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ELECTRIFICATION IN DEVELOPING COUNTRIES

UTILITIES, SCALING RENEWABLE GENERATION, AND ACCESS: CHALLENGES AND LESSONS LEARNED

ELECTRIC UTILITIES: THE KEY TO SUSTAINABLE ELECTRIFICATION

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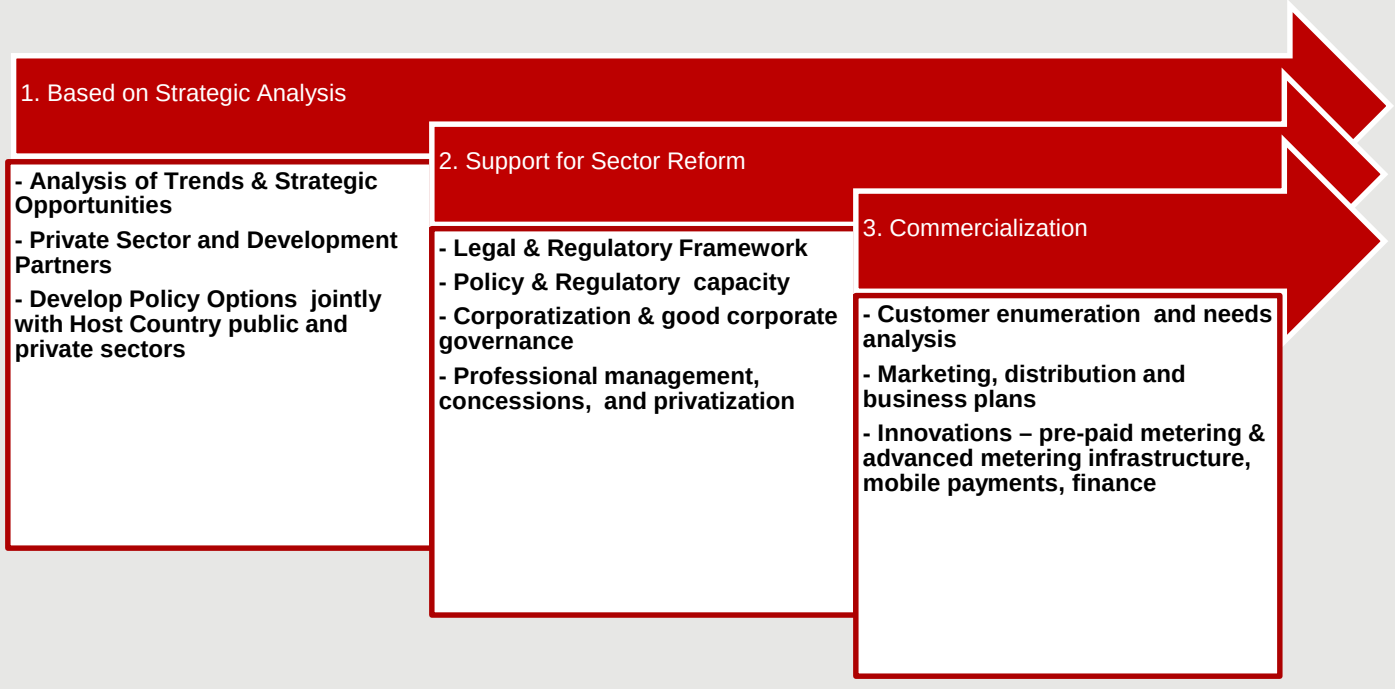
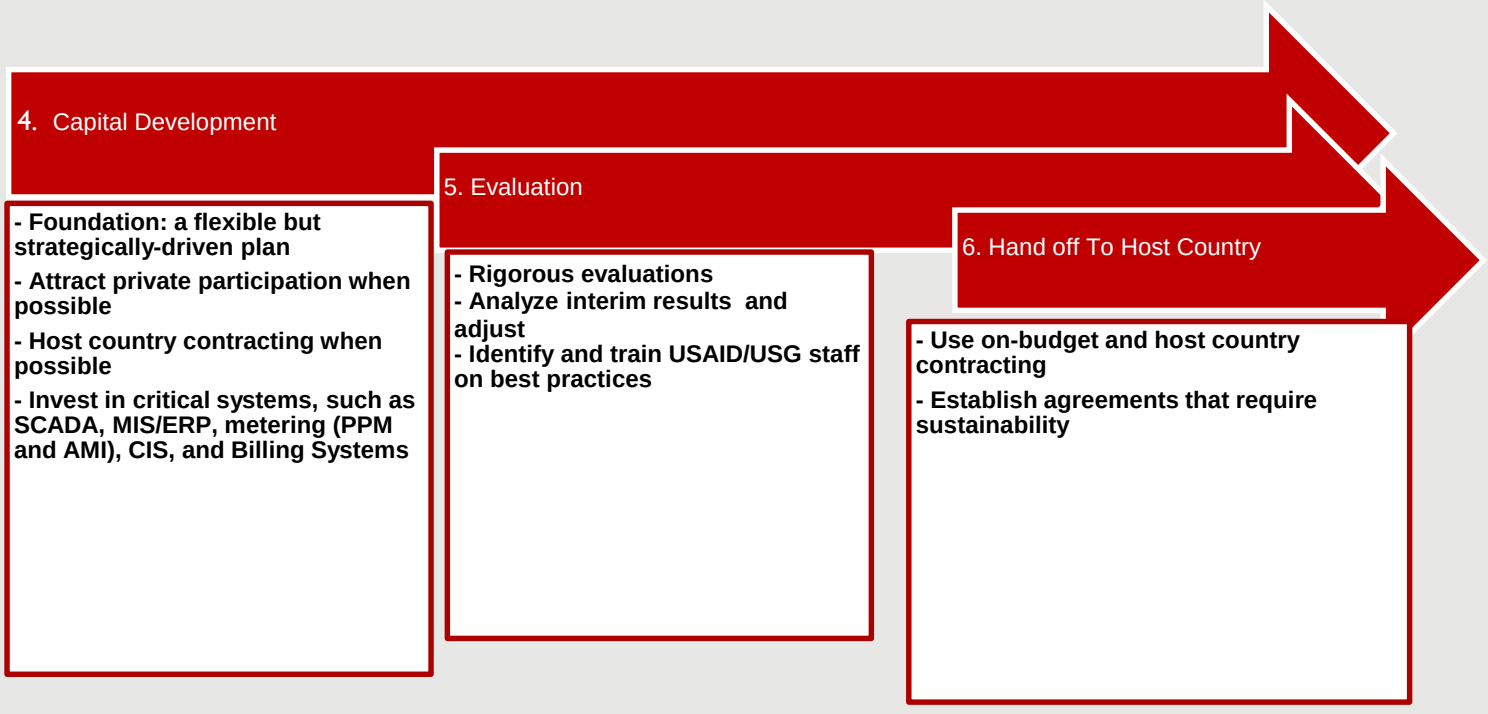
USAID'S APPROACH TO POWER SECTOR REFORM (1)



