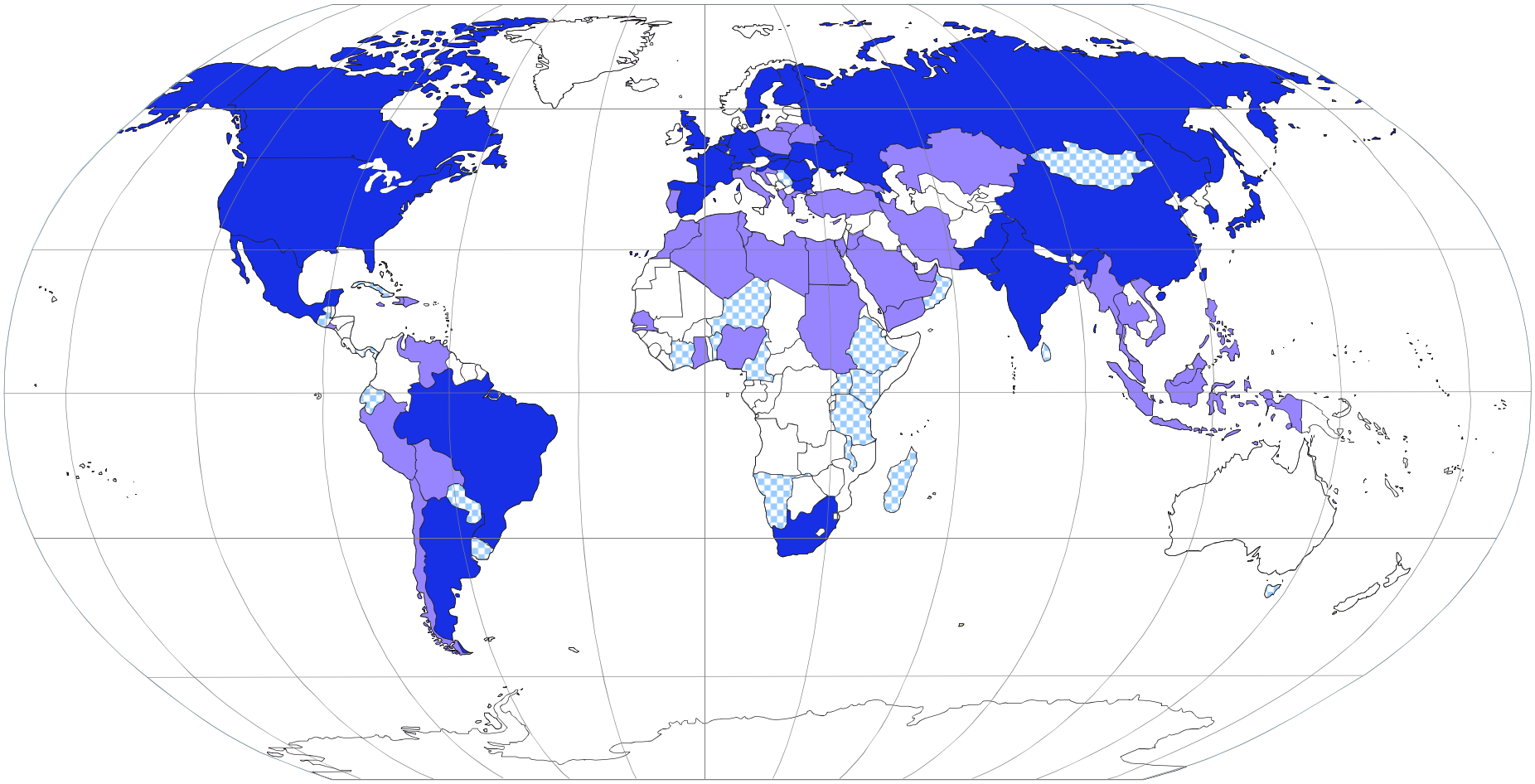
Perspective of Nuclear Power Industry on the Global Market

