Low carbon generation outlook and global power market uncertainty

Discussion Document

December 12, 2011

Today's conversation

- US greenhouse gas emissions to 2030: a case study
- Sources of uncertainty in today's global power markets
- Baseline scenario to 2020
- Potential deviations, and implications for low carbon power
- Questions

US greenhouse gas abatement: How much and at what cost?

US CASE EXAMPLE

Objective: Develop a comprehensive, objective, consistent fact base to inform economically sensible approaches for reducing U.S. greenhouse gas (GHG) emissions

- Analyzed 250+ opportunities to reduce US GHG emissions by 2030
- Covered 7 sectors of the economy – buildings, power, transportation, industrial, waste, agriculture and forestry
- Constructed detailed “emissions reference case” based on US government agencies (e.g., DOE, USDA, EPA) for emissions forecasts
- Conducted interviews with 100+ leading authorities and companies, and leveraged McKinsey subject matter experts around the globe
- Received guidance and support from top academics and corporate and environmental sponsors (DTE Energy, Environmental Defense, Honeywell, National Grid, NRDC, PG&E, Shell).
- The Conference Board co-published and disseminated the report

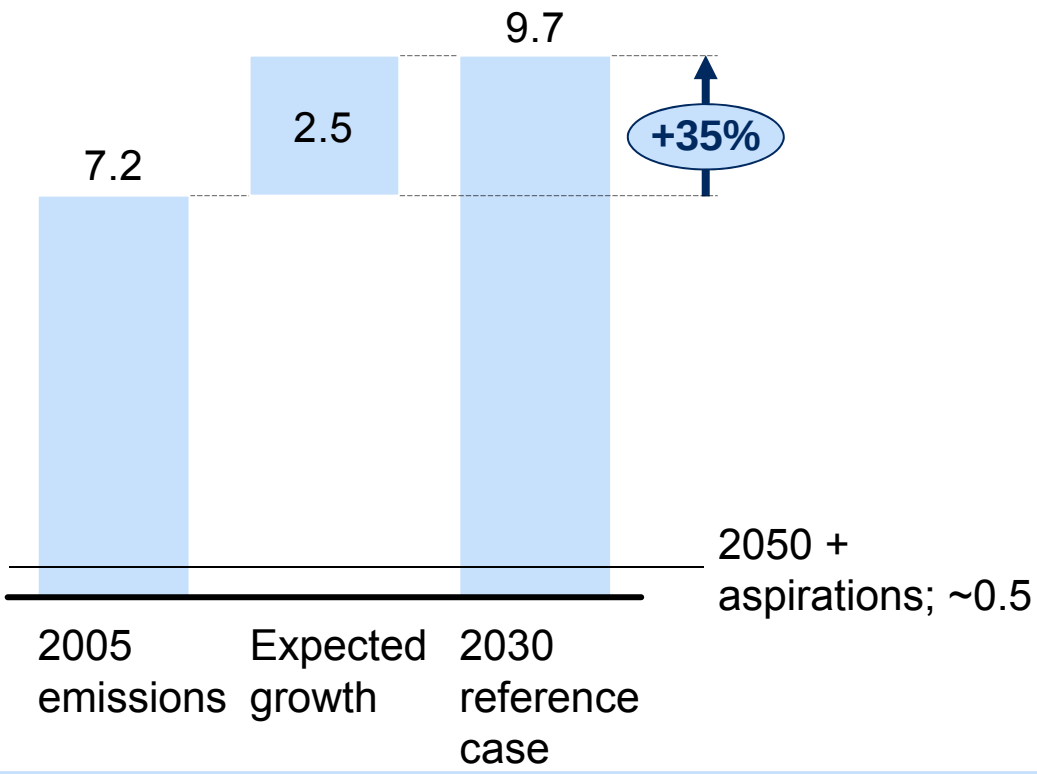
SOURCE: McKinsey

Government agencies forecast U.S. emissions to rise by 2030

US CASE EXAMPLE

Gigatons CO2e

Projected GHG emissions



Key growth drivers

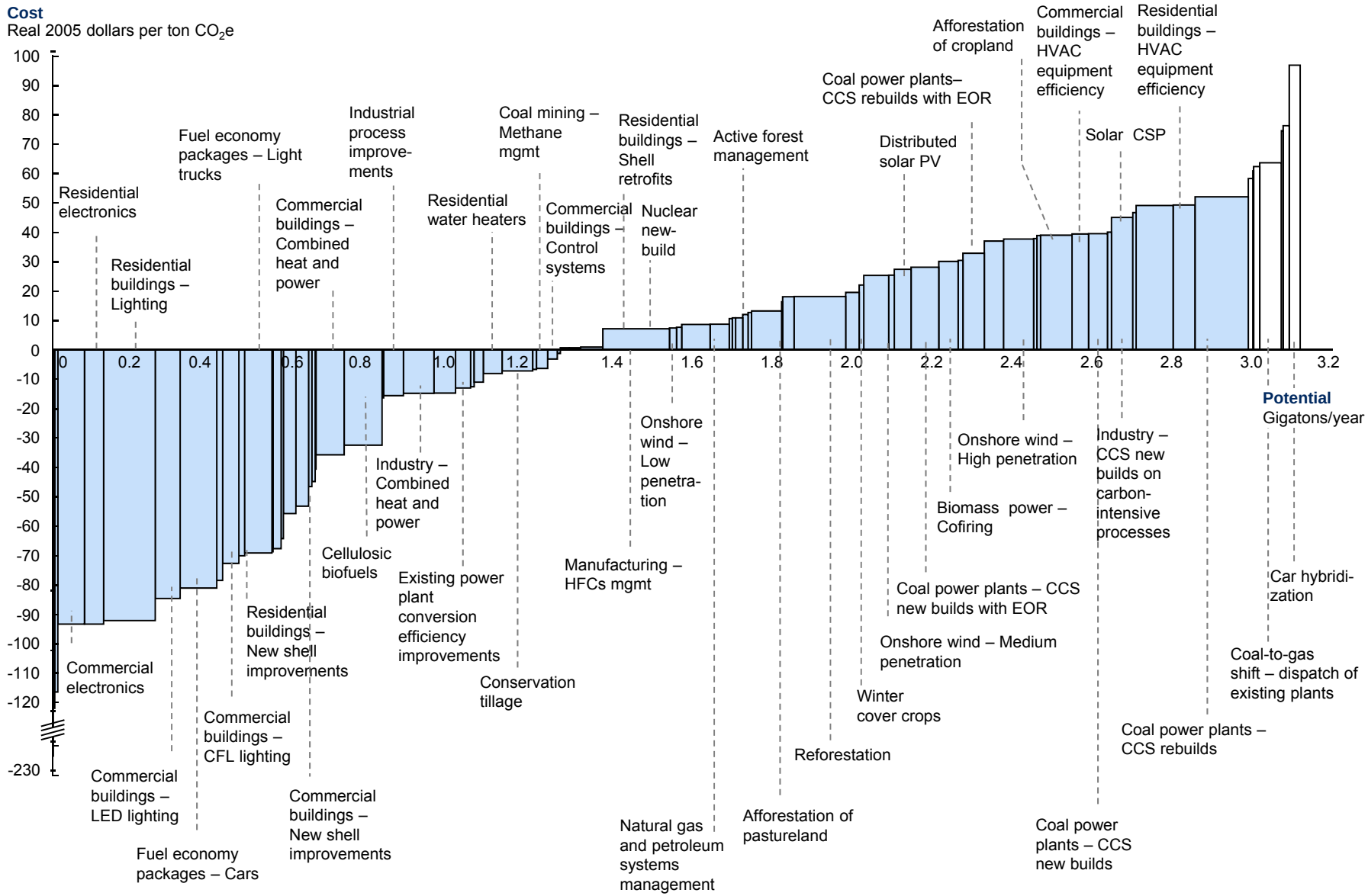
- Expansion of U.S. economy and population
- Above-average growth in buildings and appliances
- Increased coal-fired power generation (without CCS)