USAID'S APPROACH TO POWER SECTOR REFORM (2)



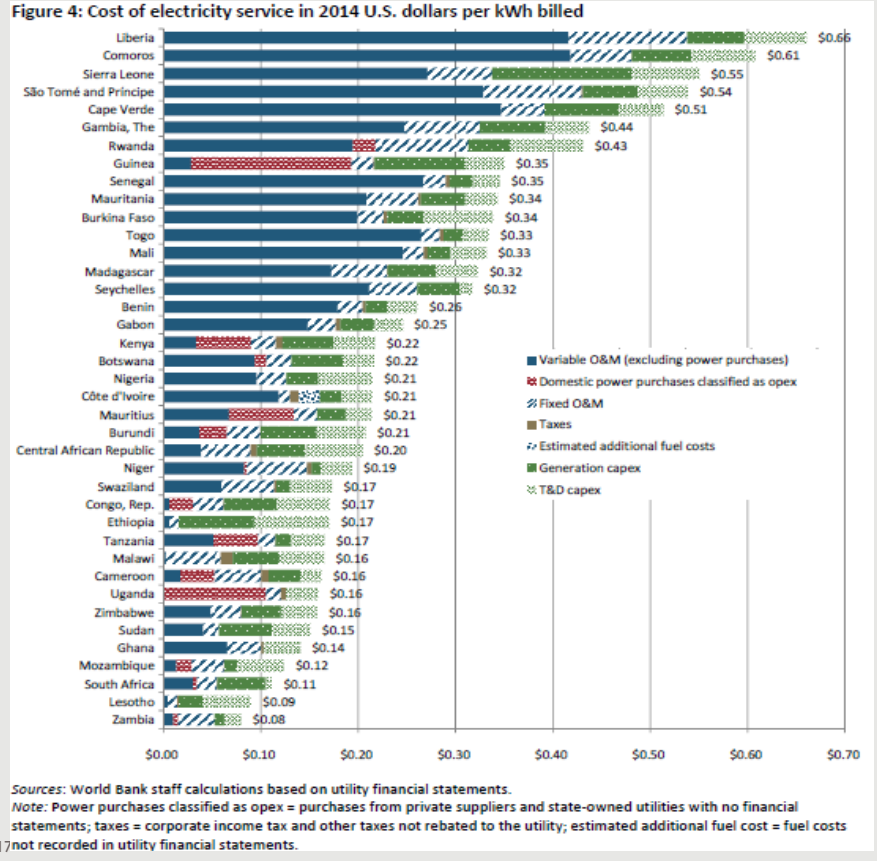
ELECTRIC UTILITY REFORM AGENDA

- Typical Interventions:
  - Institutional Reform – State Company Best Practices/IPO of 15-20% of shares in 3-5 years
  - HR/Change Management/Training/Position Descriptions & Salaries/Promotions
  - Modern IT Platform/MIS/Enterprise Resource Planning(ERP)
  - CIS/Billing System/GIS/Customer Enumeration
  - Commercial Improvements/PPM/AMI Metering & Meter Reading/Anti-Theft Campaign
  - Technical Loss Reduction – Feeder Replacement, Congested Area Strategies
  - Cost of Service - Rates & Revenue Department
  - Corporate Communications/Consumer Services/Marketing
  - DSM/Load Management/Distribution-level SCADA
  - Finance/Internal Audit.

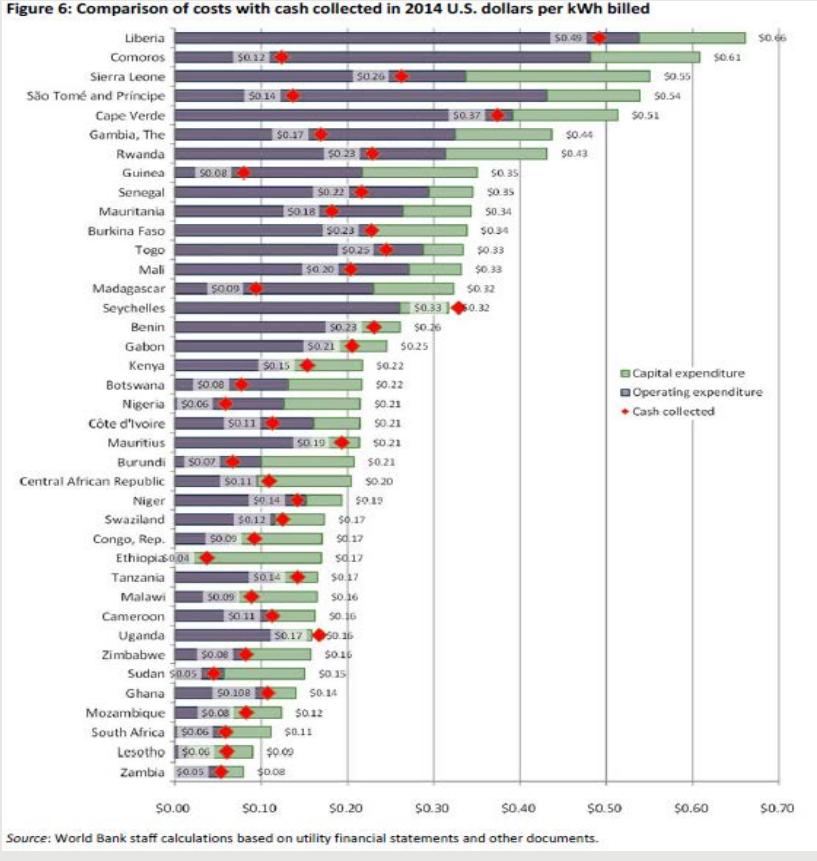
ELECTRIFICATION IN SSA: SCALE OF CHALLENGE