AtomExpo, Moscow, Russia
June 10, 2014

McKinsey&Company

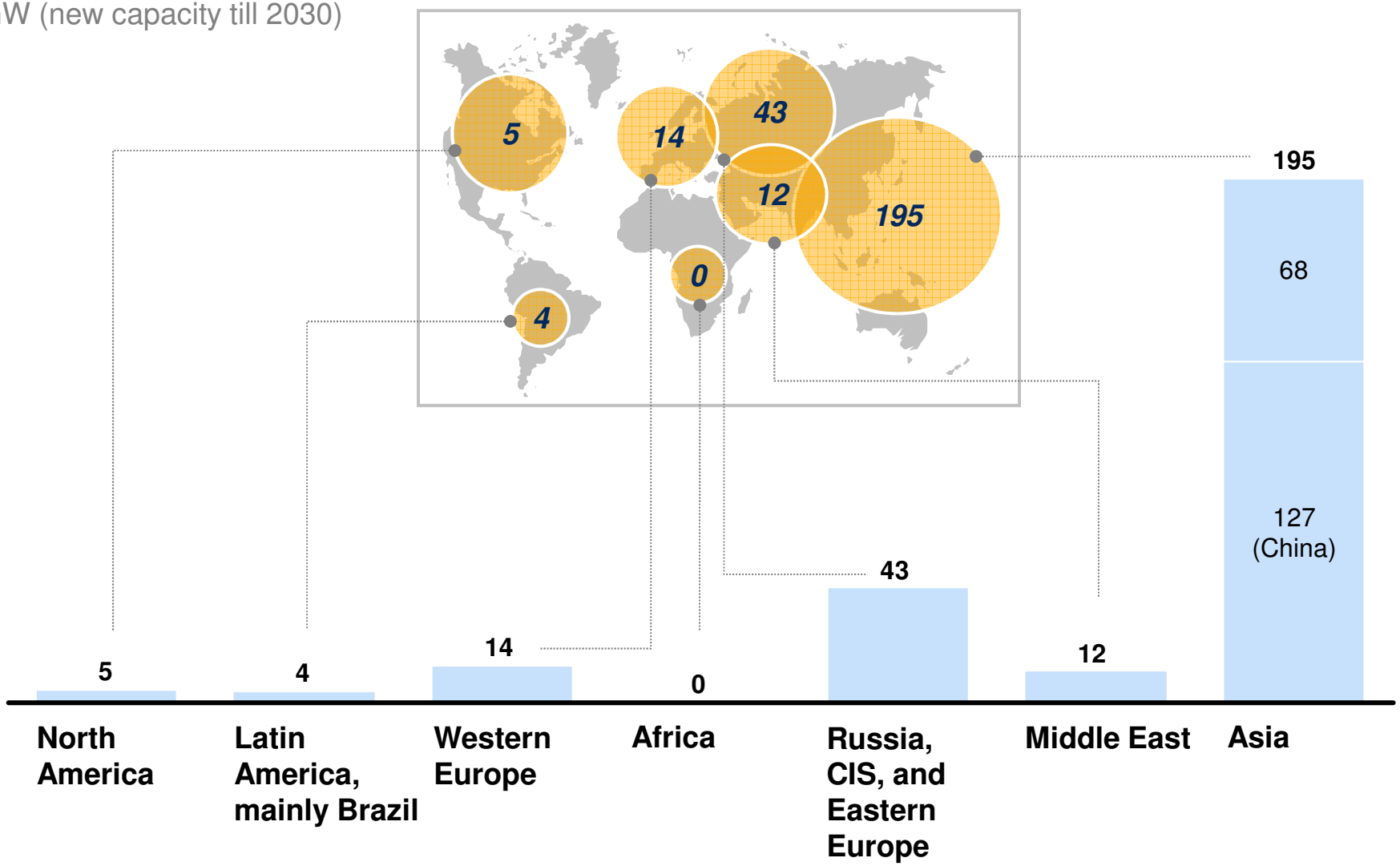
Many countries are showing interest in nuclear energy



SOURCE: McKinsey analysis

Future growth is uneven among geographies with Asia accounting for the majority stake

GW (new capacity till 2030)