SOURCE: Team analysis; AEO 2007

U.S. mid-range abatement curve – 2030

Abatement cost <$50/ton

US CASE EXAMPLE

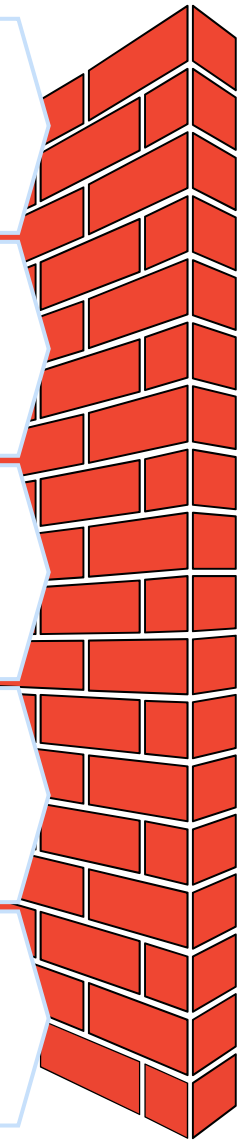


SOURCE: Team analysis

Capturing the potential of energy efficiency opportunity presents several barriers

US CASE EXAMPLE

Cost	▪ Consumers apply different discount rates than societal discount rates; or do not do a NPV calculation at all and instead do a payback analysis ▪ Consumers purchase for specific uses with a distribution of utilization times and may not experience positive NPV on lightly used equipment ▪ Regardless of payback / discount, thin working capital may prevent purchases
Agency issues	▪ Capital expenditures may be required of the owner, while the operator/tenant receives the savings ▪ Time of ownership / occupancy increases the implied discount rate to discount ▪ The builder of the building will not receive returns on the investment in energy efficiency as they will not receive higher home prices for equipment installed
Quality	▪ Perception of power or performance, “energy efficient lights aren’t bright enough” or “the washing machine wont clean my clothes with that little water” ▪ Actual quality issues (e.g. overheating CFLs, heat pump breakdowns)
Education/ awareness	▪ Consumers are unaware of savings potential ▪ Consumers are skeptical of cited savings numbers
Availability	▪ Emergency replacements limit shopping periods and often times are supplied by first available product which is usually a low capital cost product to keep independent plumber / contractor’s capital costs low ▪ High efficiency products are not available in all channels (e.g. CFL at grocery)



SOURCE: Team analysis

Demand side innovations are changing the consumer energy landscape

A **EV charging infrastructure**

- Home stations (e.g. EV home charging bundled with power supply)
- Public network
  - On-the-road charging bundles
  - Typically hosted by retailers

B **Energy efficiency**

- Home area network and inhome display
- Smart meter ready / programmable appliances
  Appliance remote control
- EE diagnostic services

C **Distributed generation**

- Solar (i.e., photovoltaics, solar thermal)
- Micro wind
- Micro natural gas

D **Demand response**

- Residential capacity
- DR Equipment installation
- DR bundled with power sale

E **Behavioral EE programs**

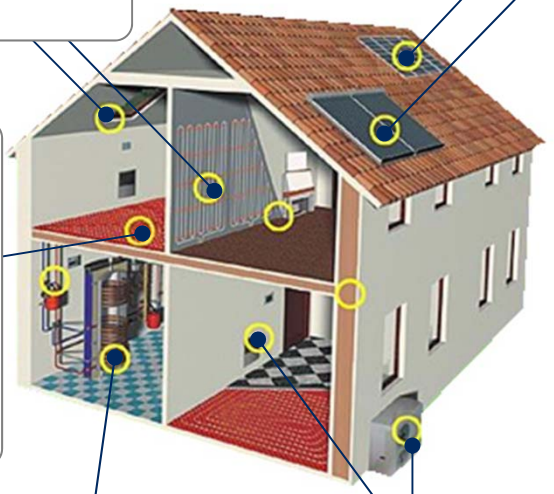
- Software for consumption management and analytics
- Home reports
- Social networks
- Rewards/incentive programs

Energy consumer of the future

Smart Home of the Future will drive significant energy usage reduction

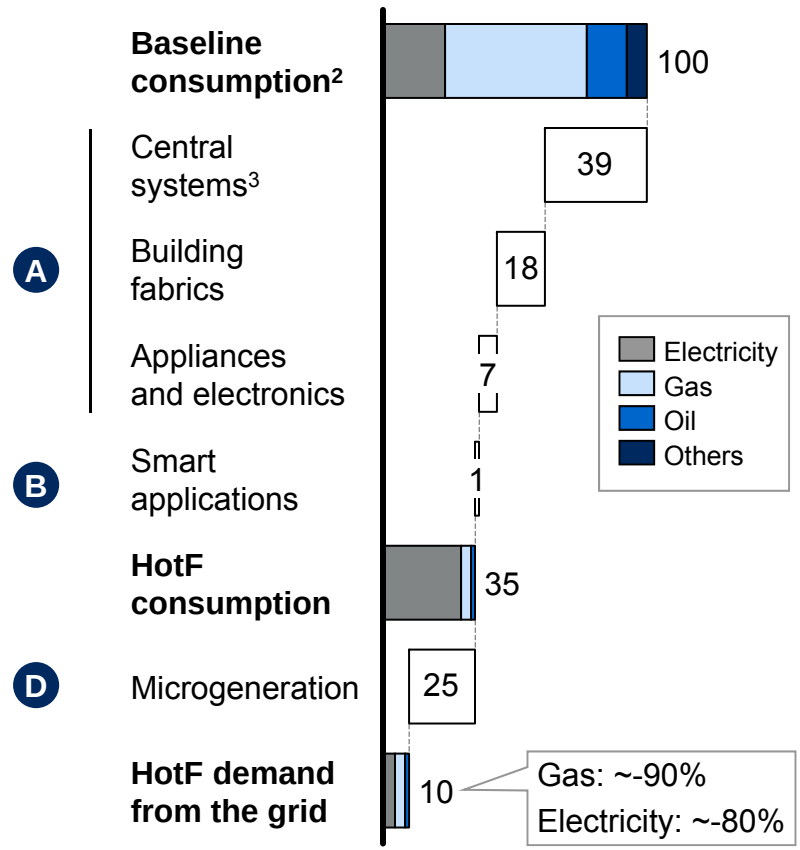
ILLUSTRATIVE EXAMPLE ITALY

The Home of the Future: example of a new single house



Decrease in energy needed from the grid by the HotF

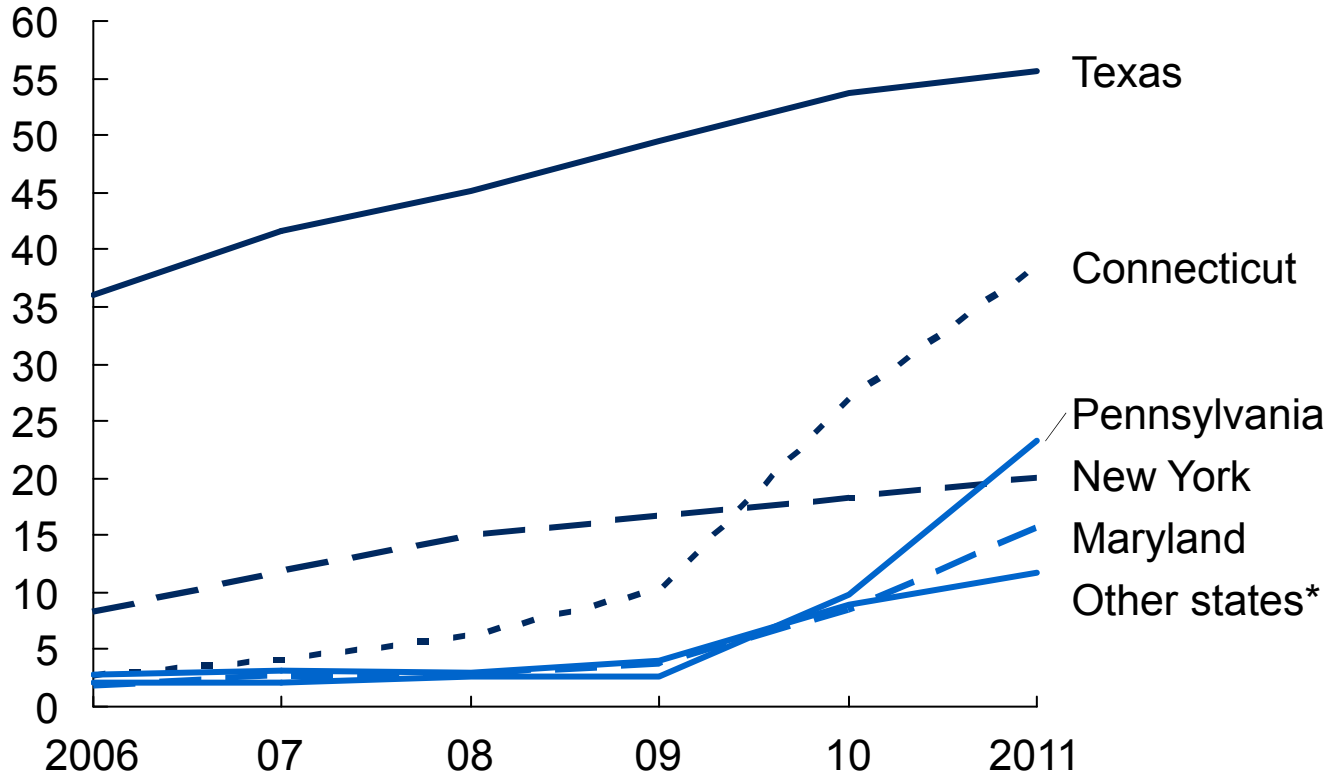
2020, Indexed, 100 = kWh of household consumption[1]