- The scale of the challenge is driving the search for solutions:
  - Approximate population of Sub-Saharan Africa is 1 billion.
  - 600-650 million people are without access to electricity. Millions more lack access to reliable power.
  - Massive dependence on wood and charcoal for cooking (estimated $1 billion spent in Kinshasa, DRC every year on charcoal alone; $700 million in Tanzania).
  - In relatively affluent parts of countries such as Nigeria, there is a large market for household and industrial diesel generators and fuel.
  - Electric utility grid extension, mini-grids, solar home systems, and propane are making inroads.
  - Countries have sovereign debt ratings below investment grade, sharply limiting access to capital for governments, state-owned enterprises, and investor-owned enterprises.

ELECTRIC UTILITIES IN SUB-SAHARAN AFRICA



Sources: World Bank staff calculations based on utility financial statements.
Note: Power purchases classified as opex = purchases from private suppliers and state-owned utilities with no financial statements; taxes = corporate income tax and other taxes not rebated to the utility; estimated additional fuel cost = fuel costs not recorded in utility financial statements.



Source: World Bank staff calculations based on utility financial statements and other documents.

Source: "Financial Viability of Electricity Sectors in Sub-Saharan Africa," World Bank, August 2016

CATEGORIZATION OF ELECTRIC UTILITIES:

- **Level of Financial Viability**
  - Level 1: Not covering existing opex.
  - Level 2: Utility covers at least existing opex.
  - Level 3: Utility covers opex plus financing costs on new concessional loans.
  - Level 4: Utility covers opex and capex on existing and new assets.

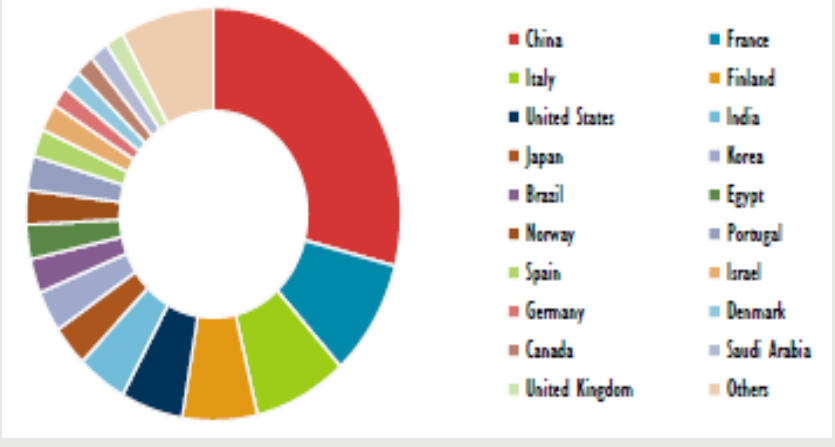
- **Financeability/Bankability**
  - Financially unviable, loss-making utility.
  - Dependent on government for capital.
  - Utility dependent on concessional loans.

  - Utility can attract non-concessional finance and private investment
  - Expands network and adds new customer connections at will.

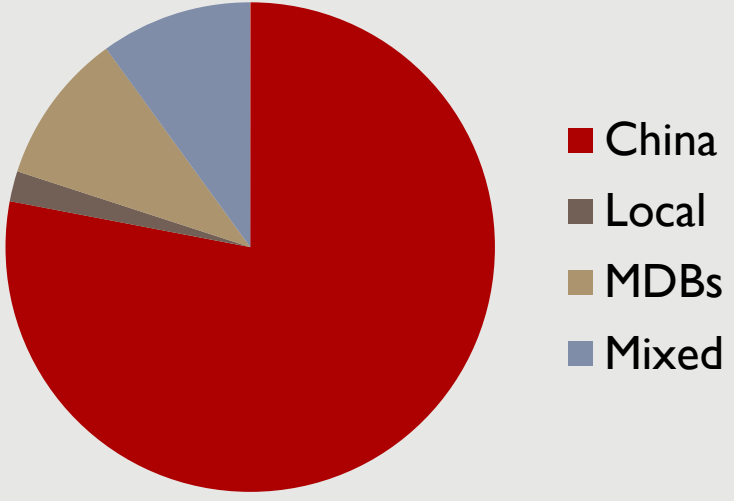
Source: "Financial Viability of Electricity Sectors in Sub-Saharan Africa," World Bank, August 2016

BUILDING & FINANCING SSA POWER GENERATION

EPC Contractors by Corporate HQ



Chinese Financing Sources



Note: 2010-2015 Data gathered by OECD/IEA for projects above 10 MW excluding solar & wind

Source: "Boosting the Power Sector in Sub-Saharan Africa: China's Involvement," OECD/IEA, 2016

