12. WORLD ELECTRICITY IN THE YEAR 2050

Asko Vuorinen

World electricity in the year 2050
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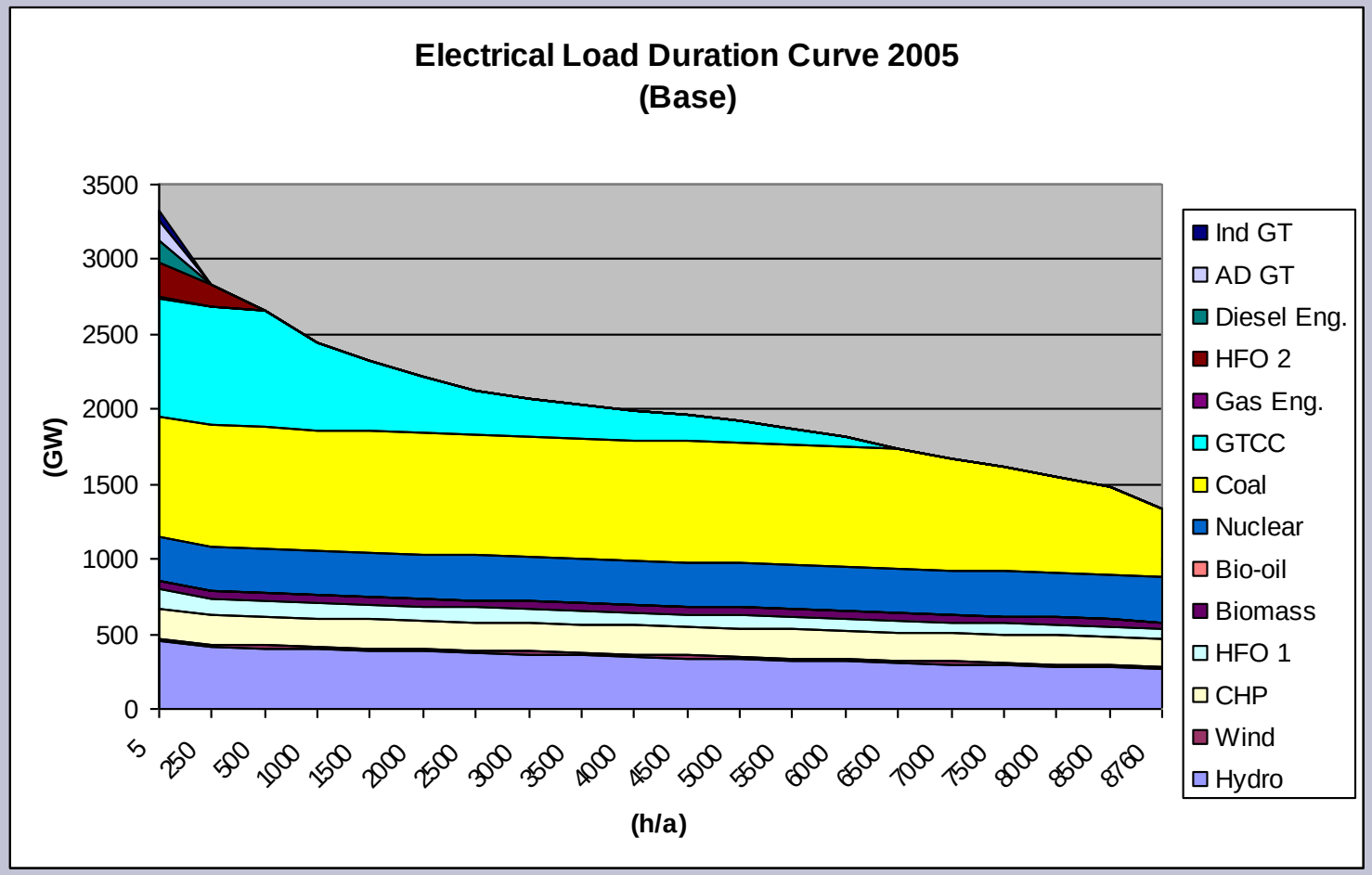
Electricity generation in the world today (2005)

Electricity in the world today
Assumptions

- The actual capacities of different type of power plants in year 2005 are used
- Hyphothetical situation where all plants would be in a single system
- The plants would operate in merit order by variable costs
- The lowest variable cost plants operate on the base load and highest cost plants in the peak load

Electricitity in the world today

Load duration curve in 2005



Electricity in the world today
Capacities and generation

	Capacity GW	Load TWh	Load %
Base load plants*	1660	8600	50 %
Coal power plants	1000	6500	38 %
Gas plants	880	2000	12 %
Peaking oil plants	600	100	< 1 %
Total	4140	17200	100%

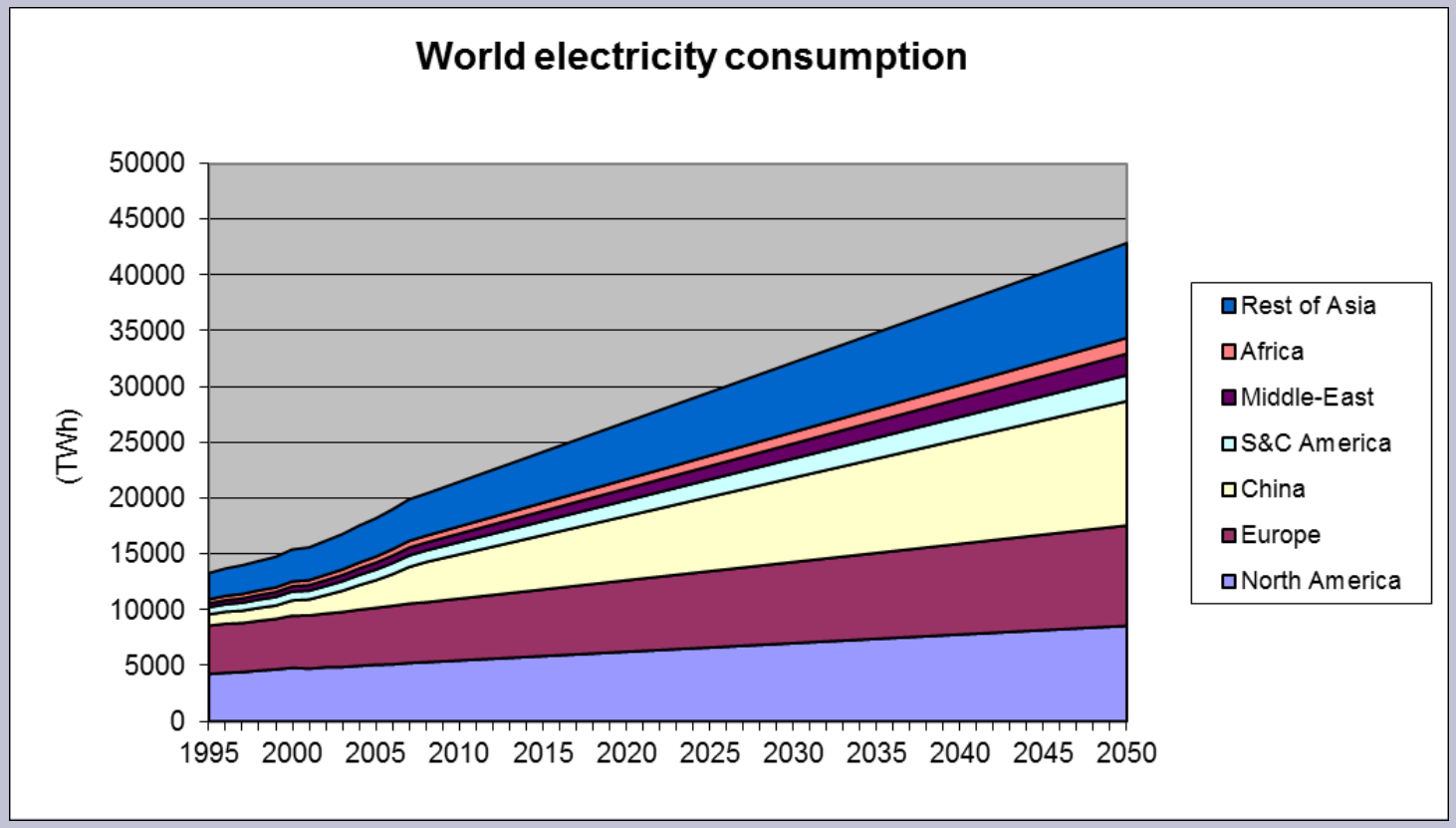
* The base load plants include here hydro, wind, CHP, Biomass, bio-oil and nuclear