1 All fuels
2 Assuming same volume/mix as 2010
3 HVAC: 35%; Lighting: 4%

Growth of residential switching in retail electric power

Households that have switched to alternative electric power suppliers
Percent



* IL, OH, NJ, MA, DE, DC, ME, NH, RI
SOURCE: state utility regulatory commissions

Key sources of uncertainty in global power markets

Demand

- GDP growth
- Energy efficiency

Commodity dynamics

- Gas
- Coal
- Oil

- ***How much generation?***
- ***Where?***
- ***What mix?***
- ***Whose technology?***

Technology

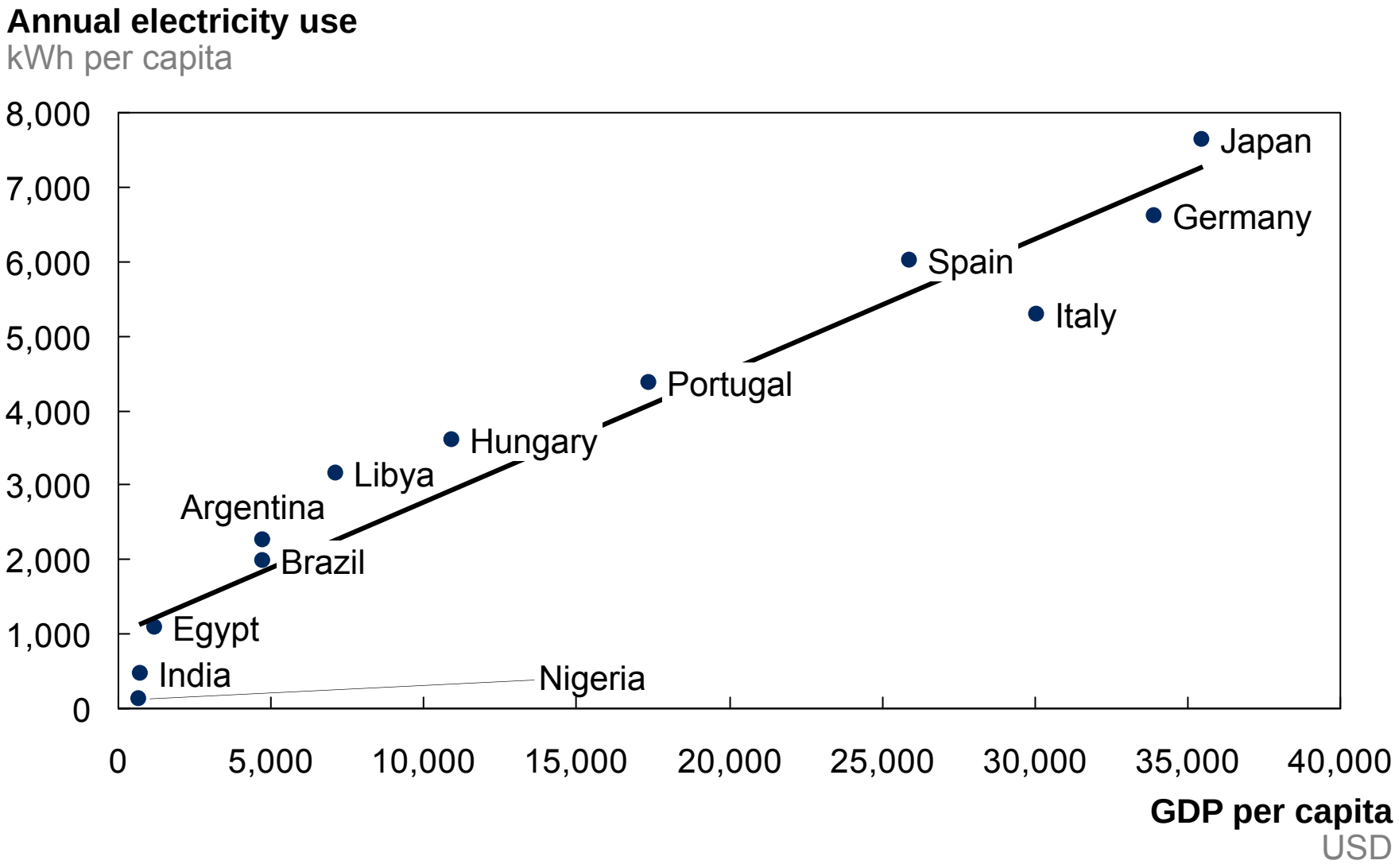
- Cost
- Perform-ance

- GHG abatement, renewables
- Industrial policy
- Energy security

Policy