SCALING RENEWABLE ENERGY: GLOBAL TRENDS AFFECTING DECISIONS

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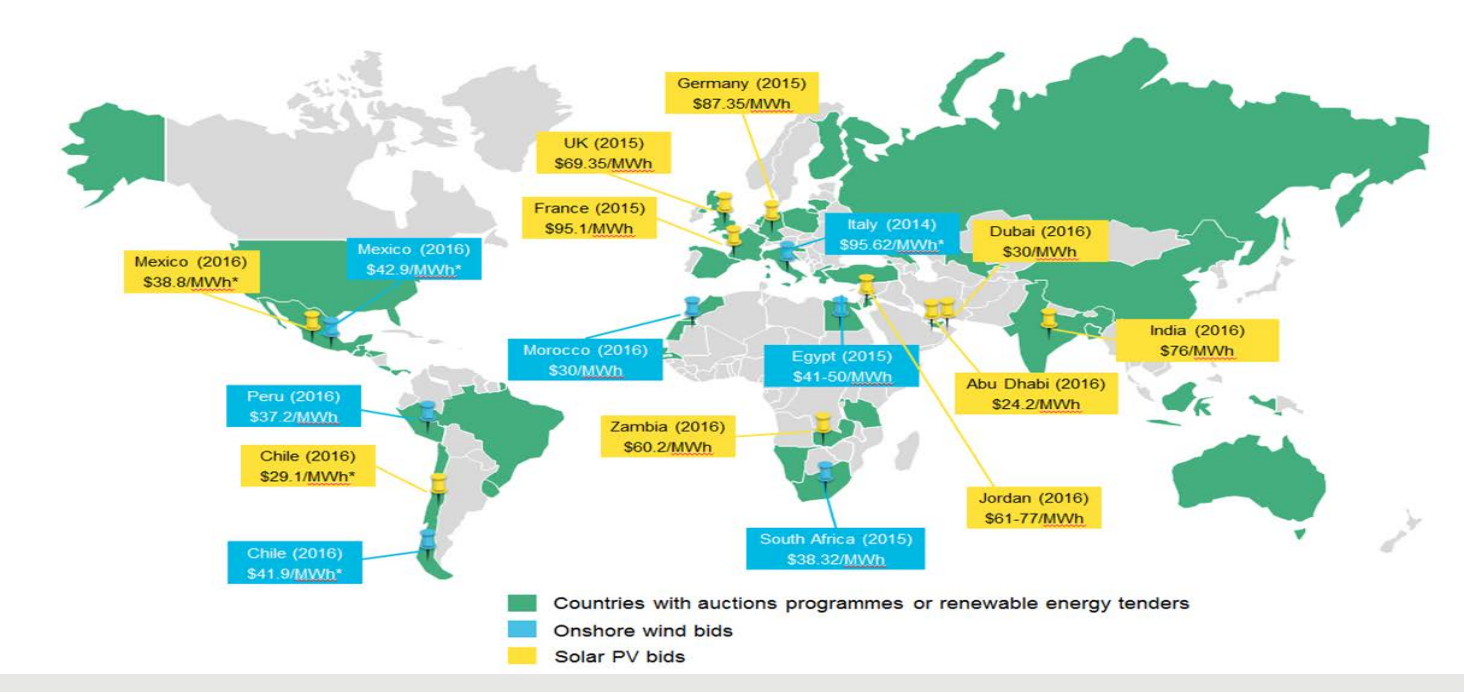
GLOBAL TRENDS: REVERSE AUCTIONS & COMPETITIVE TENDERS



- **Competition has driven down costs and prices**
- **Allowed the market to determine price**
- **Reverse auctions have streamlined the procurement process**
- **Led to an improved planning horizon for renewable energy developers**

SCALING RENEWABLE ENERGY: THE BUILDING BLOCKS APPROACH

- Supporting the addition of thousands of MW of Renewable Energy
- Increasing the percentage of lowest cost Renewable Energy in total installed capacity (MW) and in total electricity delivered (MWh)
- Establishing the building blocks:

ELECTRIFICATION VIA OFF-GRID SOLUTIONS: SEARCHING FOR SCALABILITY

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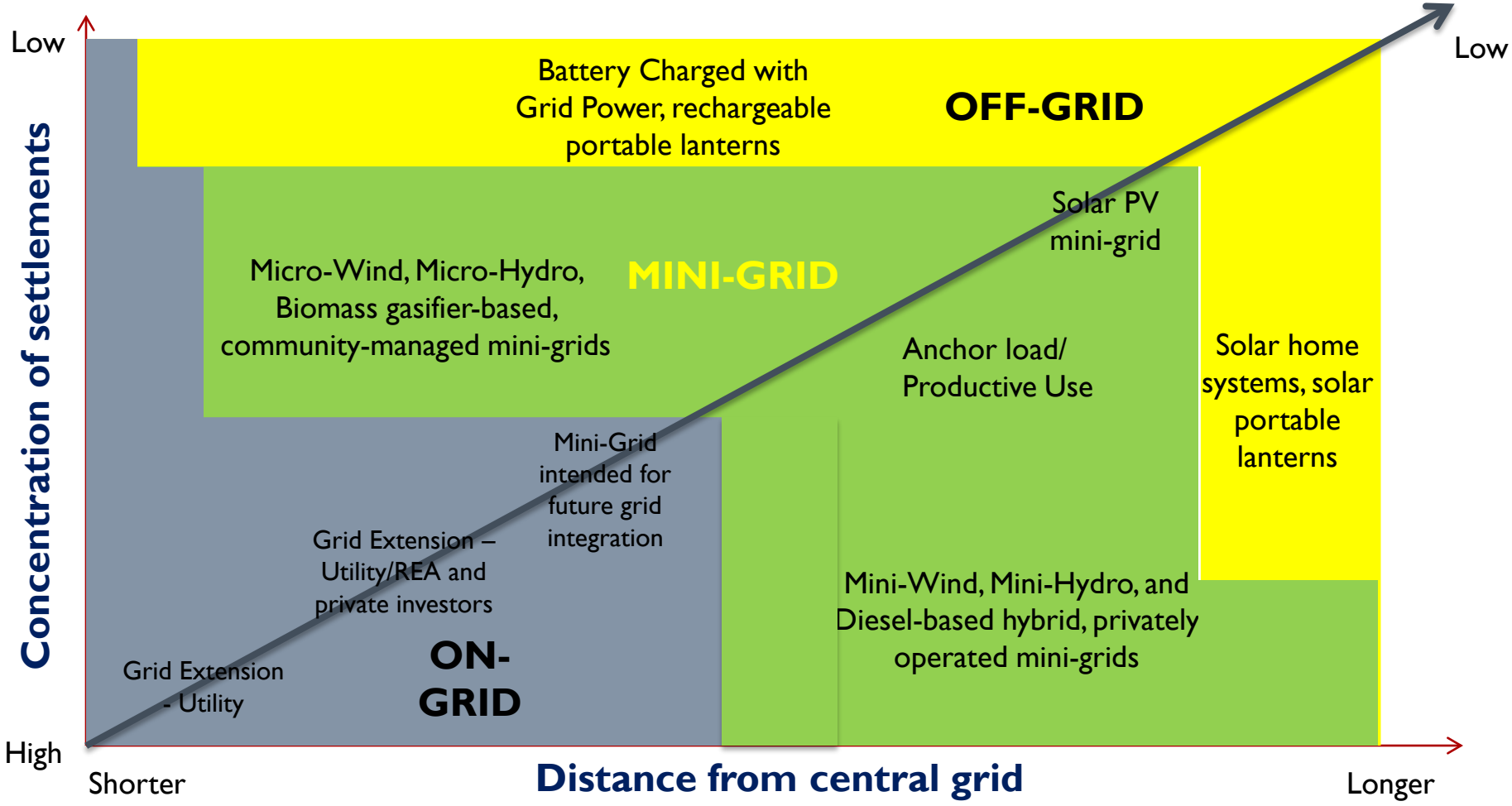
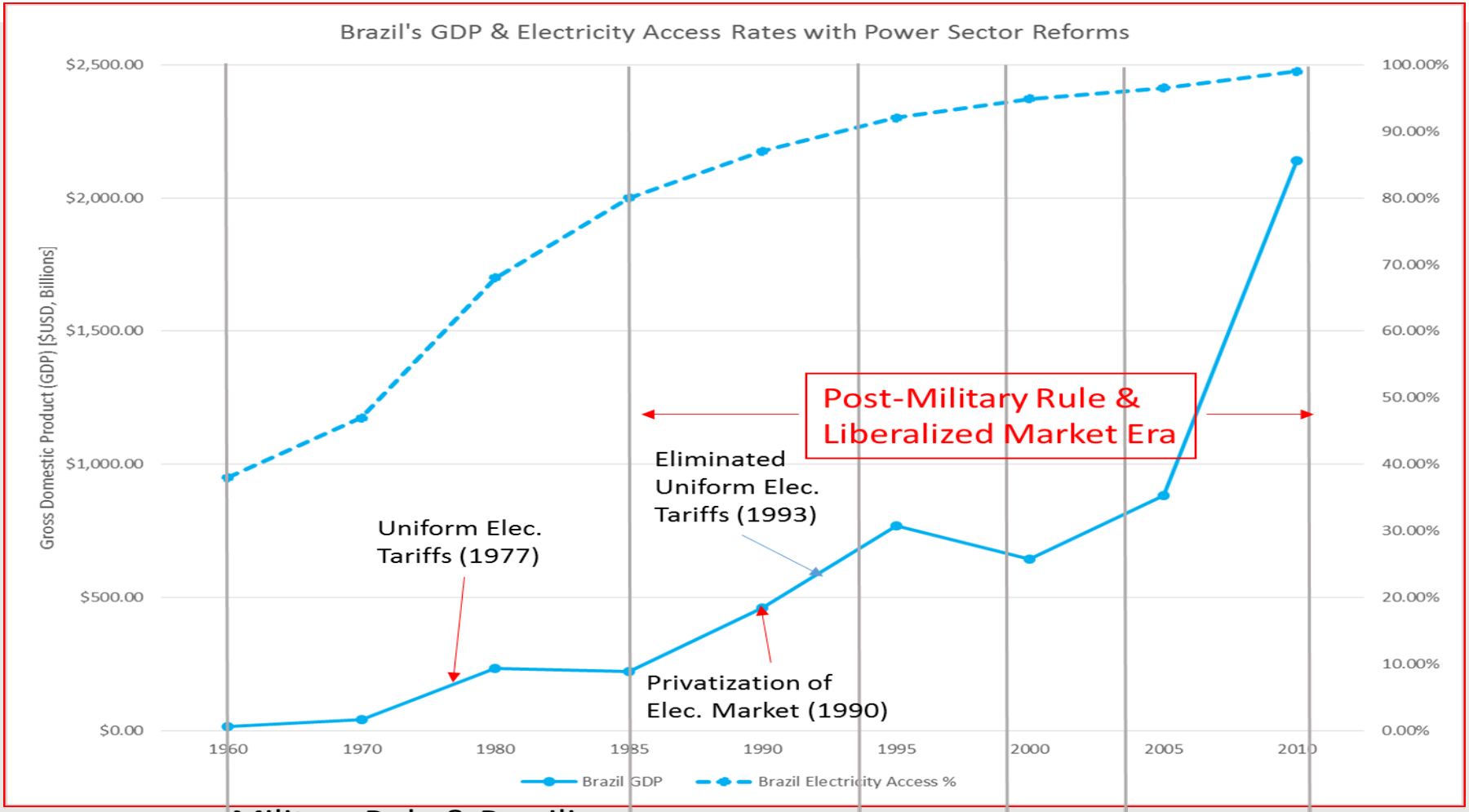
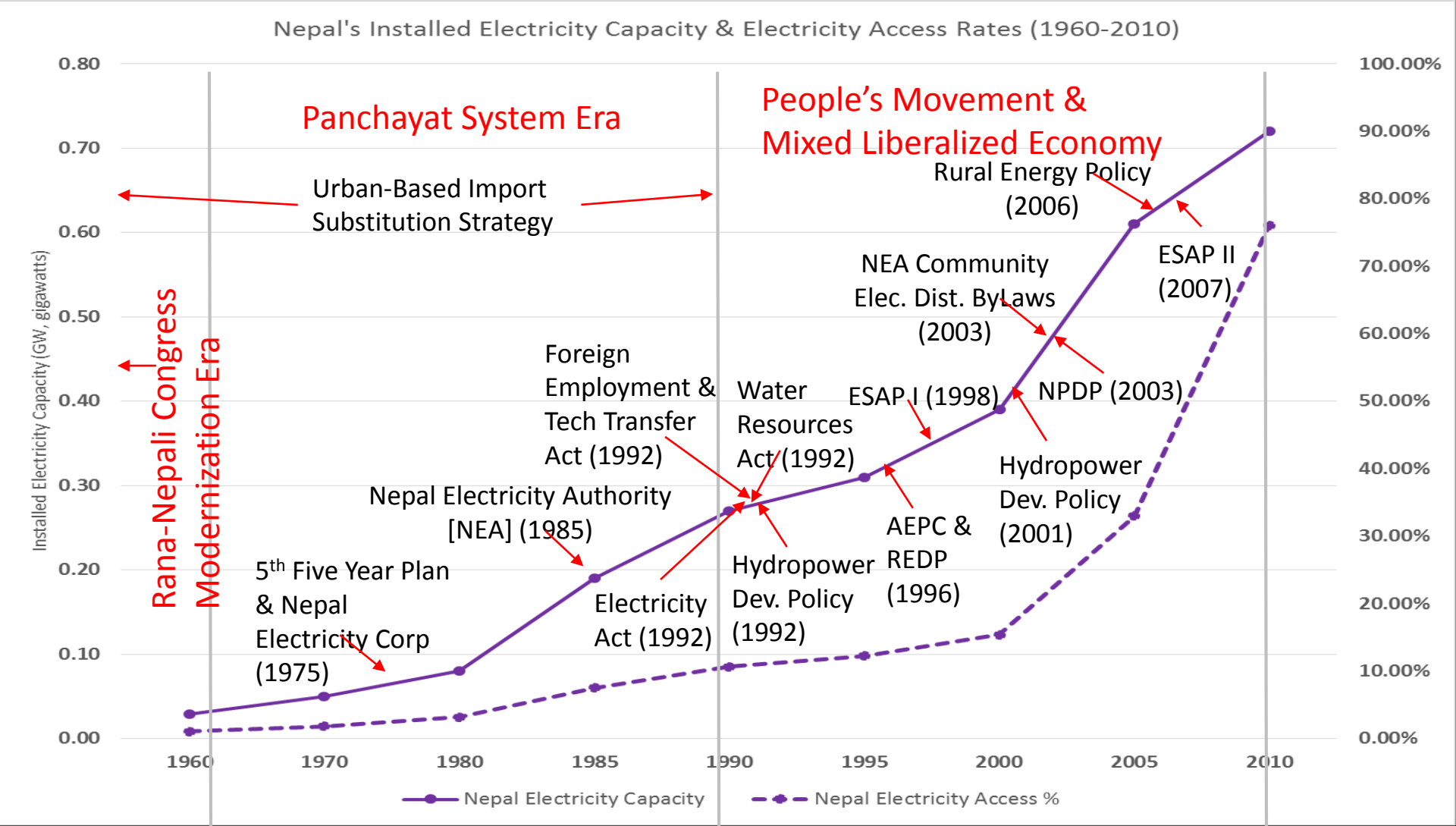