Forecast of electricity consumption in 2050

Forecast of electricity consumption in the year 2050, Methods

- Collect the actual consumption figures from last ten years from different parts of the world
- Calculate the trend of consumption using linear fit of actual figures
- Estimate the consumtion in the year 2050 using the trend

Forecast of electricity consumption in the year 2050



Forecast of electricity consumption in the year 2050 (TWh)

Year	2007 (TWh)	2050 (TWh)	Growth (TWh)	Growth (%)
North-America	5 224	8 556	3 332	64 %
Europe	5 327	8 989	3 662	69%
China	3 278	11 149	7 871	240%
S&C America	1 034	2 331	1 297	126%
Middle-East	692	1 923	1 231	178%
Africa	613	1 422	810	132%
Rest of Asia	3 728	8 491	4 763	128%
World total	**19 895**	**42 860**	**22 965**	**115%**

Electricity consumption will more than double by 2050
Consumption in China will trible and consume 34% of electricity. North-America and Europe will consume 15 % of all electricity generated in the world in 2050

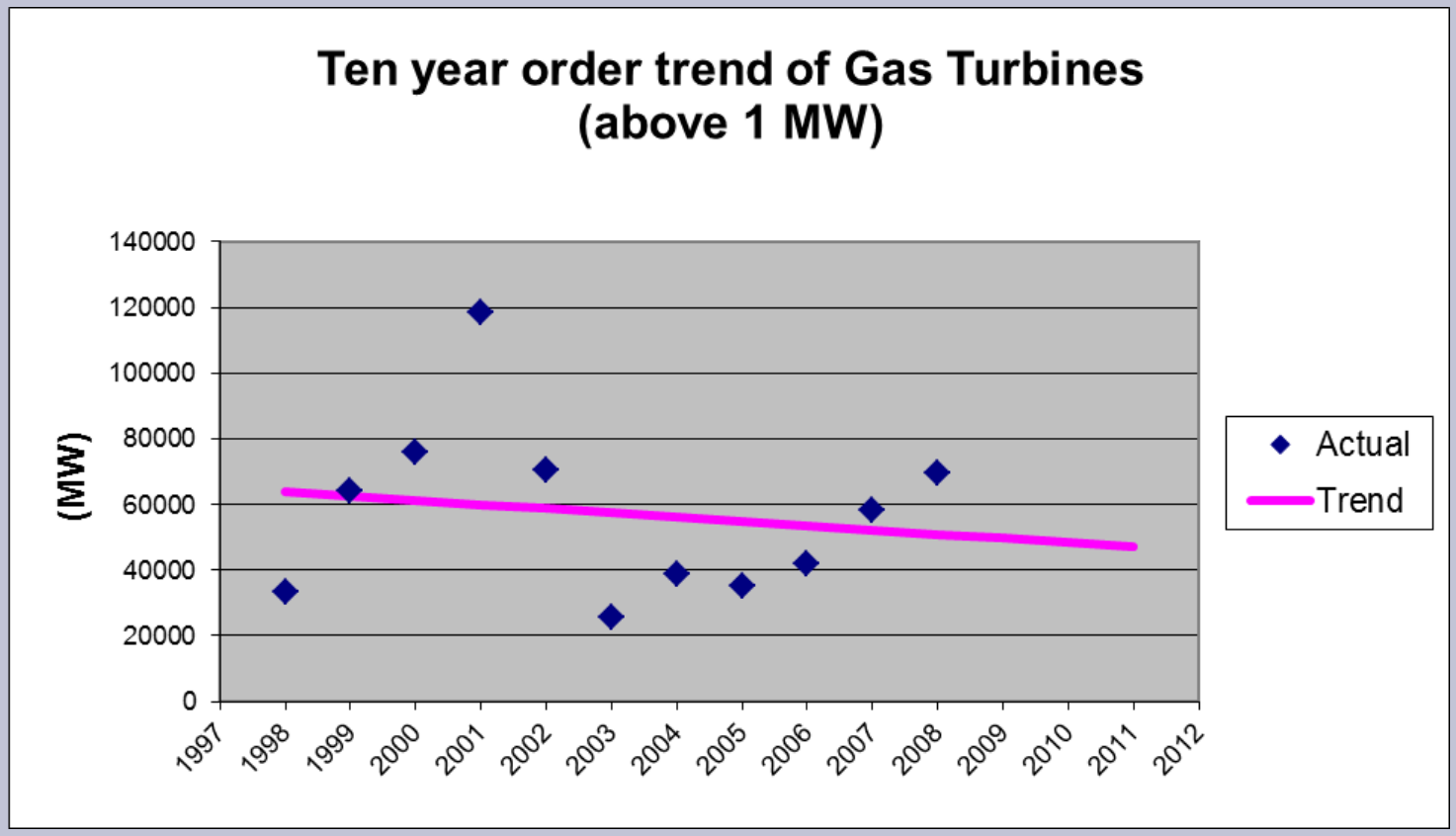
Trends in power plant construction

Trends in power plant construction
Methods

- Study orders of power plant technologies for last ten years
- Calculate trend using linear fit of points
- Estimate future orders using the trend