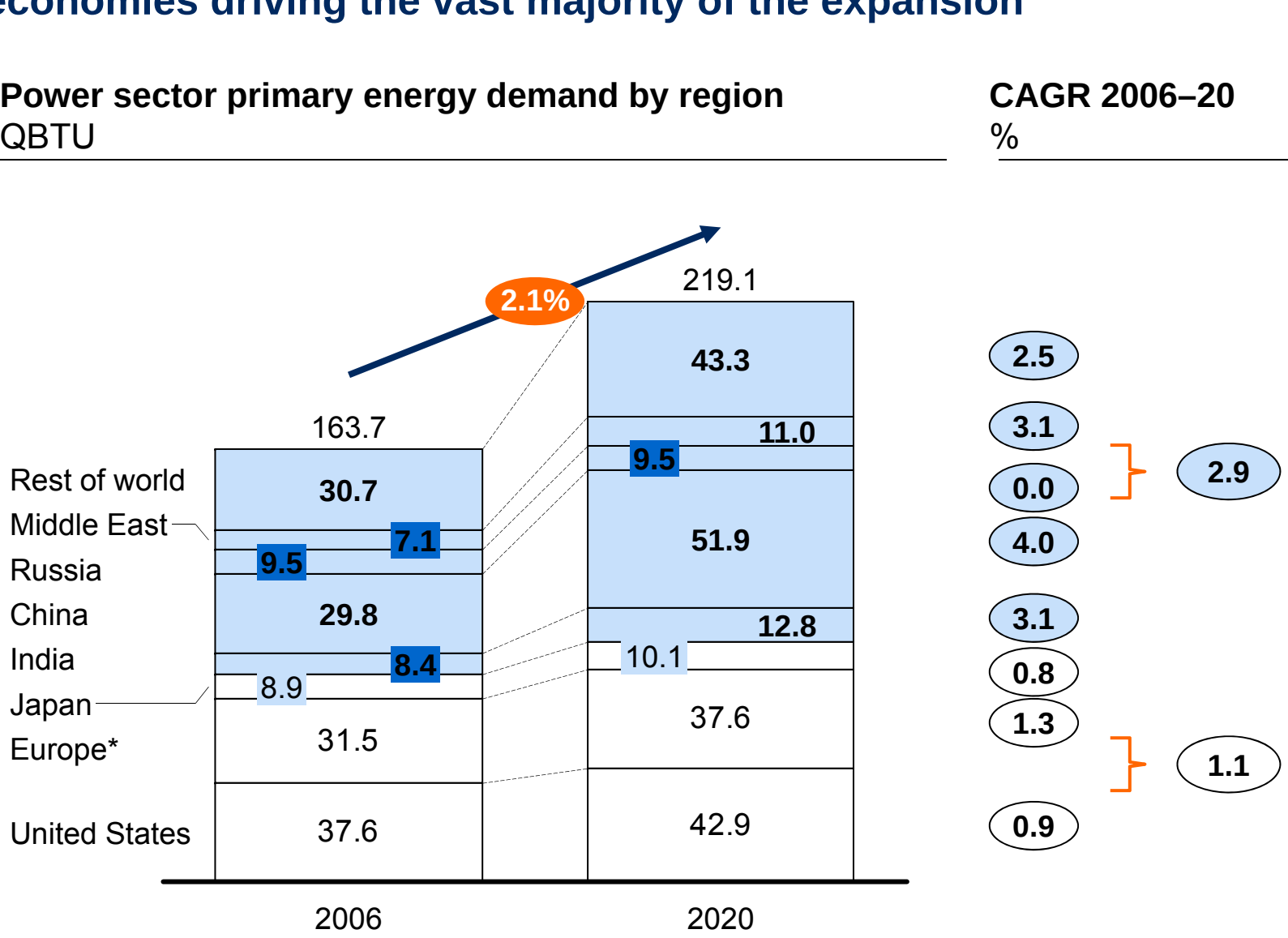
SOURCE: McKinsey

Electricity consumption is closely correlated with overall economic development



SOURCE: IEA database

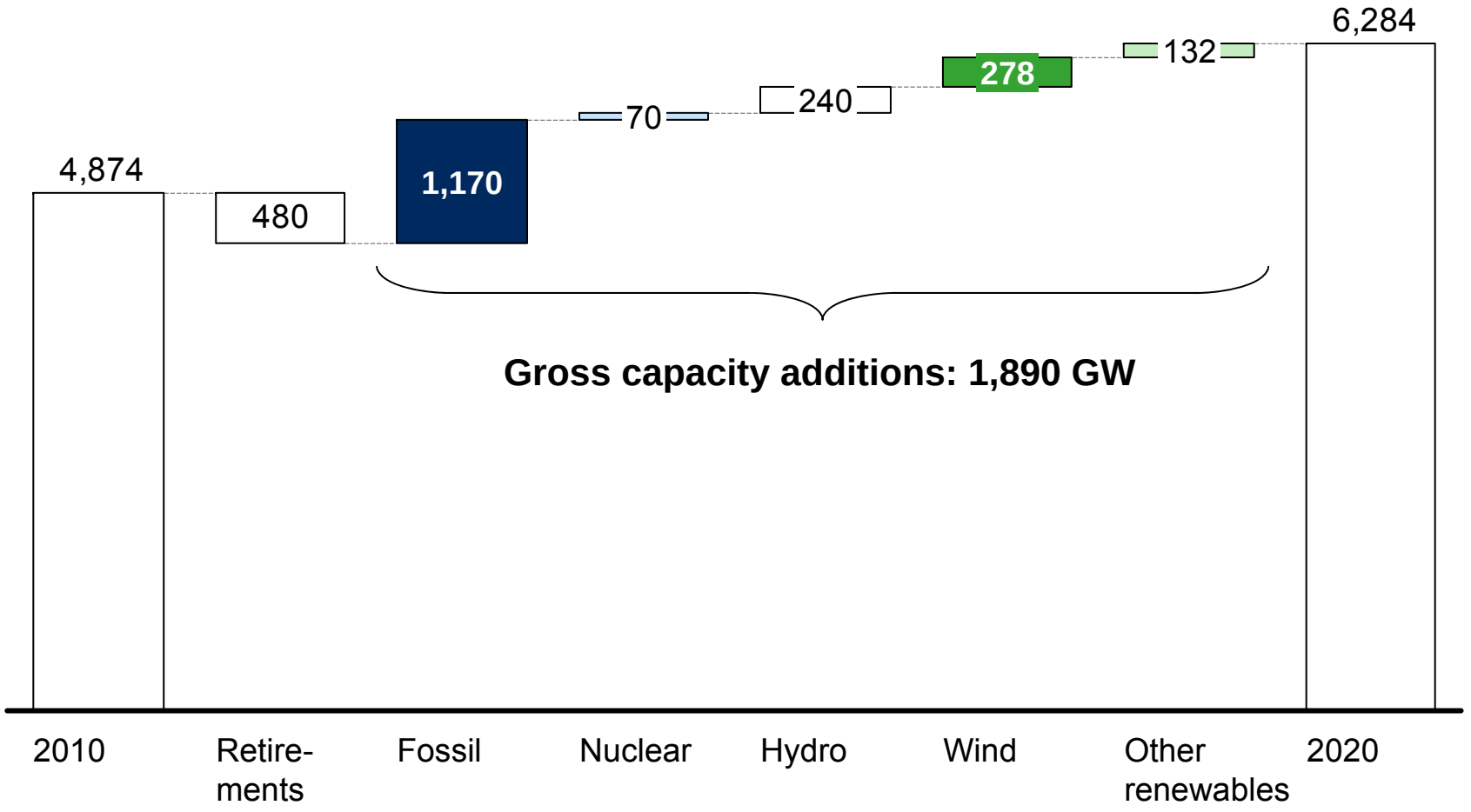
Global electricity demand is expected to continue to grow, with emerging economies driving the vast majority of the expansion



* Including Mediterranean Europe and North Africa and Baltic/Eastern Europe.
Source: IEA; McKinsey Global Institute Global Energy Demand Model 2009

In response to electricity demand growth, the worldwide power generation fleet will expand significantly between 2010-2020

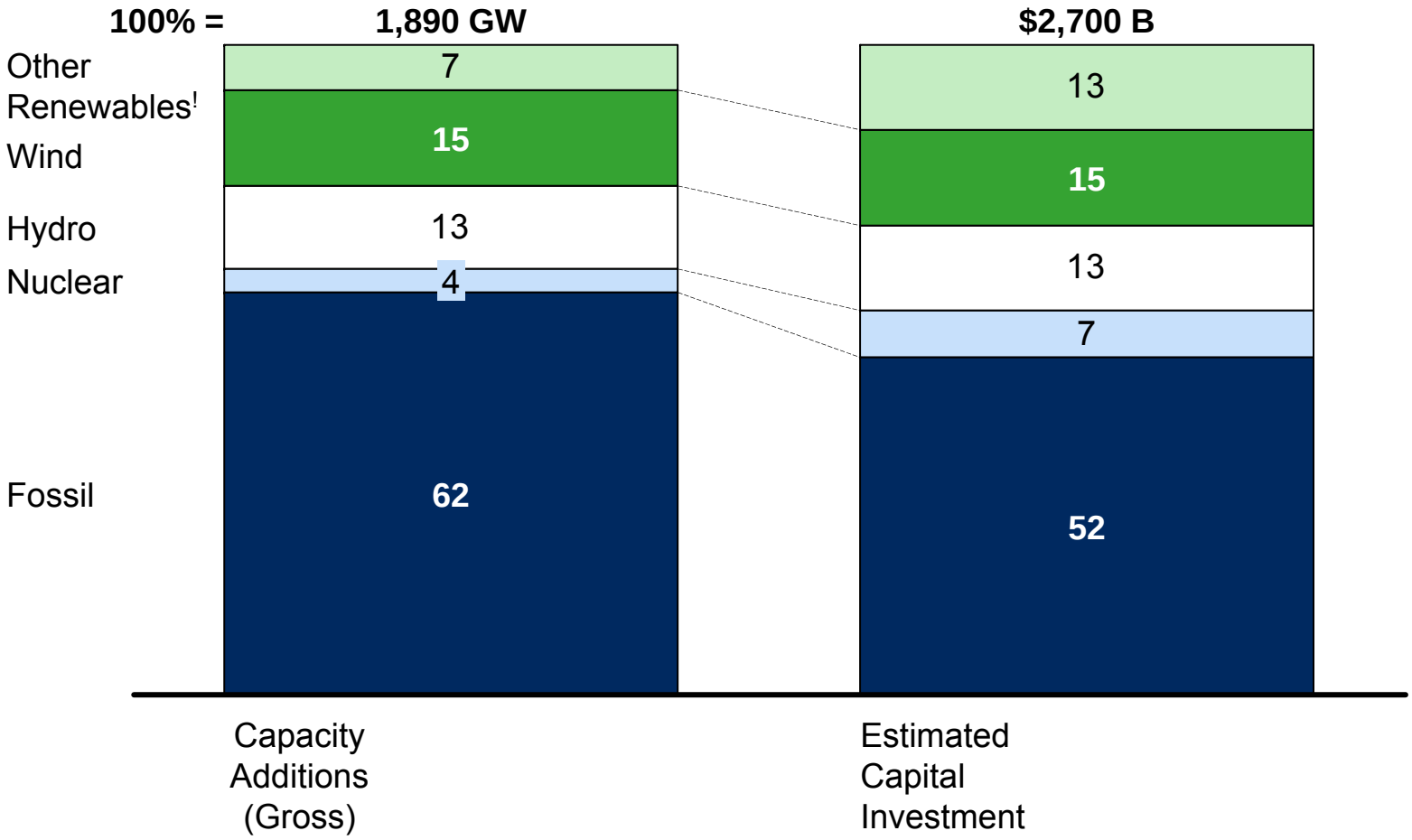
Worldwide generation capacity evolution, 2010-2020
GW