SOURCE: McKinsey analysis

There are key driving factors driving development of nuclear power in different regions

	Examples of geographies	Comments
 **Decarbonization**	• Western Europe • Canada	▪ Production of nuclear energy doesn't contribute to **carbon emissions** ▪ It does not produce **smoke particles** to pollute the atmosphere ▪ Still despite trend on decarbonization, **nuclear** energy **faces difficulties** because of **safety concerns**
 **Competing technologies**	• USA • Brazil • Denmark	▪ **Shale gas development** in USA **drives** average **gas prices down** and **reduces** the economic **incentive** of building new NPP's ▪ **In some countries renewable** energy sources are **developing rapidly** and **begin to compete** with all types of energy, including **nuclear power**
 **Stable and reliable growth**	• India • Turkey • China	▪ Production energy from NPP **does not depend** on the **weather** and is **not subject to the price volatility** associated with gas-fired plants ▪ It is relatively **easy to forecast the output**
 **Energy diversification**	• China • USA	▪ Countries which significantly **dependent on prices** for traditional energy sources are **willing to diversify** ▪ **Nuclear energy** can be considered as a **good substitute** for traditional energy supply, but need to compete with other types of energy
 **Nuclear suppliers**	• Russia • China • S. Korea • France	▪ A number of countries are building NPPs at home to strengthen their position as **world nuclear suppliers** and **to prove latest technology references** to increase or protect their presence in the industry

▪ **Ultimately, economics should be right to compete in any region**

SOURCE: McKinsey analysis

DECARBONIZATION

Despite the potential of adoption as a carbon free source of energy in Western countries nuclear faces strong challenges which limits growth

Current situation

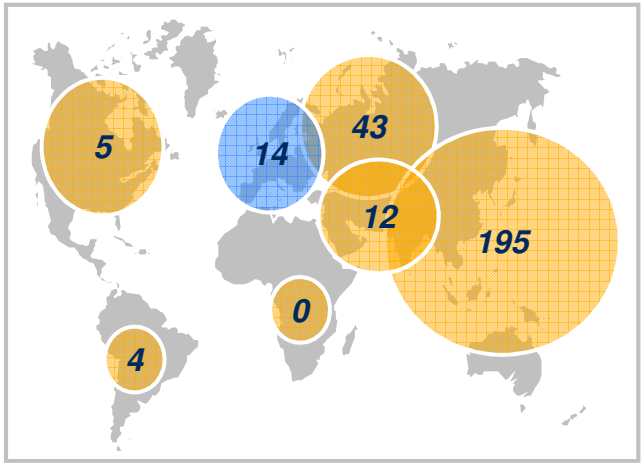
- Nuclear has **advantage due** to trend for **decarbonization**
- At the same time **strong challenges** due to:
  - **safety concerns** (especially audible in Germany)
  - charge of **back-end cost**
  - **high CAPEX,** which might lead to comparatively high LCOE

Comments

- Merkel announced **Germany will shut 17 NPP's** by 2022, the decision made due to safety concerns after accident at Fukushima
- **Charge of back-end cost is often underestimated** in evaluation of total project LCOE
- **NPP** Hinkley Point C will be **more expensive than offshore** wind when commissioned (in 2023):
  - estimated LCOE for considered NPP will be ~10.7 EUR ct per KWh
  - LCOE for offshore wind will be <10.0 EUR ct per KWh in 2023 and will **continue to fall**

New capacity

GW (new nuclear capacity till 2030)



- **Opportunity to build new NPP's reduced to few southern markets, France and UK.**
- **Is this a European oddity or highlighting the challenges the nuclear industry will be facing going forward in other markets?**

SOURCE: IEA; Eurostat; Platt's; EIA; McKinsey analysis; WNA; press search; McKinsey EPNG LCOE model

COMPETING TECHNOLOGIES

US is dominated by shale agenda and nuclear energy has very limited potential

EXAMPLE 1

Current situation

- Very **low gas prices**
- **Limited** appetite to **finance** and guarantee large **nuclear projects**
- **Modest increase** in **demand** for energy