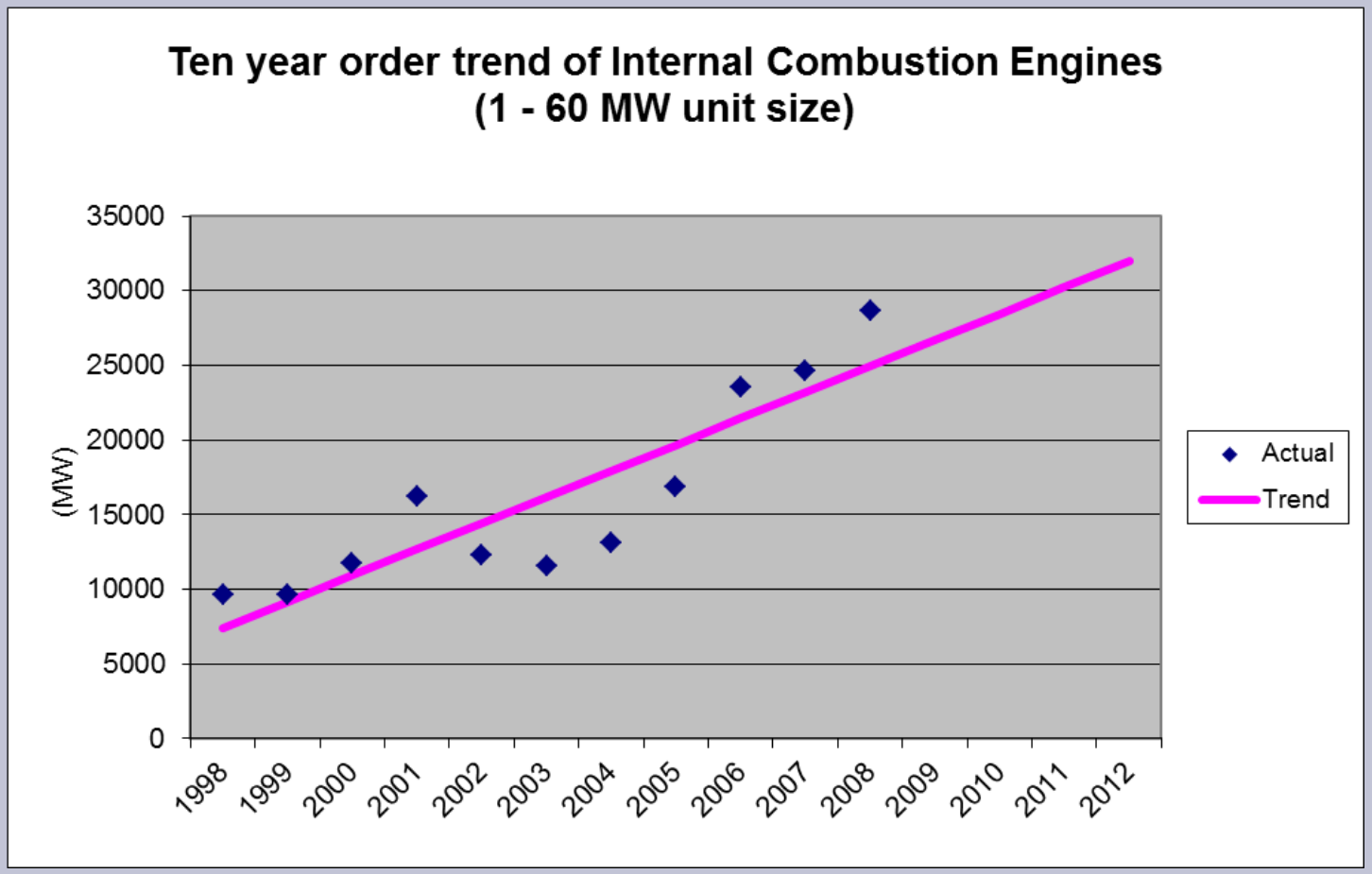
Trends in power plant construction

Orders of gas turbines



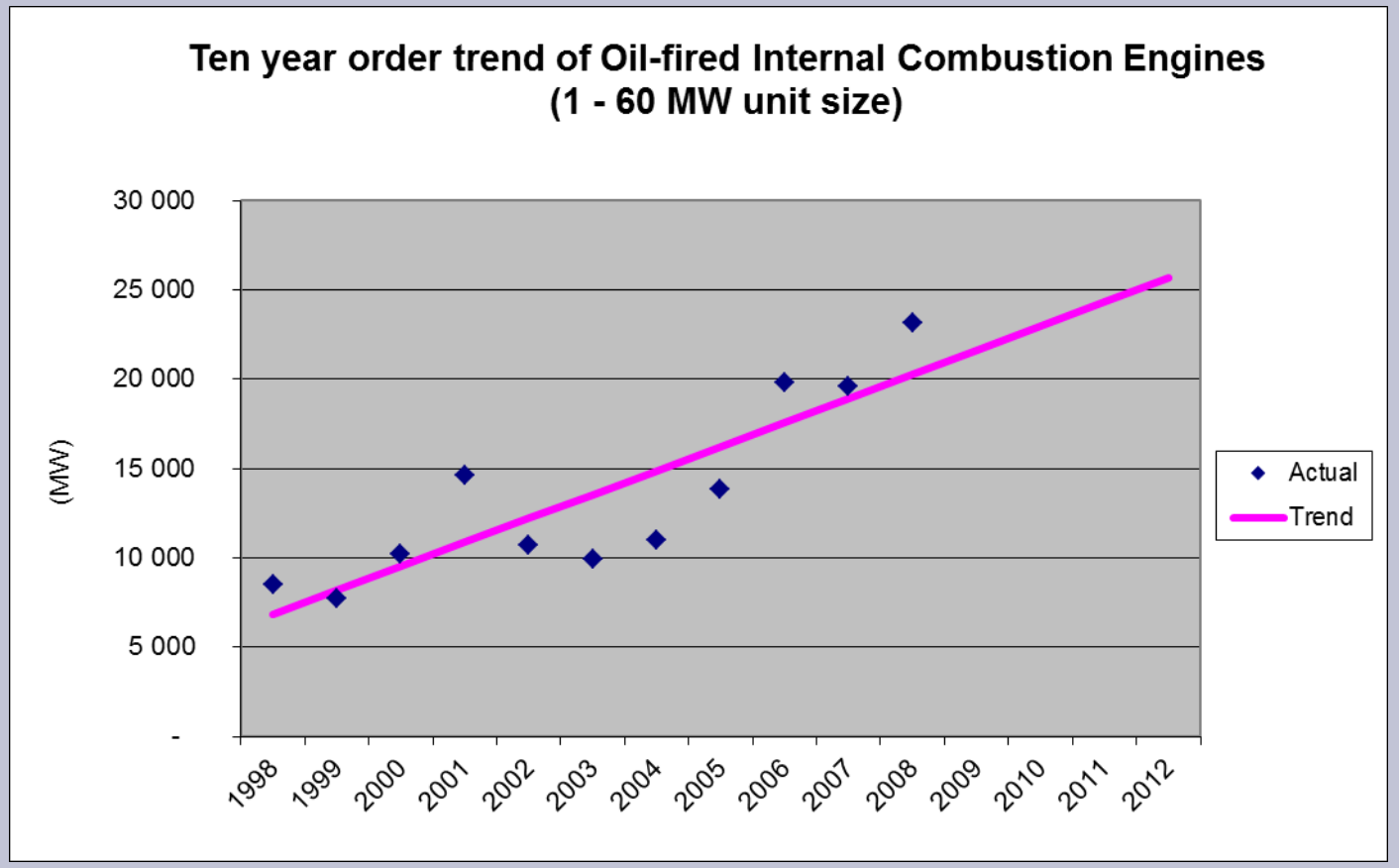
Trends in power plant construction

Orders of internal combustion engines



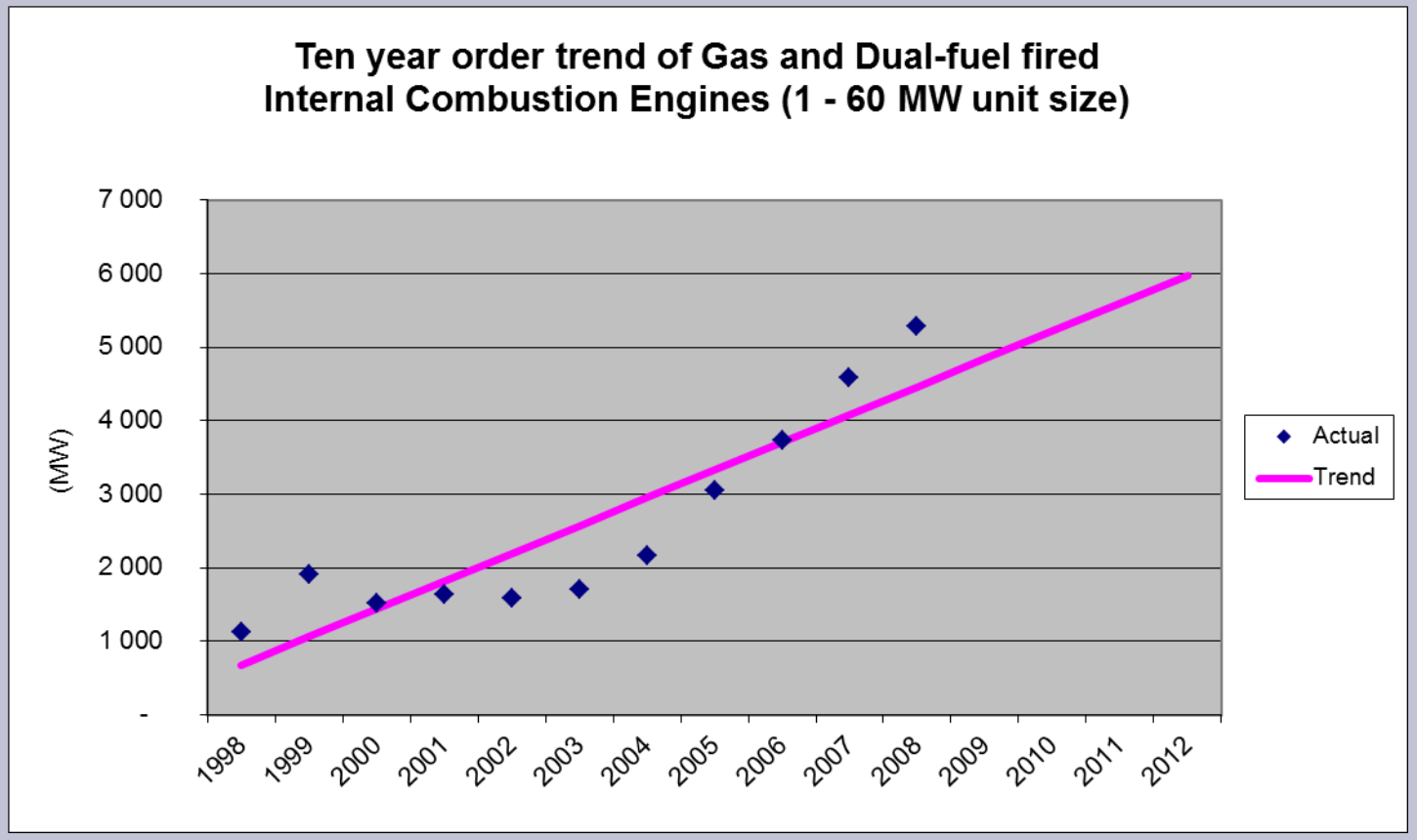
Trends in power plant construction