SOURCE: IEA World Energy Outlook 2009; McKinsey analysis

Fossil generation will account for the largest fraction of both new capacity and (barely) new investment

Percent

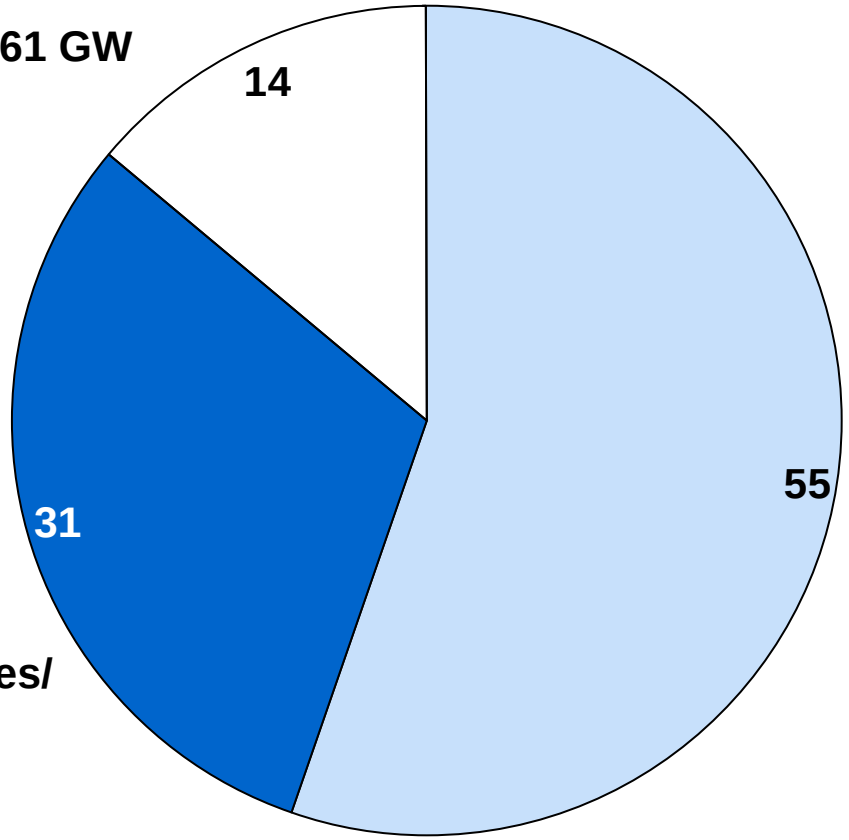


1 Biomass and waste, geothermal, tidal and wave

SOURCE: IEA World Energy Outlook 2009; McKinsey analysis

Large emerging economies will account for the majority of new capacity additions in 2010-2020; China is by far the largest single contributor

Percent; 100%=1,895 GW



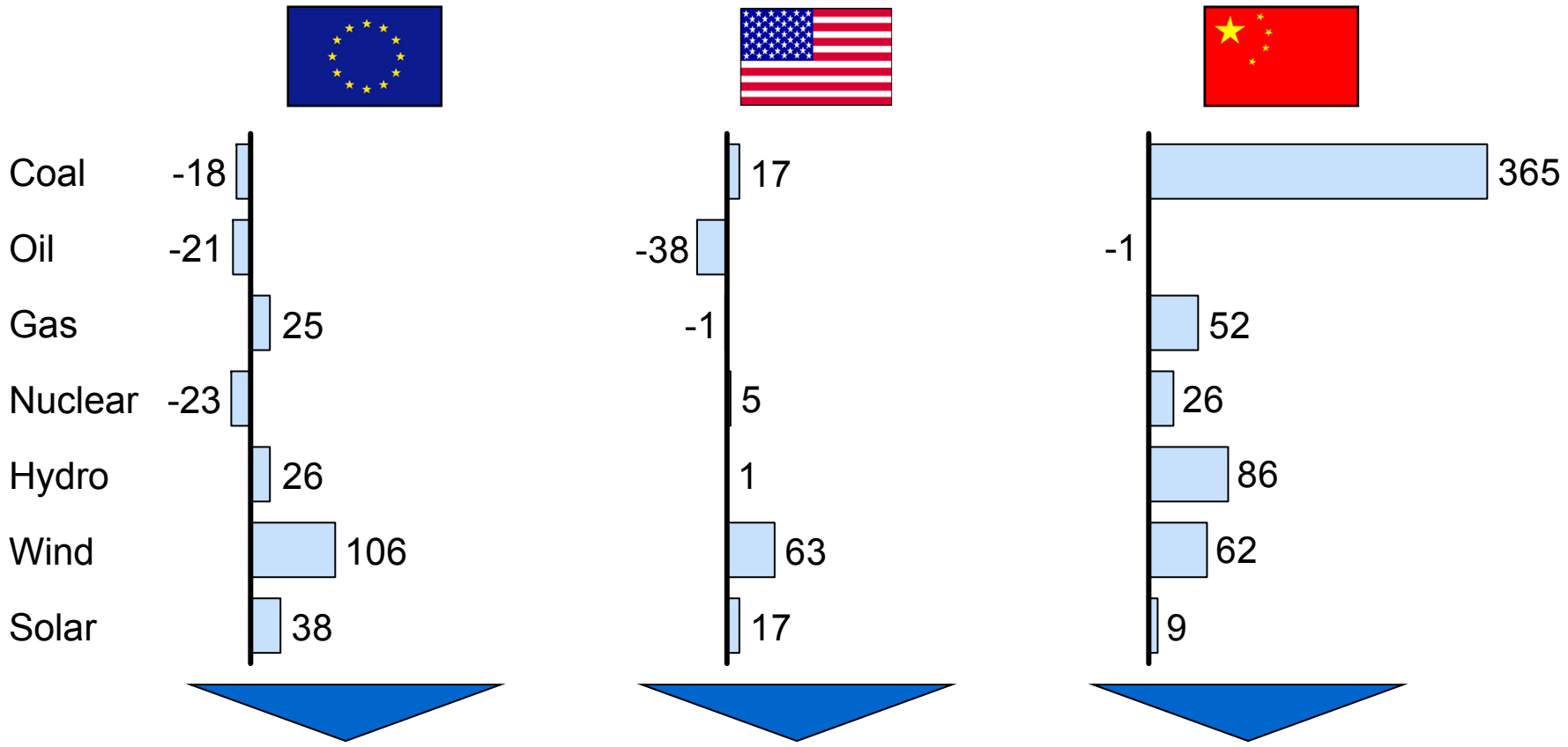
Large emerging countries/ regions: 1,049 GW
China: 642
India: 161
LatAm: 86
Middle East: 84
Russia: 76

Developed countries/ regions: 585 GW
EU27: 243
US: 203
Japan: 40
Other OECD: 99

SOURCE: IEA World Energy Outlook 2009; McKinsey analysis

Under the “default” scenario, China rapidly grows its fleet, Europe mainly replaces fossil capacity with renewables, and the US fleet changes little