Comments

- **Shale gas** development in US drives **average gas prices down** and makes construction of new merchant nuclear power plants in competitive markets uneconomical now and in the nearest future
- **LCOE** of new power generation on natural gas is **~ 4 EUR ct per KWh**, which **is lower than for nuclear energy**
- Recent world financial crisis and problems with debt make it more **difficult to finance NPP projects**, which requires big CAPEX
- **Share of nuclear energy** in overall power production in US is expected to **decrease** from 19% in 2010 to 13% in 2030
- **Overall demand for energy** in US is **expected to rise significantly slower compared to rest of the world**: by ~20% in 2030 compared to 2010, while average demand for energy in the world is expected to rise by almost 60% in the same period

Perspective for nuclear energy

- **Opportunity to build new NPP's depends greatly on macroeconomic environment (ex. gas price), which now creates negative trends**
- **At the same time nuclear has to compete against energy efficiency and demand management programs, which also add tension to future nuclear growth in NA region**

1 Carbon-Capture-and-Storage (CCS)

SOURCE: McKinsey Global Energy Perspective, McKinsey analysis

COMPETING TECHNOLOGIES

Brazil experienced significant increase in demand for energy, but nuclear has limited potential due to favorable conditions for renewables

EXAMPLE 2

Current situation

- Significant **increase** in **demand** for **energy**
- **Onshore wind** has **huge potential**
- **Huge** existing **hydro facilities** in Brazil and significant **potential** for **small hydro plants**

Comments

- **Power demand** in Brazil is estimated to **increase by 2.4 times** in **40 years**: from 500 TWh in 2010 to 1200 TWh in 2050, which creates great opportunities for development of power production
- Brazil has a **wind power** generation **potential** of at least **~143 GW**, most of them yet to be explored, and could aspire to reach **higher** than average (>30%) **net capacity factor** by selecting better locations at the beginning and setting up new turbines
- Almost **80%** of the energy generated by Brazil and consumed domestically originates from **big hydro plants**. **Unexplored potential** of **small hydro plants** in the country is estimated in **~26 GW**
- Economically, **power** from existing **NPP's** at **~$75/MWh is ~1.5 times more expensive** than that from established hydro, which makes nuclear energy less competitive