Orders of oil fired internal combustion engines

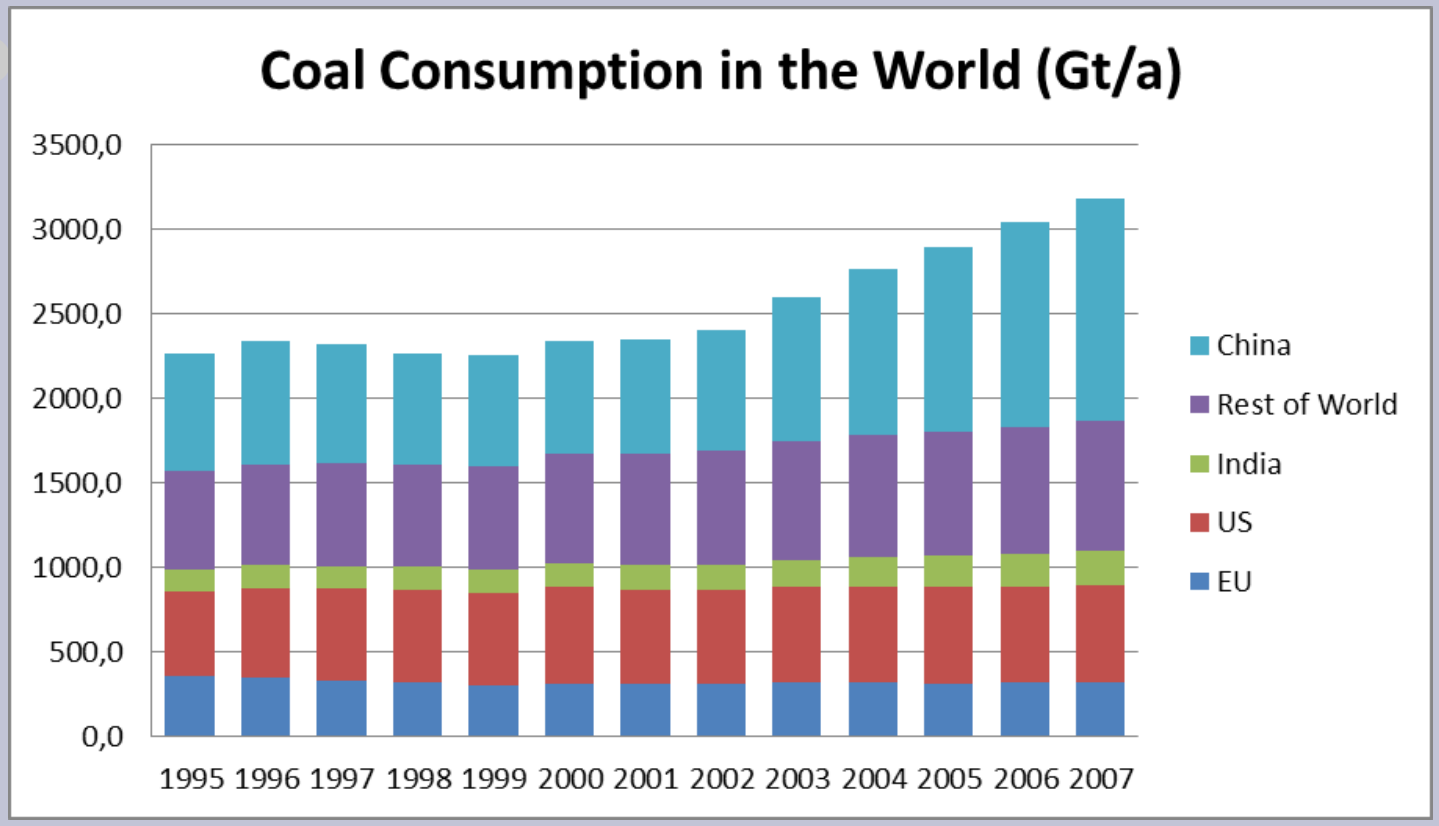


Trends in power plant construction

Orders of gas and dual-fuel fired internal combustion engines



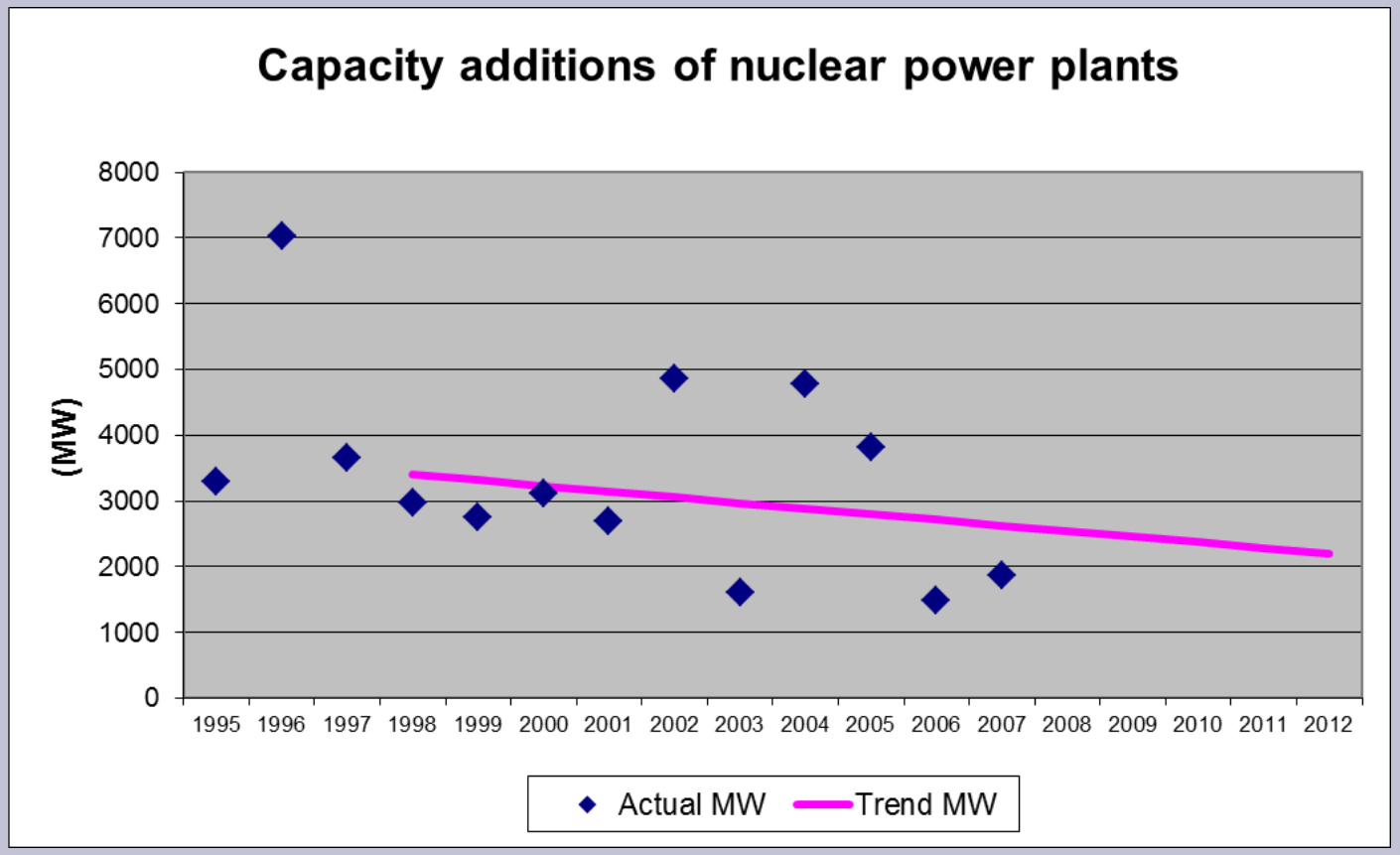
Trends in power plant construction
Consumption of coal