Low
Concentration of settlements
High
Low
Battery Charged with Grid Power, rechargeable portable lanterns
OFF-GRID
Micro-Wind, Micro-Hydro, Biomass gasifier-based, community-managed mini-grids
MINI-GRID
Solar PV mini-grid
Anchor load/ Productive Use
Solar home systems, solar portable lanterns
Mini-Grid intended for future grid integration
Grid Extension – Utility/REA and private investors
Mini-Wind, Mini-Hydro, and Diesel-based hybrid, privately operated mini-grids
Grid Extension - Utility
ON-GRID
Shorter
Distance from central grid
Longer


Brazil's GDP & Electricity Access Rates with Power Sector Reforms
Gross Domestic Product (GDP) [$USD, Billions]
$2,500.00
$2,000.00
$1,500.00
$1,000.00
$500.00
$0.00
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
1960
1970
1980
1985
1990
1995
2000
2005
2010
Post-Military Rule & Liberalized Market Era
Eliminated Uniform Elec. Tariffs (1993)
Uniform Elec. Tariffs (1977)
Privatization of Elec. Market (1990)
Brazil GDP
Brazil Electricity Access %
Military Rule & Brazilian Economic Miracle
PRODEEM
Luz No Campo
Light for All


Nepal's Installed Electricity Capacity & Electricity Access Rates (1960-2010)
Installed Electricity Capacity (GW, gigawatts)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
1960
1970
1980
1985
1990
1995
2000
2005
2010
Panchayat System Era
People's Movement & Mixed Liberalized Economy
Urban-Based Import Substitution Strategy
Rana-Nepali Congress Modernization Era
Rural Energy Policy (2006)
ESAP II (2007)
NEA Community Elec. Dist. ByLaws (2003)
NPDP (2003)
ESAP I (1998)
Foreign Employment & Tech Transfer Act (1992)
Water Resources Act (1992)
Nepal Electricity Authority [NEA] (1985)
Hydropower Dev. Policy (2001)
AEPC & REDP (1996)
5th Five Year Plan & Nepal Electricity Corp (1975)
Electricity Act (1992)
Hydropower Dev. Policy (1992)
Nepal Electricity Capacity
Nepal Electricity Access %

Common Features of Successful Access Initiatives

- Consistent, centralized funding and support and ongoing sector reform
- "walking on two legs" – Decentralized and centralized approaches
- Prioritized agricultural production areas
- Consolidation of mini- and micro-grids on to integrated grid system

Other Features of Successful Programs

- Investment in large-scale Generation and Transmission assets to drive distribution investment (Brazil, Ghana)
- Emphasis on productive use, especially industrialization (Brazil, Ghana, China)

Governance Models – Grid Expansion

- Private Concessionaires: Chile, Brazil, Guatemala
- Cooperatives: U.S., Costa Rica, Bangladesh
- Government REA Led: Tunisia, Thailand, Vietnam

Micro-grid Management and Ownership Models

Cooperatives	Private Investors	Utility/REA	Hybrid
Strengths: • Investment by communities in cash and kind.	Strengths: • Attracts private investment	Strengths: • Experienced in utility operation	Strengths: • Benefit from strengths of multiple models.
Challenges: • Attracting financing. • Capacity for O&M • Can't raise tariffs	Challenges: • High tariffs, need to earn ROE. • Community buy-in and conflict.	Challenges: • Low priority. • Private investment difficult	Challenges: • Added complexity and increases tariff.
Sri Lanka, Mali, Nepal, Philippines	Cambodia, Mali, Senegal, Tanzania	Indonesia, Tanzania, Colombia, Ghana	Nepal, Pakistan

Technology Challenges

- Load Management/System control (Voltage, Power Quality)
- Hybrid system control electronics
- Storage
- DC standards and appliances
- Low cost wiring solutions