Perspective for nuclear energy

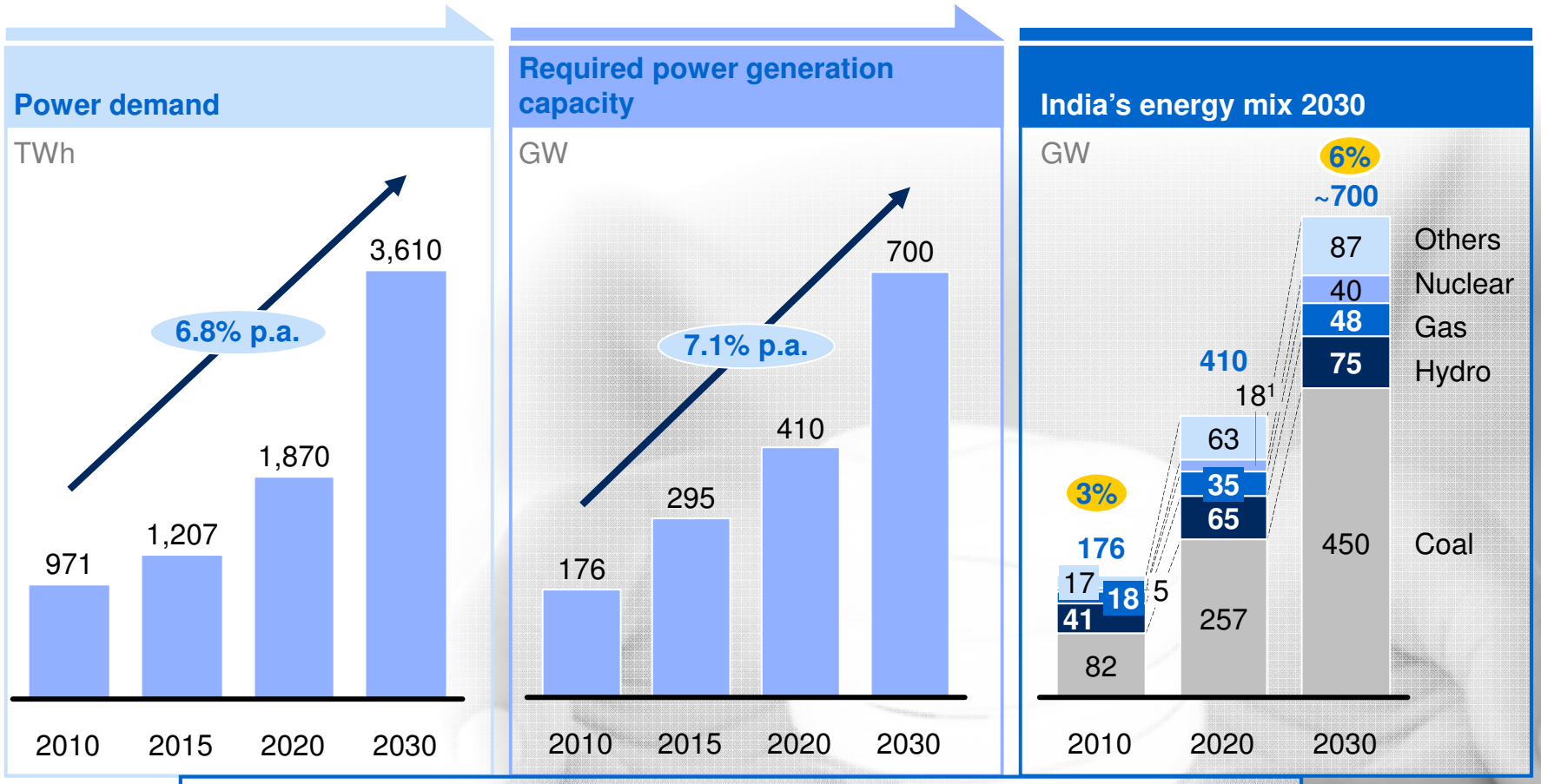
- **Despite significant increase in demand for energy, opportunity to build new NPP's may be limited by other alternatives**
- **High dependency on hydro power may stimulate building new NPP's because of shortages in energy supply during draught periods**

SOURCE: McKinsey Global Energy Perspective; Atlas Eólico Nacional; BNDES; ANEEL; BTM Consult; McKinsey Analysis; WNA; Aneel, imprensa, análise da equipe

India will require ~700 GW of power by 2030 and nuclear power share in India's total energy mix will double from 3% to 6%