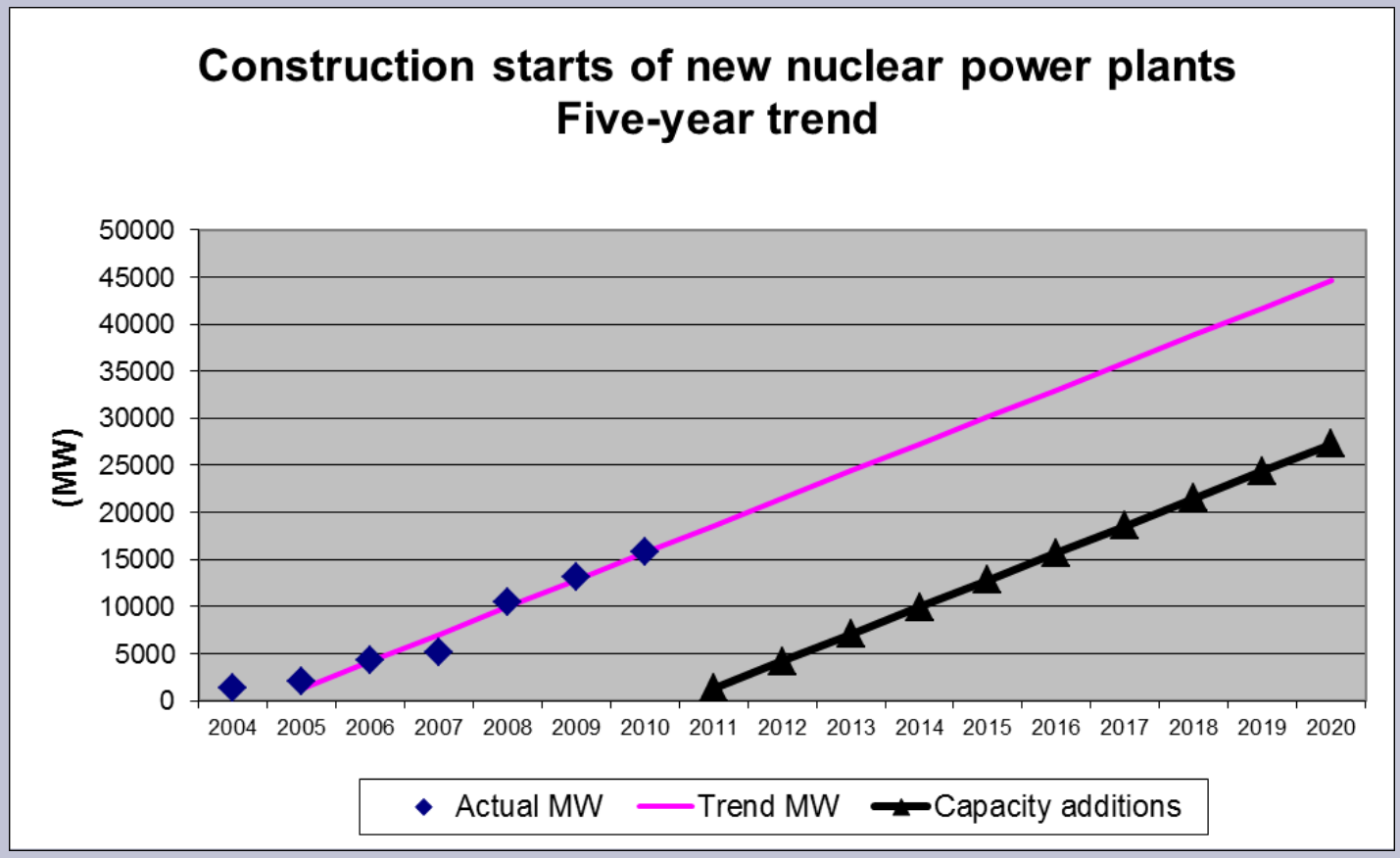
Coal power generation is increasing at the rate 443 TWh/a in China. This corresponds to 60 GW capacity additions.

Trends in power plant construction

Capacity additions of nuclear power plants

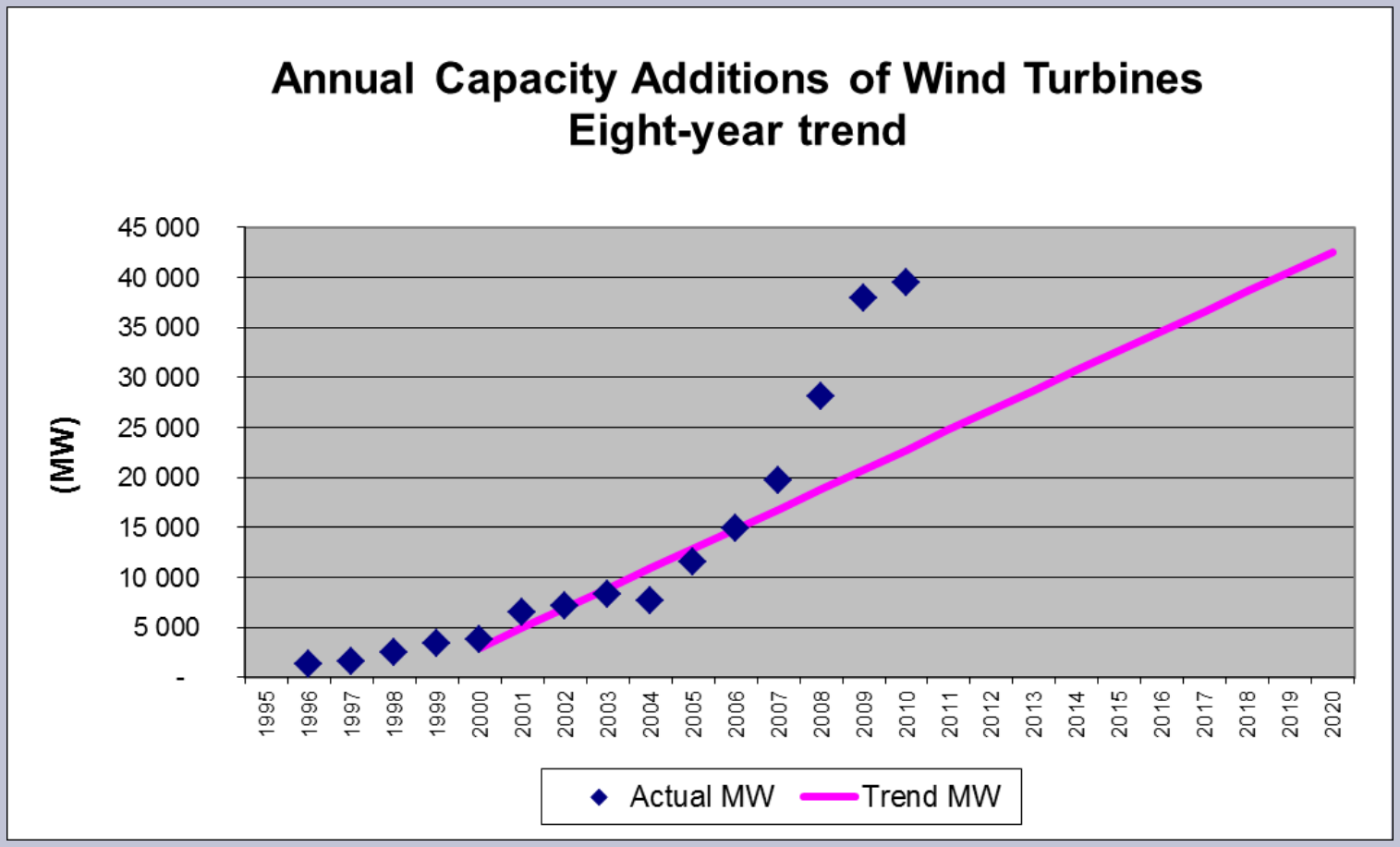


Construction starts of new nuclear power plants



Trends in power plant construction

Capacity additions of wind turbines



Trends in power plant construction Summary

- Capacity additions of gas turbines and coal plants stay stable
- Capacity additions of wind turbines increase by 4000 MW annually
- Orders of internal combustion engines increase by 1750 MW each year
- Nuclear plant construction starts increase 1000 MW each year