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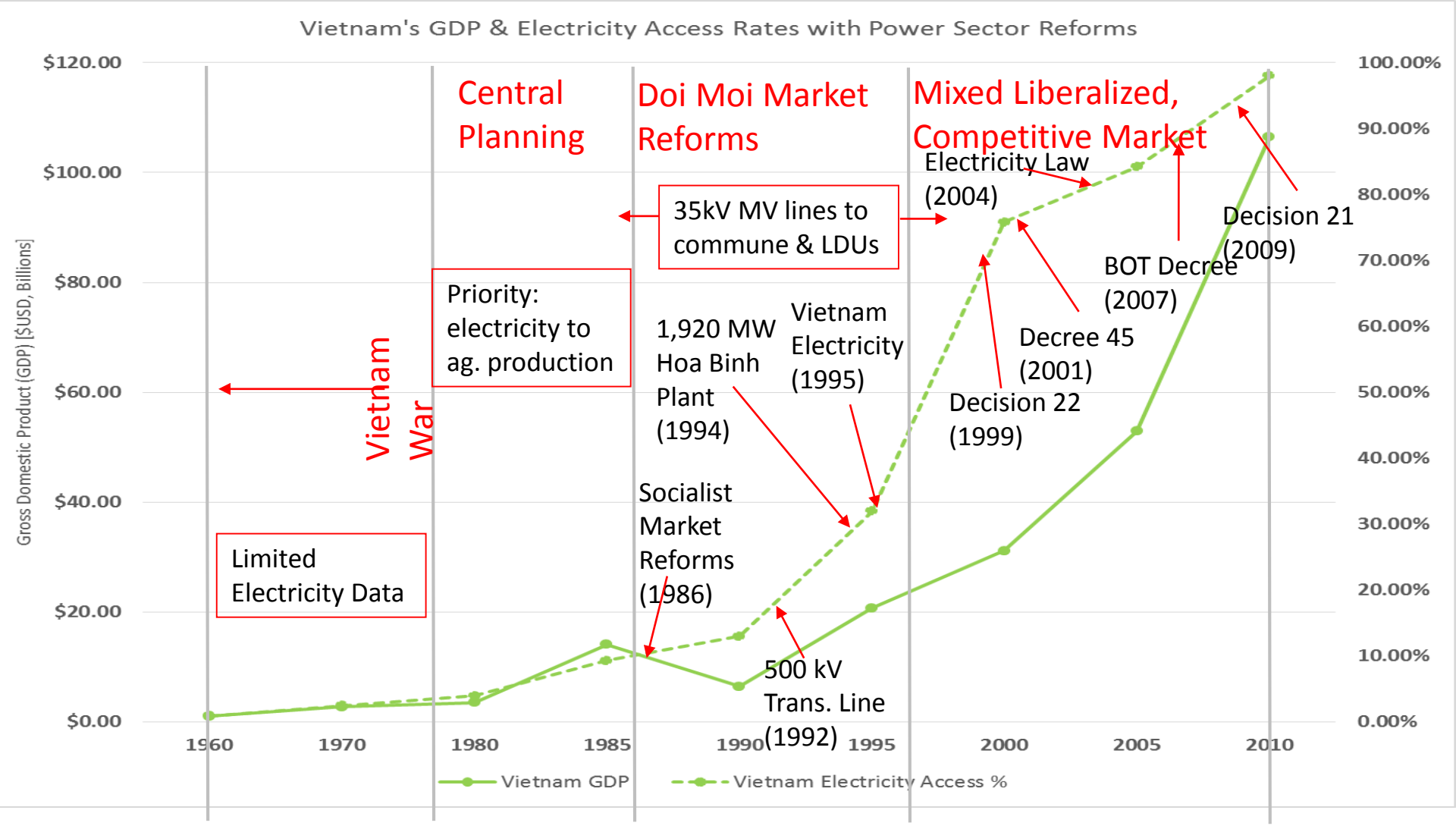
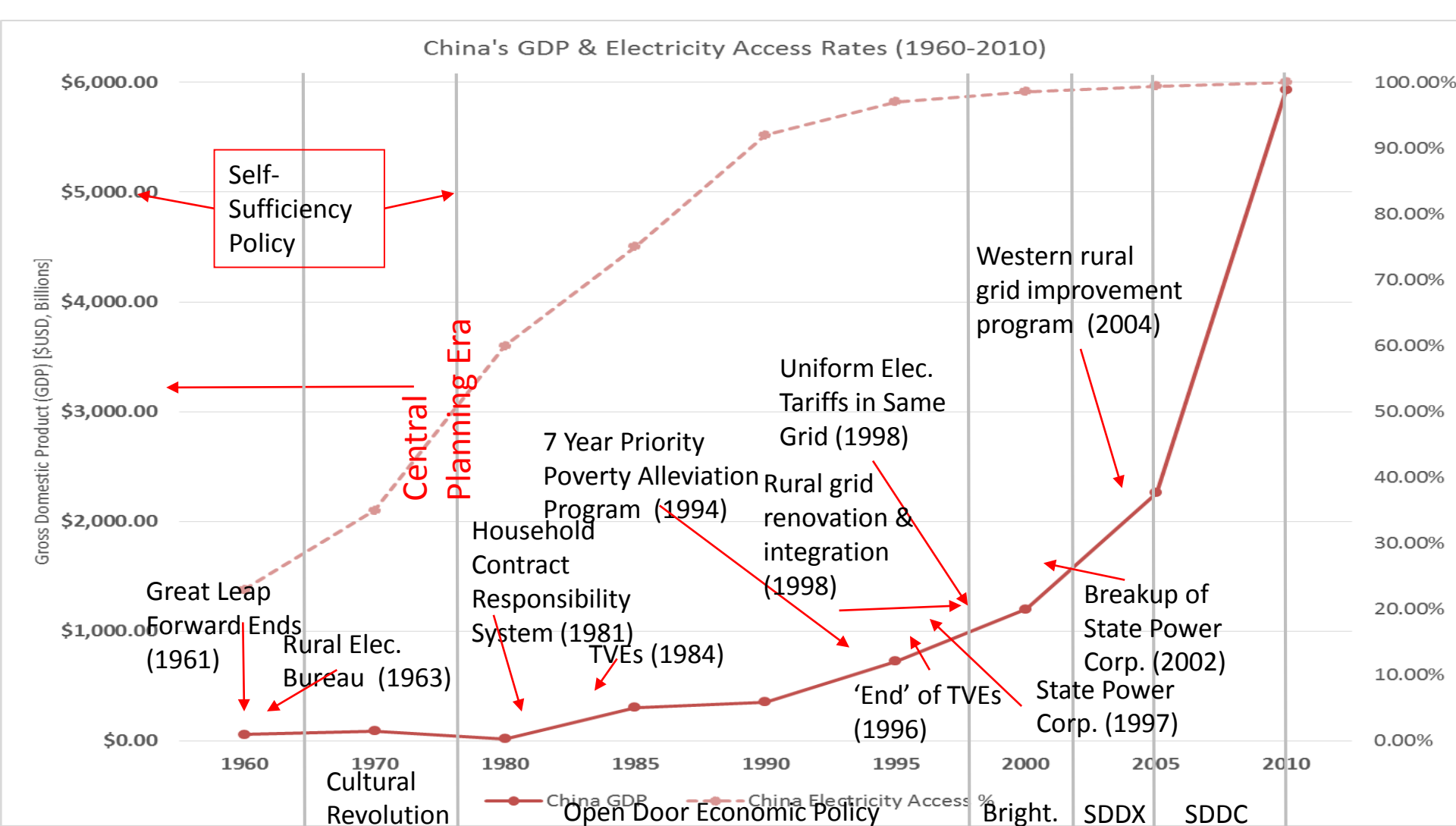
BACKUP SLIDES


Vietnam's GDP & Electricity Access Rates with Power Sector Reforms
Gross Domestic Product (GDP) [$USD, Billions]
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
1960
1970
1980
1985
1990
1995
2000
2005
2010
Central Planning
Doi Moi Market Reforms
Mixed Liberalized, Competitive Market
Vietnam War
Limited Electricity Data
Priority: electricity to ag. production
35kV MV lines to commune & LDUs
1,920 MW Hoa Binh Plant (1994)
Vietnam Electricity (1995)
Socialist Market Reforms (1986)
500 kV Trans. Line (1992)
Electricity Law (2004)
Decision 22 (1999)
Decree 45 (2001)
BOT Decree (2007)
Decision 21 (2009)
Vietnam GDP
Vietnam Electricity Access %


China's GDP & Electricity Access Rates (1960-2010)
Gross Domestic Product (GDP) [$USD, Billions]
$6,000.00
$5,000.00
$4,000.00
$3,000.00
$2,000.00
$1,000.00
$0.00
100.00%
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
1960
1970
1980
1985
1990
1995
2000
2005
2010
Self-Sufficiency Policy
Central Planning Era
Great Leap Forward Ends (1961)
Rural Elec. Bureau (1963)
Cultural Revolution
Household Contract Responsibility System (1981)
7 Year Priority Poverty Alleviation Program (1994)
TVEs (1984)
Uniform Elec. Tariffs in Same Grid (1998)
Rural grid renovation & integration (1998)
'End' of TVEs (1996)
Western rural grid improvement program (2004)
Breakup of State Power Corp. (2002)
State Power Corp. (1997)
Open Door Economic Policy
Bright.
SDDX
SDDC
China GDP
China Electricity Access %