PRELIMINARY

xx CAGR

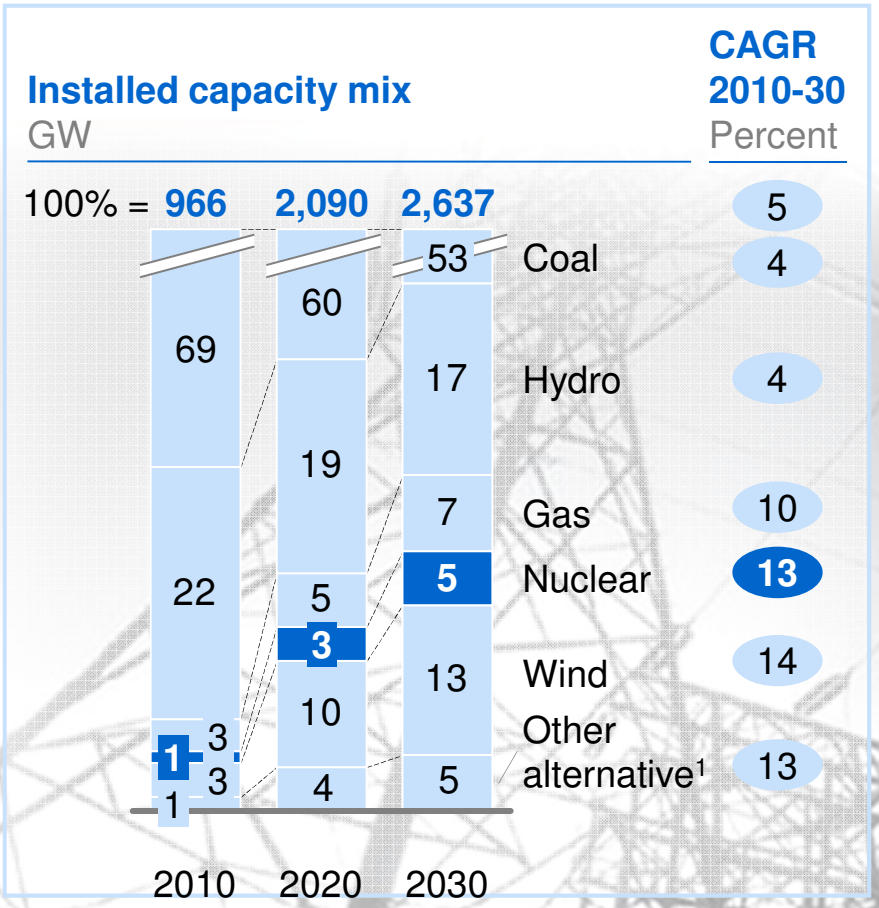


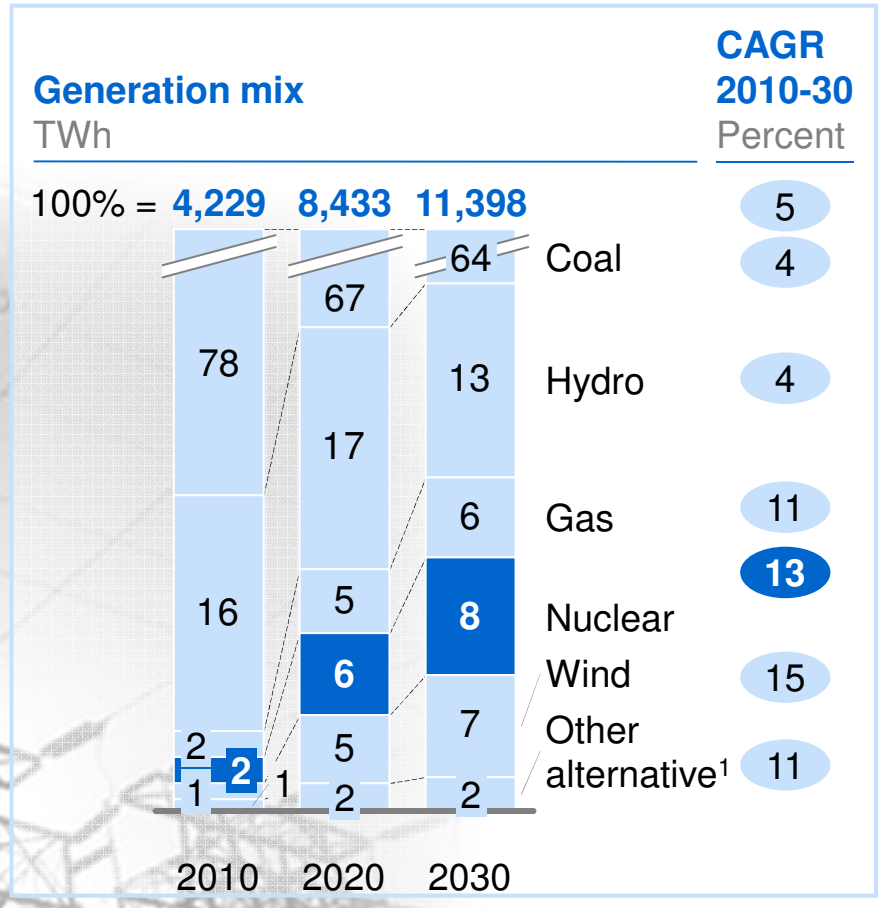
- Significant growth in demand for energy in India requires more stable energy sources which are less price volatile
- There is great opportunity for development of nuclear energy, which has seen a slowdown in recent years