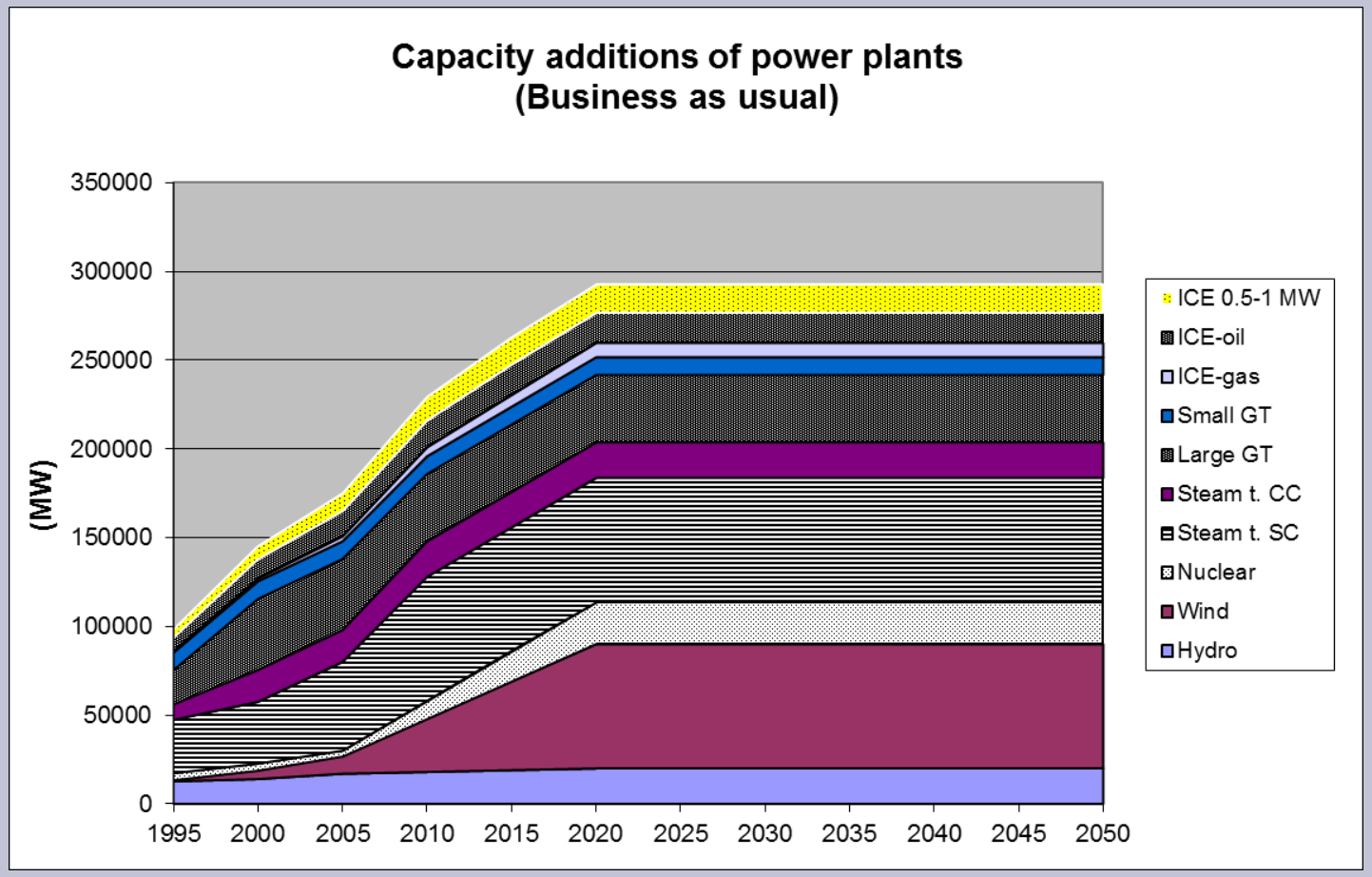
Scenario a)
Business as usual

Scenario a) Business as usual
Strategy

- The present trend of increasing capacity additions continues to 2020
- After 2020 capacity additions stay at constant level