Net capacity additions, 2010-2020
GW



- Aggressive replacement of existing fleet with renewable
- Heavy incentives

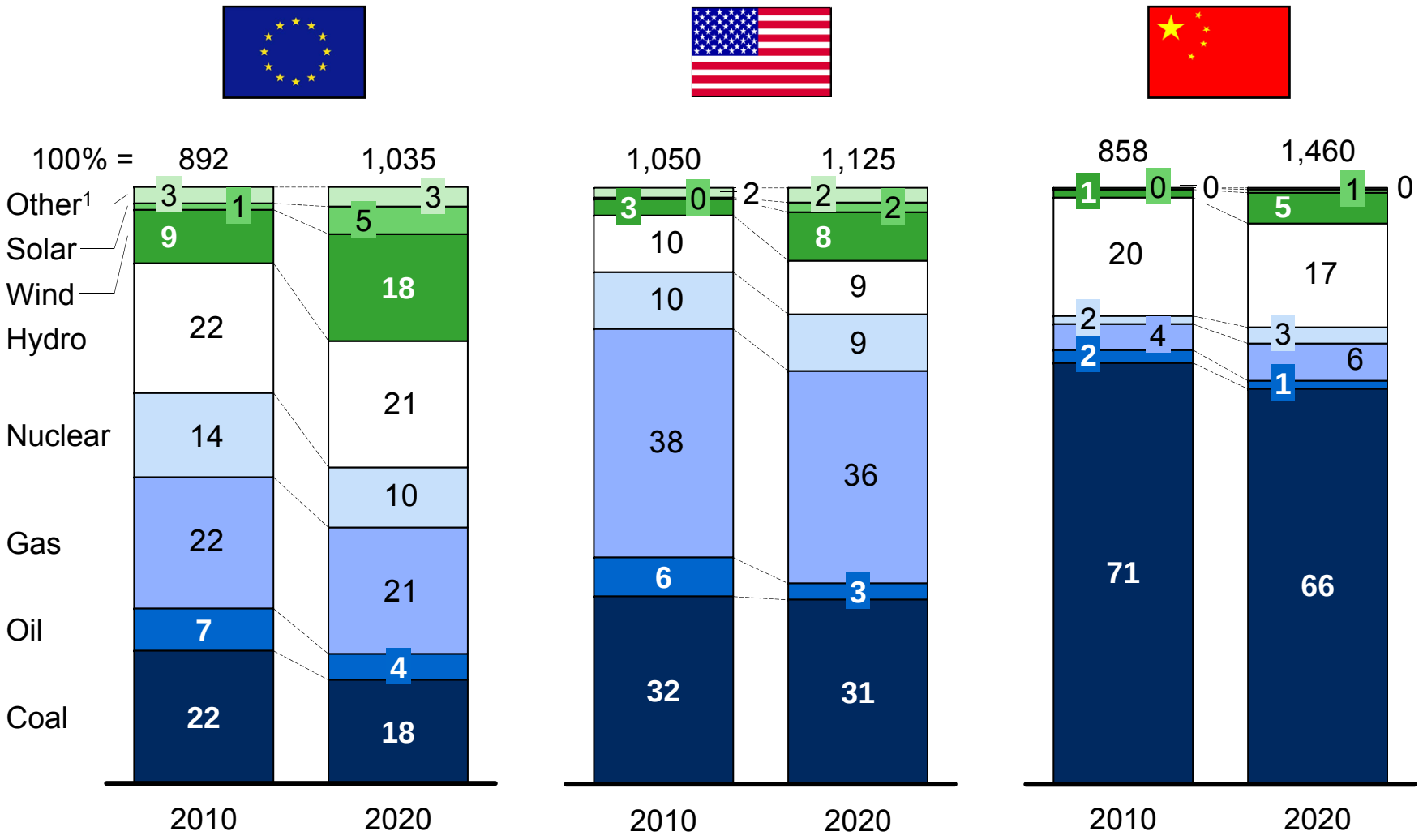
- Limited new construction relative to existing

- Accelerated expansion to stay ahead of demand growth
- Coal as the primary fuel

SOURCE: IEA World Energy Outlook, 2008; McKinsey analysis

The projected additions will partially 'green' the generation fleet, but not shift the base dramatically – except in Europe

Installed capacity, GW



1 Other renewables, including Geothermal, Biomass / Waste, and Tidal / Wave

SOURCE: IEA's World Energy Outlook 20009; McKinsey analysis

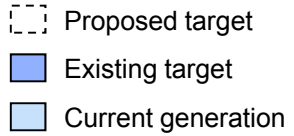
Some potential deviations away from the “default” path

1. **Significant slowdown in EU/US renewables buildout**
   - Worsening of renewable economics relative to “conventional” sources
   - Subsidies becoming unaffordable or politically unacceptable
   - Difficulty obtaining financing for new projects

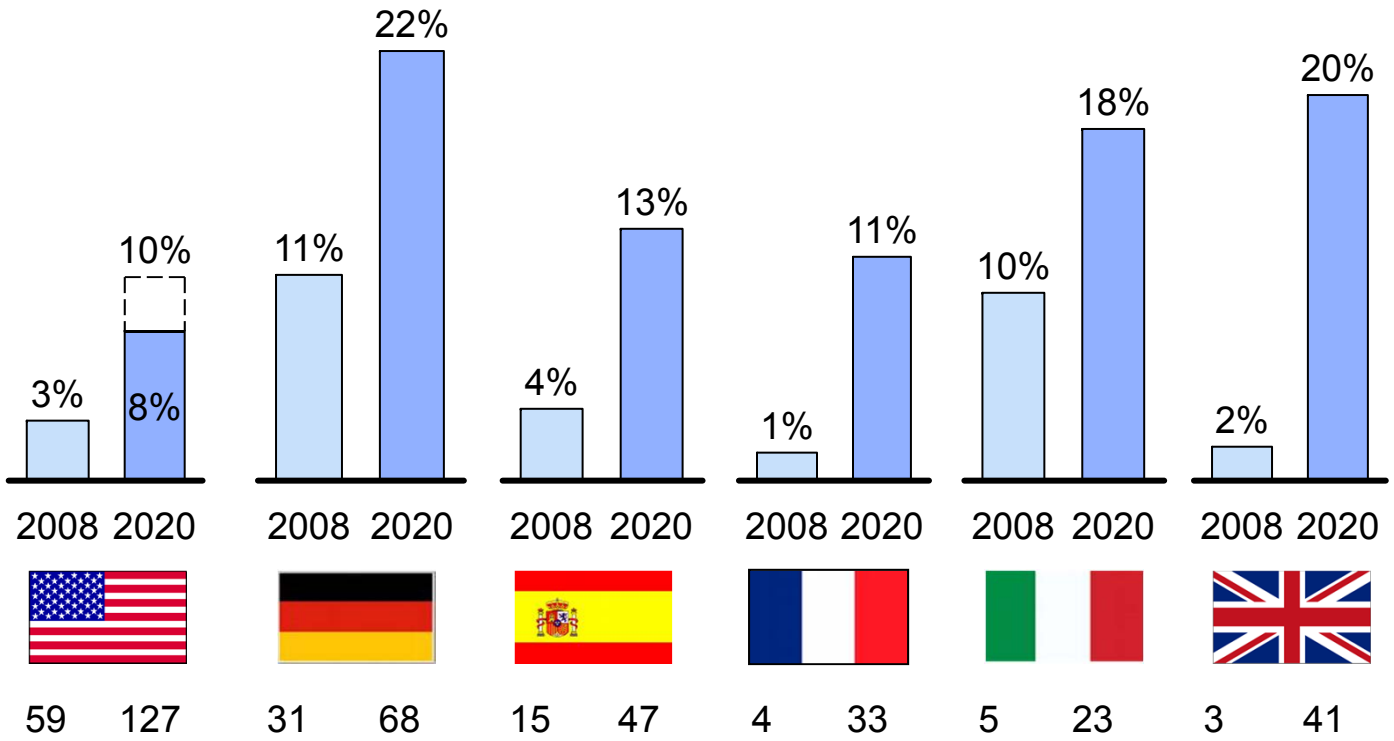
2. **Accelerated coal retirements in the US**
   - Structural reduction in demand as a result of the crisis?
   - Long-term reduction in gas prices
   - Sustained, aggressive emissions reduction efforts

3. **Shift towards low GHG emissions in China**
   - “Default” path shows enormous increase in GHG emissions, and also raises “security of supply” concerns
   - There are early indications for a push towards lower-emissions paths (energy efficiency, nuclear, wind)

Europe and the US have established very aggressive renewables targets for 2020 – but will they be reached?