SOURCE: Powering India: The Road to 2017, Global Data, EPS Estimates, McKinsey analysis

DIVERSIFICATION

Increased demand for energy in China stimulates increase in energy supply and need for diversification of energy generation





- China as a one of the biggest consumer of oil and natural gas, needs diversification
- Nuclear energy has significant potential in China, and installed nuclear capacities are estimated to increase by ~13% annually until 2030
- Nuclear power needs to compete intensively with another power sources, including RES

1 Include solar, biomass, etc.

SOURCE: NDRC ERI; IEA; UBS; Expert interviews; McKinsey analysis

Competition, both geopolitical and economic, is really a test to see who can contain and reverse the overall cost of power…

Key players are competing on the global market …

GE HITACHI

Westinghouse TOSHIBA

AREVA EDF

ROSATOM

KHNP KEPCO

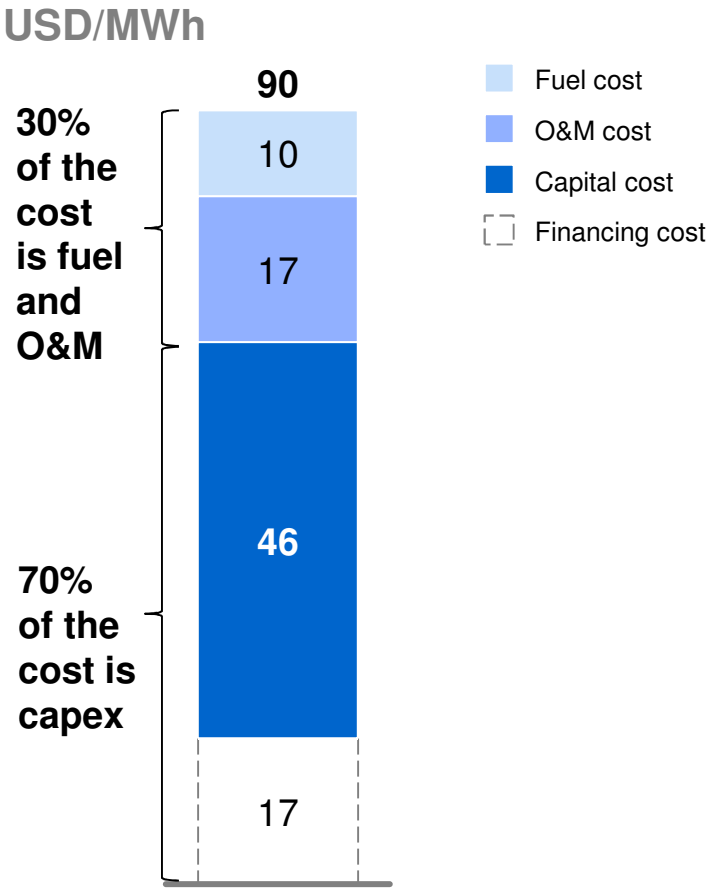
哈尔滨电站设备集团公司 Harbin Power Equipment Corporation DEC

中核集团 CNNC

上海电气 SHANGHAI ELECTRIC

… and their governments!

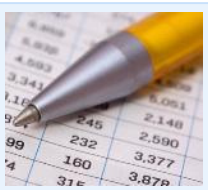
Levelized cost of electricity (LCOE) based on 3900 $/kW installed



SOURCE: McKinsey EPNG Practice (LCOE model)

NUCLEAR SUPPLIERS

… as well addressing economic, safety and other strategic criteria of competitiveness

	Description
 **Project economics**	▪ Overnight construction cost ▪ Utilization factor ▪ Construction period ▪ Plant service life ▪ Operating and maintenance costs ▪ Fuel costs ▪ Decommissioning costs
 **Safety level**	▪ Conformity with generations III and III+ requirements ▪ Radioactive releases and emissions ▪ External impacts (storms, explosion wave, plane crash) ▪ Seismic stability ▪ Time during which the plant will remain safe in autonomous state in case of off-design accident ▪ Evacuation and long-term resettlement area in case of major accidents
 **Strategic aspects**	▪ Political leverage, support ▪ Financing plan ▪ References ▪ Team experience ▪ Local content level ▪ New job creation ▪ Maneuverability ▪ Ability to use MOX fuel ▪ Independence from a single fuel manufacturer