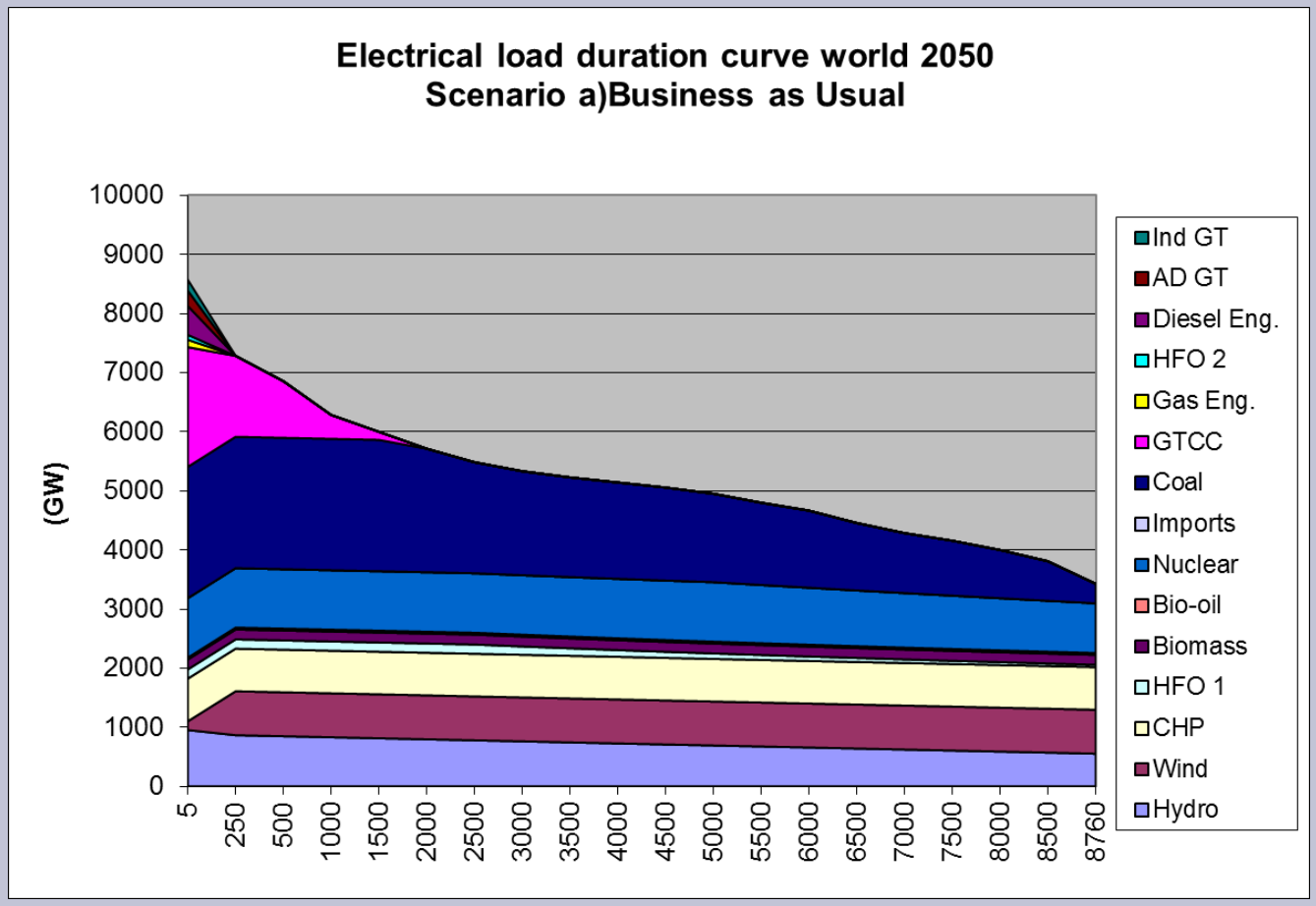
Scenario a) Business as usual

Capacity additions



Scenario a) Business as usual

Load duration curve in 2050

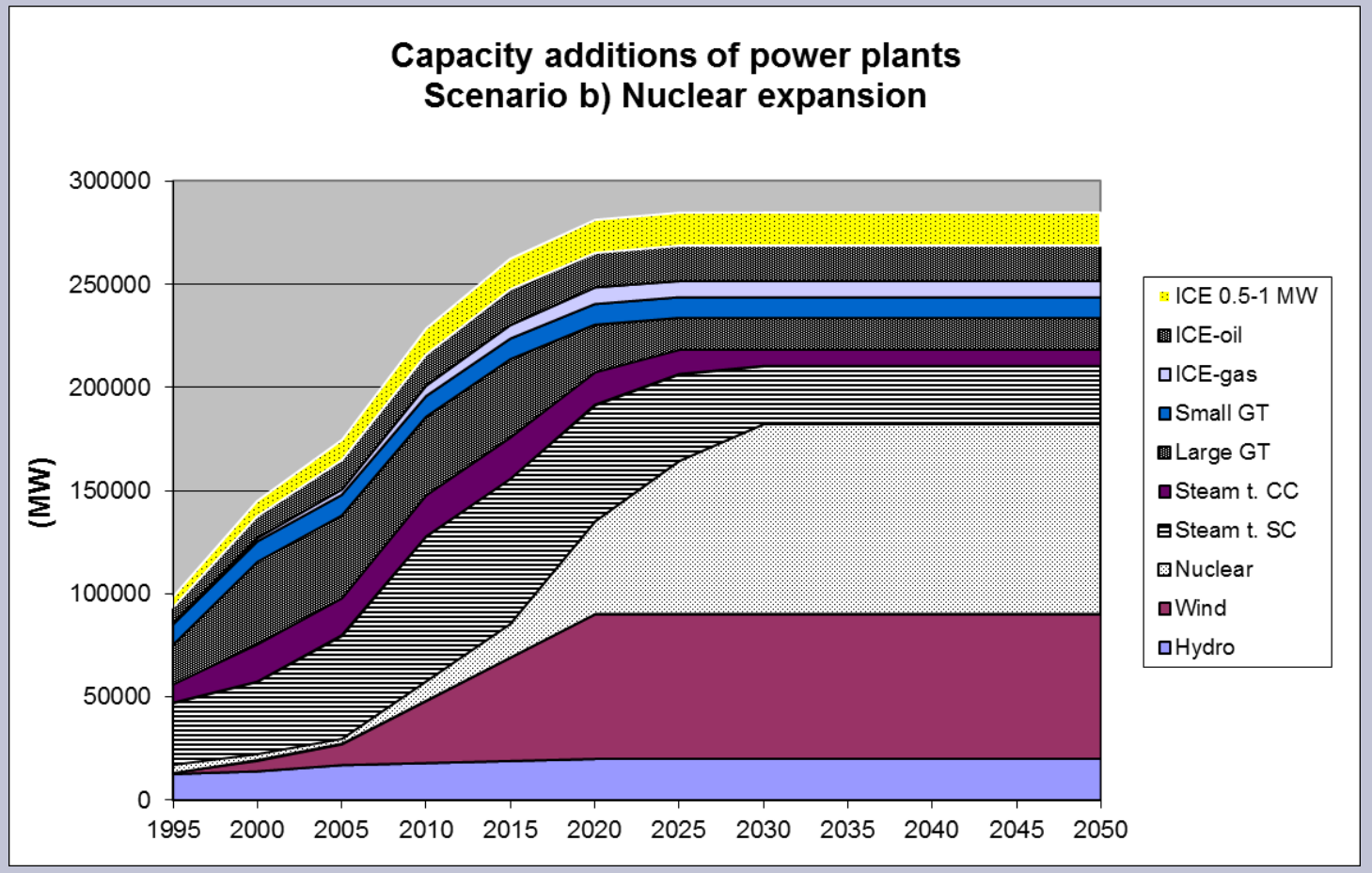


Scenario b)
Nuclear expansion

Scenario b) Nuclear expansion Strategy

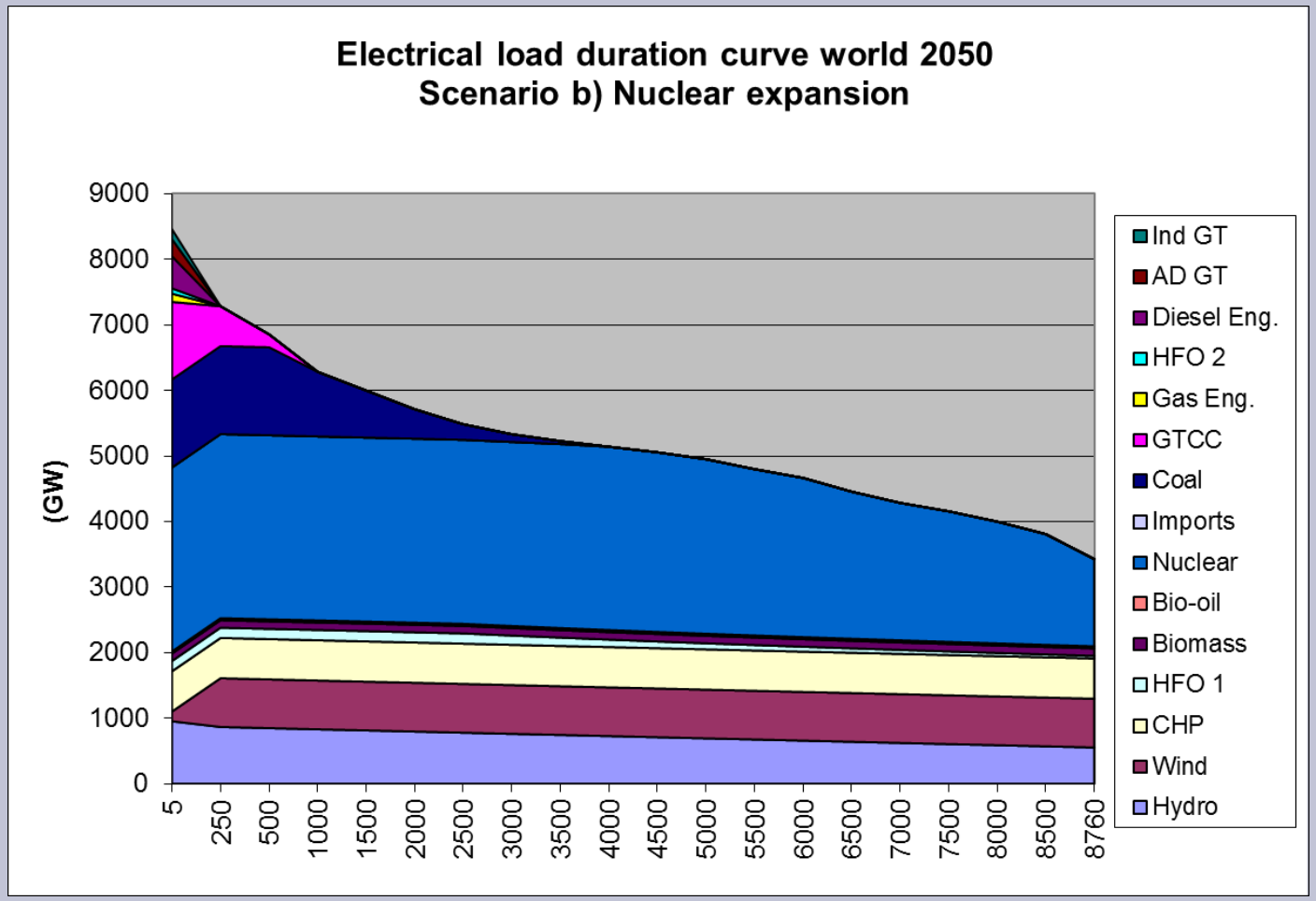
- Building of coal fired condensing and gas fired GTCC plant is stopped
- Coal and GTCC capacity additions have been replaced by nuclear plants

