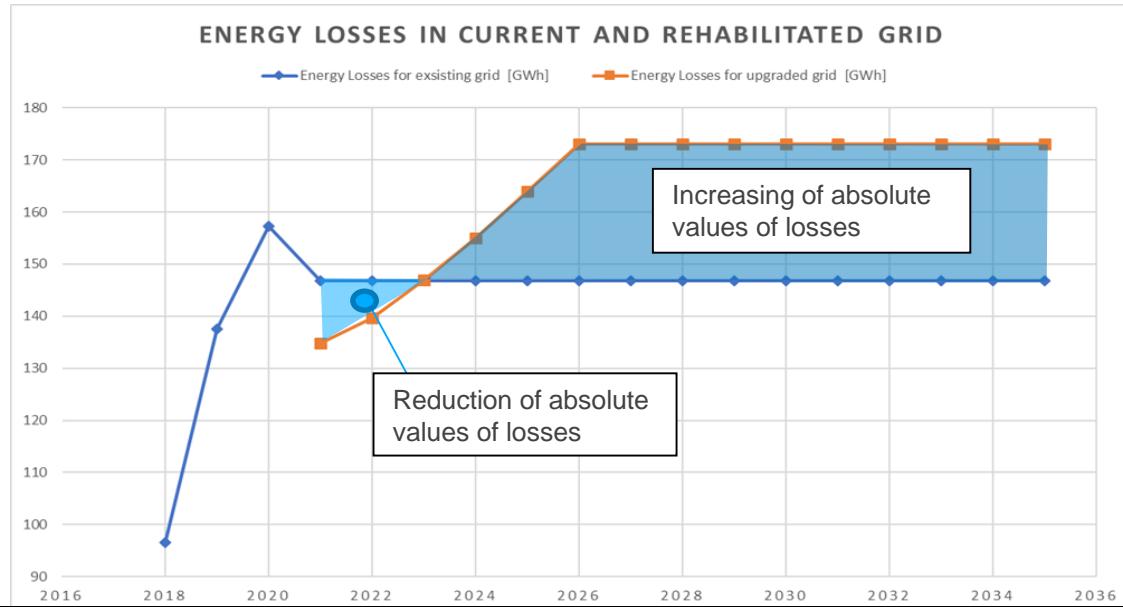
# Eingesetzte Technologie Einfluss der Energieeffizienz