SOURCE: interview of experts, power practice McKinsey

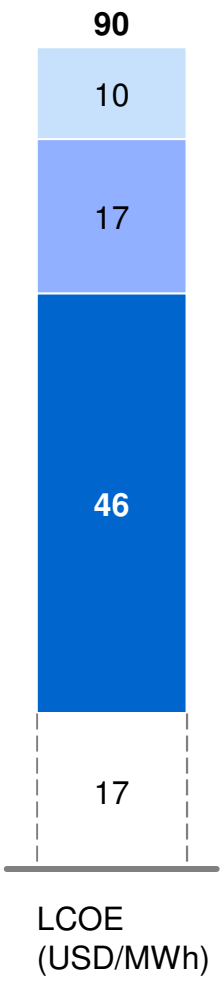
To be competitive, today's nuclear projects will need to manage risks and find upside in a pre-defined set of areas

USD/MWh, Levelized cost of electricity (LCOE)

Fuel cost | Capital cost | O&M cost | Financing cost

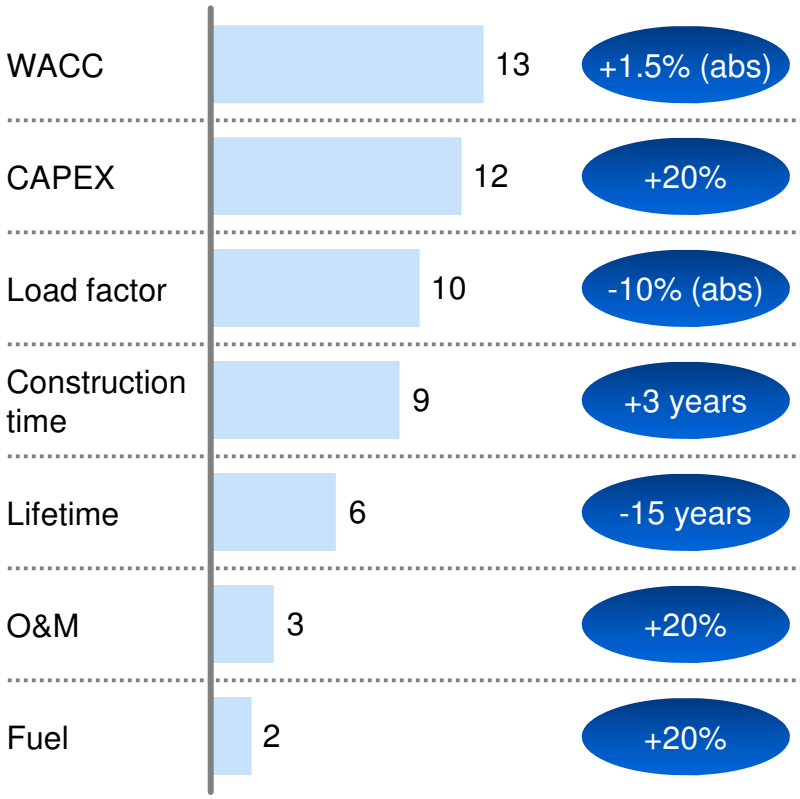
Basic assumptions

- WACC: 9%
- Capex: USD 3,900/kW
- Load factor: 90%
- CO_2 emissions: 0 t/MWh
- Construction: ~6 years
- Lifetime: 40 years
- Thermal efficiency: 35%
- O&M fixed: USD 130/kW
- O&M variable: USD 0/MWh
- Fuel: USD 3.9/MWht



Increase of LCOE depending on sensitivities to key factor changes

USD/MWh, impact on LCOE of sensitivities



Areas

- Financing
- Project management
- Operations excellence
- Project management
- Regulatory
- Operations excellence
- Sourcing
- Sourcing

Scenarios are non-additive

SOURCE: McKinsey EPNG Practice (LCOE model)