Renewable generation targets
Percent of total electricity generation



Target renewable capacity[1] (cumulative)
GW

59	127	31	68	15	47	4	33	5	23	3	41

These additions represent about $0.5 T in new investments in a conservative estimate

1 Assumes 25% average capacity factor for renewables

SOURCE: Current national plans on governments' declarations, National Energy Administration, European Energy and transport EU report (trends to 2030), McKinsey analysis

U.S. is introducing aggressive new regulations for fossil generation

NOT EXHAUSTIVE

	Description
Clean Air Transport Rule (CATR)	▪ Covers plans across 31 Eastern states ▪ Will reduce SO_2 by 71% NO_x by 52% by 2014 (vs. 2005 levels) ▪ A second transport rule covering National Ambient Air Quality Standards for NO_x is expected next year
CAA Title III: Mercury and other air toxics	▪ EPA will establish maximum achievable control technology (MACT) standards for new and existing coal-fired power plants ▪ MACT likely to be set for other air toxics, such as acid gases and heavy metals
Clean Water Act: Cooling Water Intake Structures	▪ EPA may require closed-loop cooling systems at larger plants that currently use once-through cooling ▪ CA already issued a rule to eliminate once-through cooling at coastal power plants
Coal combustion residuals impoundment	▪ Failure of a TVA coal ash pond drew scrutiny ▪ EPA issued two options in May 2010 – Federal enforcement and phase out – State enforcement with continued use
Emerging Green House Gas rules	▪ Requires use of Best Available Control Technology (BACT) for large fixed industrial facilities emitting GHGs ▪ Preliminarily thresholds set at 100,000 tons/yr of CO_2e for new facilities; 75,000 tons/yr for expansion of existing facilities

SOURCE: EPA; NERC; Trade press

The amount of U.S. coal that is uneconomic to retrofit will depend on which regulations are enacted and the gas price outlook

"Base case"

Additional coal capacity uneconomic to retrofit by 2020[1]
GW

Investments needed for compliance

Cumulative set of environmental regulations[2]

	Natural gas price $/MMBtu 4	6	8	10	Investments needed for compliance
At risk under current conditions[3]	75	24	13	11	▪ N/A
CATR only	88	29	16	15	▪ Sufficient SO_2/NO_x emission controls (varies by player)
+ MATS	91	35	22	20	▪ FGD, SCR and fabric filters
+ 316(b)[4]	98	47	30	27	▪ Closed-loop cooling installed (chiller)
+ CCR regulation	99	49	31	28	▪ Ash storage pond installed
+ $10/ton CO_2 tax	128	69	41	33	▪ N/A

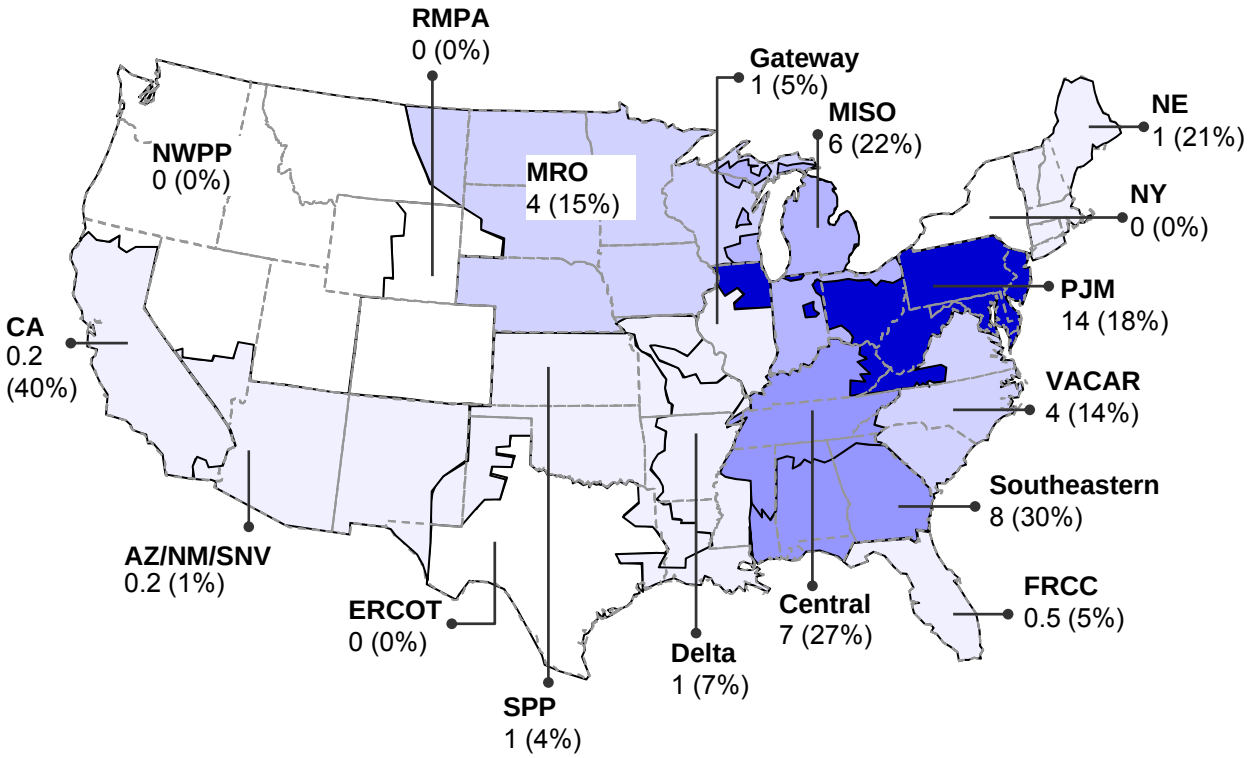
1 In addition to 11GW already planned for retirement by 2020; analysis includes all US coal-fired generation 50MW+ in capacity (~310GW total); all cases assume average coal price of ~$2/MMBtu
2 CATR regulation assumes reduced emission levels of SO_2 (71% reduction) and NO_x (52% reduction)
3 Due to age of plants, impact from renewables, and state-level environmental legislation
4 Operation of cooling infrastructure reduces overall plant capacity by 4% where retrofits necessary; de-rating losses included in uneconomic estimate

SOURCE: McKinsey analysis, Energy Velocity

PJM, Southeastern, Central and MISO contain ~75% of uneconomic coal capacity in the base case example

BASE CASE

Coal capacity uneconomic to retrofit by 2020[1]
GW (% of coal capacity)



40-50 GW of additional capacity will be needed to maintain reserve margins if uneconomic coal is retired[2]

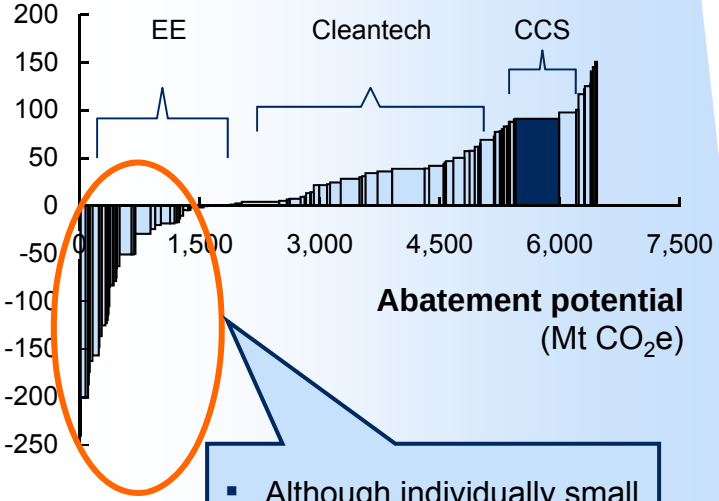
Current pipeline of new construction is likely sufficient to meet these needs

1 Incremental uneconomic capacity in addition to 11 GW of capacity already planned for retirement; assumes CATR, MACT, 316(b), CCR regulations enforced, $0/ton CO2 price; compliance is met through "capital-heavy" methods (e.g., FGD, SCR, fabric filters)
2 Assumes 15% reserve margin must be maintained in each NERC region; demand growth based on EIA projections through 2020

SOURCE: McKinsey analysis, US Energy Information Administration, Energy Velocity

With favorable economics, EE is considered the first priority for GHG abatement by the Chinese government

China GHG abatement cost curve, 2030



- Although individually small, the **aggregate abatement potential is big**
- Most initiatives also are **economically more favorable than cleantech and CCS**

Actions taken by the Chinese government

Mandates

- **Incorporate EE targets into KPI for local governments**, e.g., by 2010, reduce energy consumption per unit of GDP by 20% and reduce major pollutants by 10%
- Governments failing to meet targets must provide remedies within one month of notice and deliver within a probation period

New standards/ regulations

- **Create a new set of building codes:**
  - 65% reduction from 1995 standards for four municipalities (Beijing, Shanghai, Tianjin, and Chongqing) and Northern provinces
  - 50% in other areas

Subsidies

- **Subsidize energy-saving equipment manufacturers**, e.g.:
  - RMB 350-RMB 800/set of air-con.
  - RMB 5/compact fluorescent lamp (CFL)