Increasing of Energy Power Supply



# Eingesetzte Technologie Einfluss der Energieeffizienz

Energie Verlust Reduktion in Prozent zum Energieverbrauch

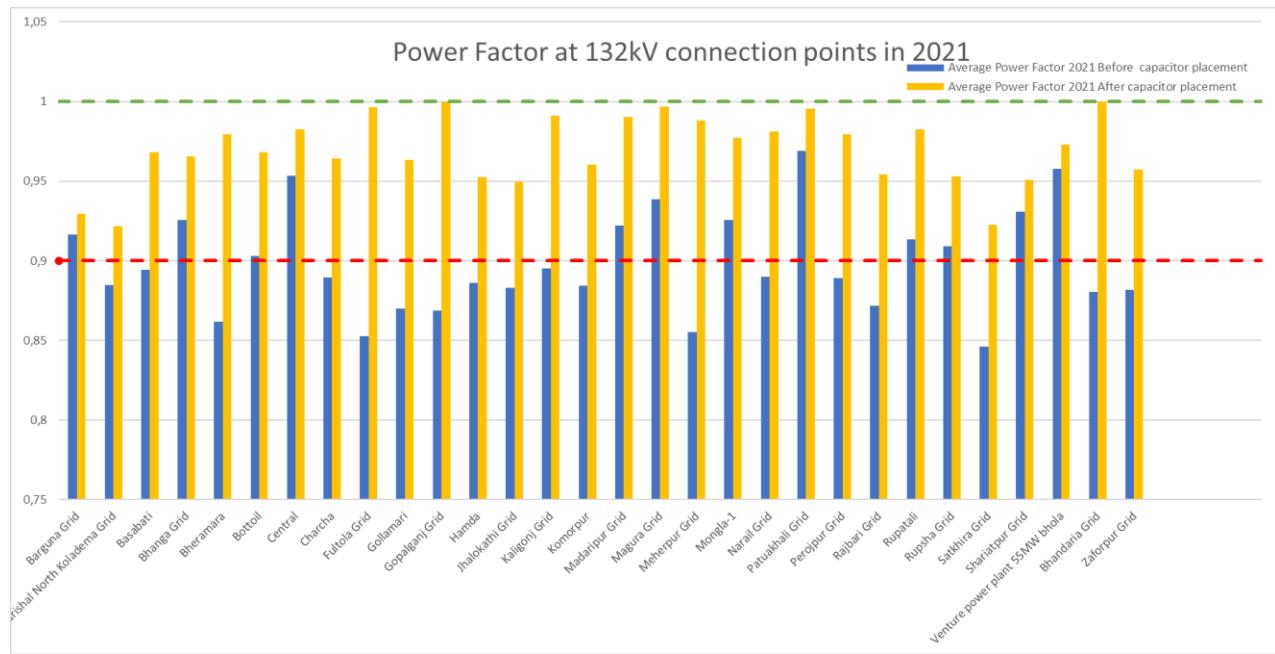


	2018	2019	2020	2021	2022	2023	2024	2025	2026
Delta Energy Supplied by KfW Rehabilitation Program [GWh]	-	-	-	0	181,2583	420,5157	671,0726	943,2785	1223,743
Energy Losses reduction due to KfW rehabilitation Program [GWh]	-	-	-	11,95696	7,138668	-0,158459	-8,16073	-17,10161	-26,2258
System Energy loss [%]	3,3141282	4,0360291	4,014789	3,264245	2,985187	2,988335	2,998296	3,012621	3,024417

# Eingeführte Technologie Einfluss der Kapazitoren

## Improvement of Power Factor

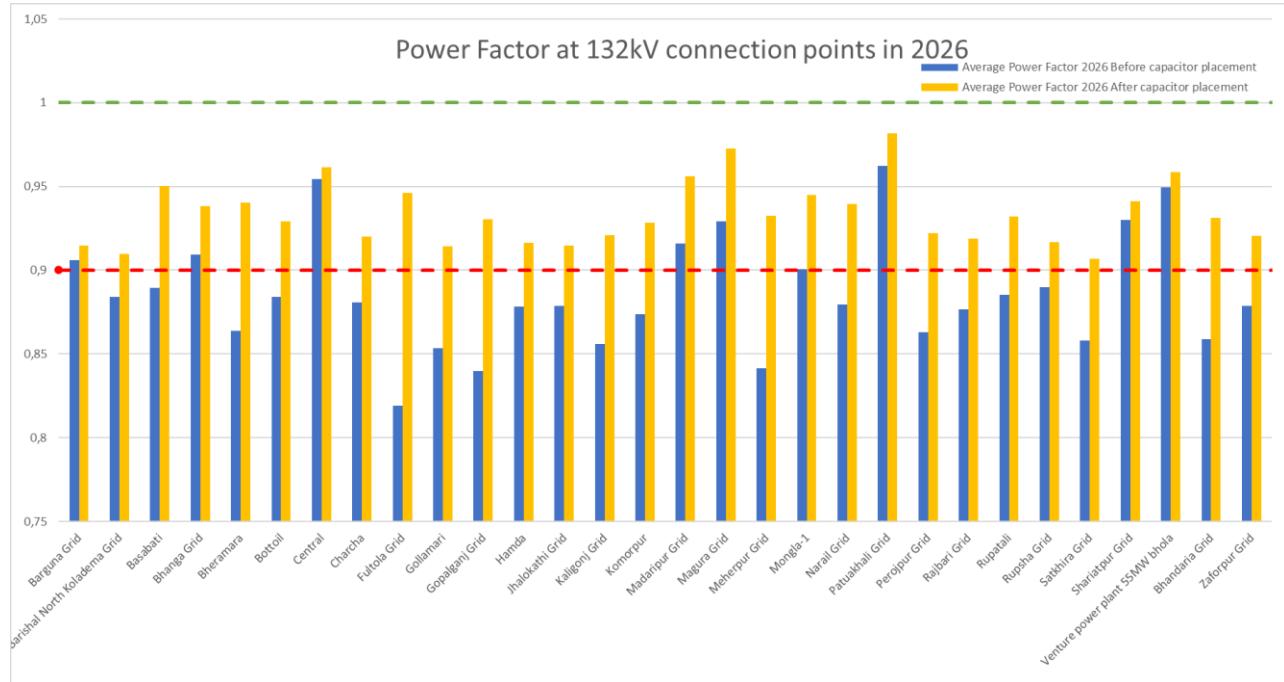
The placement of capacitor banks improved the power factor at the Point of Common Coupling with the Transmission system above the requested 0.9.



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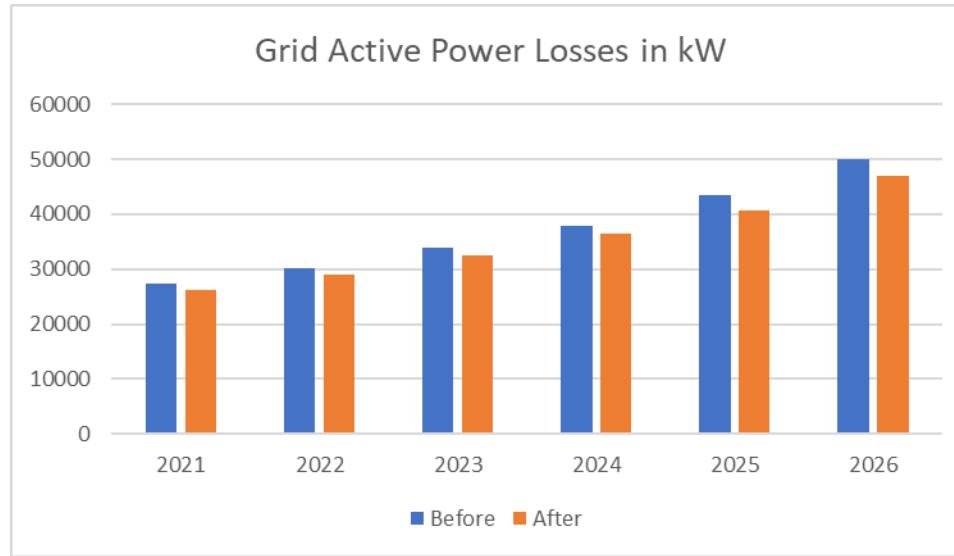
## Improvement of Power Factor

The placement of capacitor banks improved the power factor at the Point of Common Coupling with the Transmission system above the requested 0.9.



# Eingeführte Technologie Einfluss der Kapazitoren

## Reduction of Active Power Losses



# Implemented Technology

## Definition Smart Grid

- In General technologies that fullfill following functions:
  1. Measure-
  2. Communication-
  3. Control technolgies
- Technologies under these requirements in developing countries
  - a. Supervisory and Data Acquisition Systems
  - b. Automated Meter Reading Systems

# Benefits vs. Costs

## Economic Benefits

- Reduction Losses
- Reduction supply interruptions / blackouts
- Reduction power factor losses
- Reduction Operation Costs
- Reduction small diesel generator produced current
- Reduction  $CO_2$ -emissions

# Results and Conclusion

## Economic Results

Social  
Discount  
Rate

Net Economic Benefit of Investment	TEUR	Net Benefit	Discounted Net benefit
		7,931,675	3,018,758
Investment Costs	TEUR	(91,117)	(79,593)
Losses	TEUR	(26,758)	(9,390)
Outages	TEUR	(240)	(51)
Power Factor Charge	TEUR	7,347	3,073
Social Cost of Carbon	TEUR	169,088	59,958
Economic Value of Energy Not Served	TEUR	7,861,274	3,039,040
Maintenance Cost	TEUR	12,081	5,722
Substation Maintenance Costs	TEUR	10,853	4,478
SCADA Maintenance Cost	TEUR	(4,042)	(1,483)
OHL Maintenance Cost	TEUR	5,269	2,727

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