Tax benefits

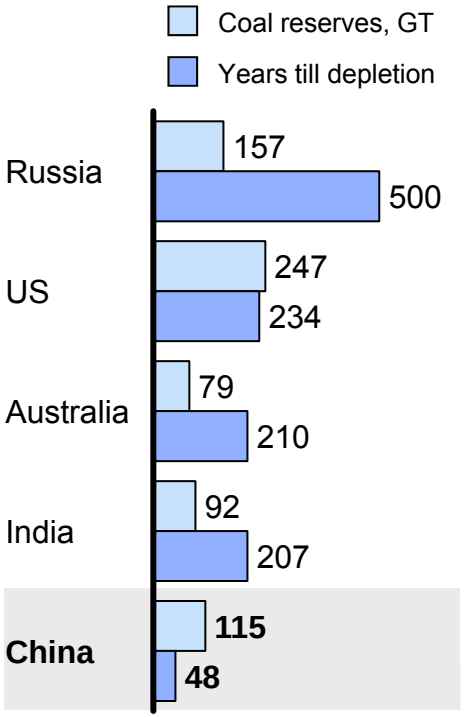
- **Offer up to 10% income tax rebate** for companies that purchase energy-saving equipments

Sources: McKinsey climate change cost curve v2.0; NBS; literature search; team analysis

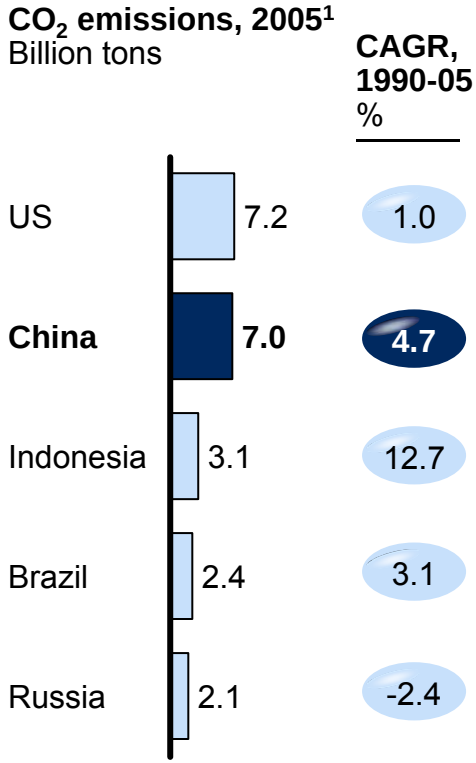
China's "default" generation expansion path is increasingly a concern for the Chinese government

Currently, 78% of China energy comes from coal, which is being rapidly depleted

China's coal reserve



China is already one of the world's leading CO_2 emitters



China's environment has deteriorated over the previous decades

- Glaciers in the nation's northwest have decreased by 21% since the 1950s
- All China's major rivers have shrunk over the past 5 decades
- Annual average air temperature has increased by 0.5°C~0.8°C in the last century
- The rate of sea level rise along China's coasts during the past 50 years was 2.5 mm/year, higher than the global average

1 Includes emissions associated with deforestation and end-use changes

SOURCE: National Power Industry Statistics Express 2008; National Development Bank; UNFCCC; McKinsey analysis

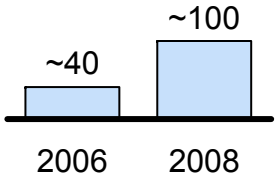
Wind could reach 100 GW by 2020

Key drivers to improve wind competitiveness

Economics

- **Capex to further go down due to:**
  - **Adoption of better technology** (e.g., 2.5 GW)
  - **Increasing competition**

Number of wind equipment suppliers in China



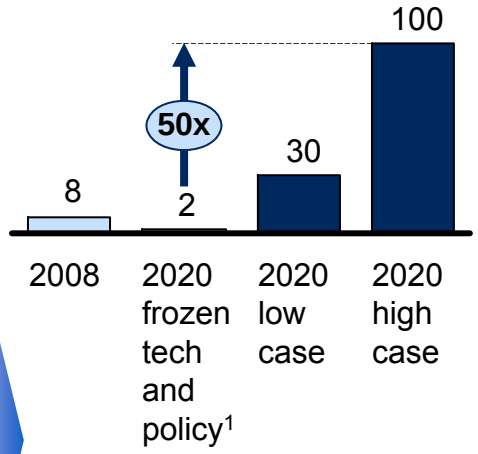
Supply-side support

- **Component manufacturing capacity** (e.g., gearbox) will **debottleneck** in the next 3-5 years
- Local manufacturers to reach annual production capacity to a total of **approx. 12 GW-15 GW by 2010-11**
- While wind resources are located in areas with low T&D density, the government is investing **more than $90bn** to **improve infrastructure** in the next 3-5 years

Government policies

- The **government is committed to a 30 GW target** in the "mid- to long-term renewable development plan"
- Recent speeches by government officials suggest a potential increase to **100 GW**
- **Very generous subsidies and tax rebates** (e.g., income tax exemption in the first three years)

Installed capacity
GW



- Wind cost is already comparable with peak tariff for coal power[2]
- With further cost reduction potential and strong government push, high-case **target is achievable**

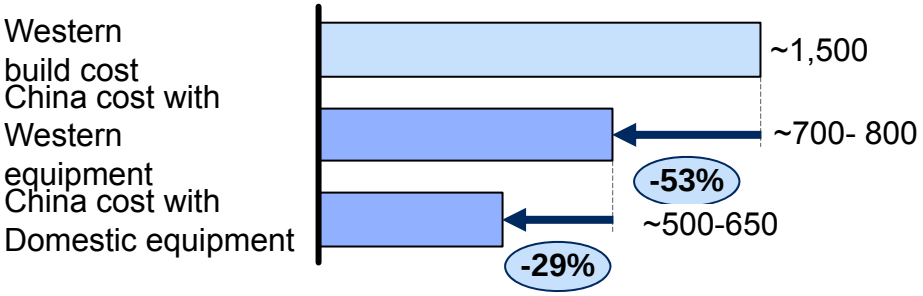
1 Freezing technology and policy status as of 2005
2 Proxyed by gas power generation cost

Sources: NDRC; CWEA; literature search; team analysis

A shift towards renewables would create excess manufacturing capacity in traditional generation – and potentially displacement of other players

Chinese companies build more cheaply…

Construction costs for coal-fired power plant*
$/kW



Chinese players have significantly raised capabilities . . .

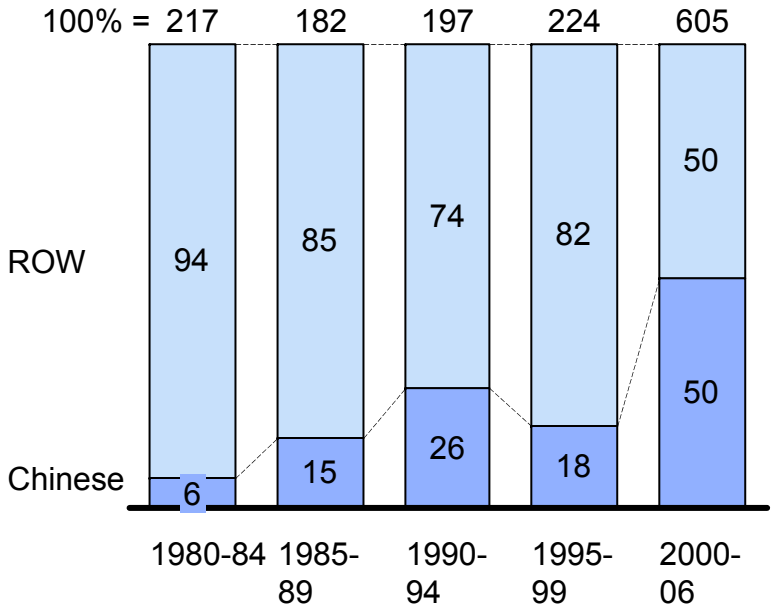
Generation product	Localization level
300-600 MW turbine	
900-1,000 MW turbine	
300-600 MW boilers	
900-1,000 MW boilers	
Supercritical turbines	
Ultra-supercritical turbines	

During the past boom years, all local players moved up the tech ladder; vendors that used to do 300 MW, can now do 600 MW

– Industry expert

... thus have taken large market share globally

Steam turbine orders
GW



Source: National Power Industry Statistics Express 2008; National Development Bank; analyst report

Questions?

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