Scenario b) Nuclear expansion
Capacity additions



Scenario b) Nuclear expansion

Load duration curve in 2050



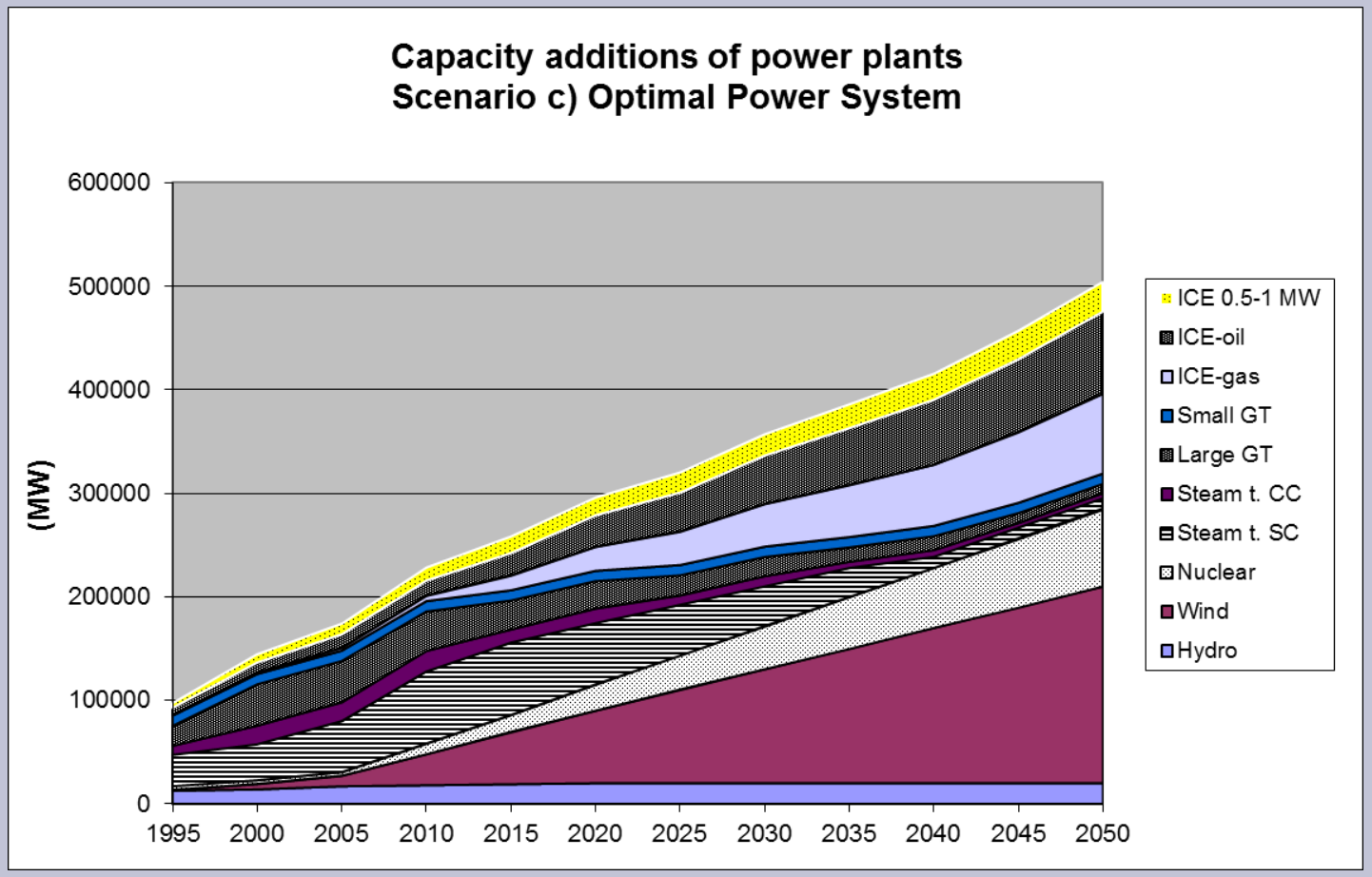
Scenario c)
Optimal power system

Scenario c) Optimal power system
Strategy

- Wind and internal combustion engine expansion continues with the increasring trend to 2050
- Annual capacity additions of CHP and biofuel plants double
- Nuclear plants take the rest of capacity of coal and gas fired base load plants

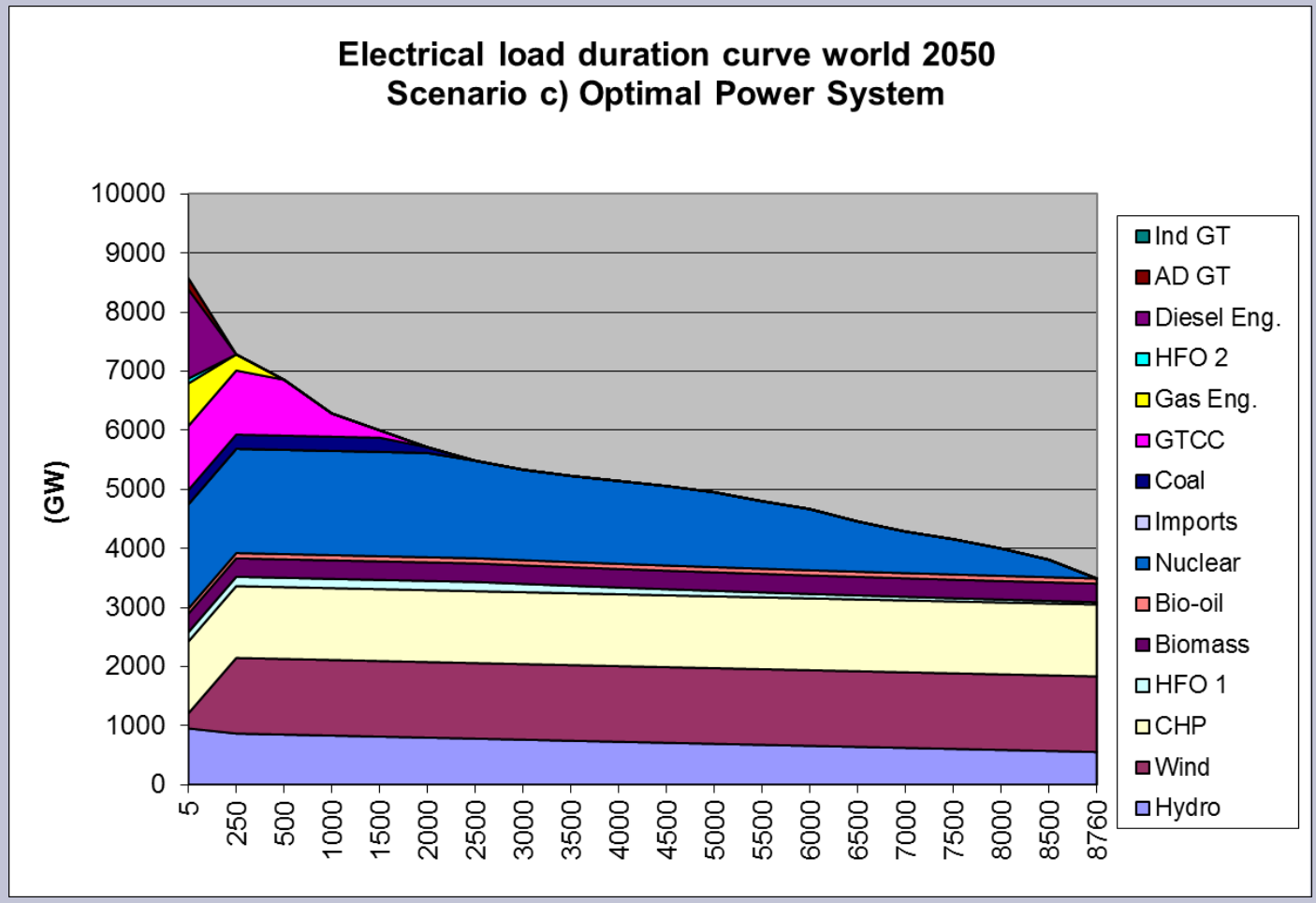
Scenario c) Optimal power system

Capacity additions



Scenario c) Optimal power system

Load duration curve in 2050



Summary

Power generation in 2050

Year		2005	2050	2050	2050
Scenario		Base	a)	b)	c)
		Present	Business	Nuclear	Optimal
		system	as usual	expansion	Power system
Hydro	(%)	16 %	14 %	14 %	14 %
Wind	(%)	1 %	14 %	14 %	25 %
CHP	(%)	10 %	14 %	12 %	24 %
HFO 1	(%)	4 %	2 %	2 %	2 %
Biomass	(%)	3 %	3 %	2 %	6 %
Bio-oil	(%)	0 %	1 %	1 %	2 %
Nuclear	(%)	15 %	19 %	49 %	24 %
Coal	(%)	42 %	30 %	6 %	1 %
GTCC	(%)	9 %	3 %	1 %	3 %
Peaking	(%)	0 %	0 %	0 %	0 %
Total		100 %	100 %	100 %	100 %

Coal Nuclear Wind

Summary

Generation costs in 2050

Year		**2005**	**2050**	**2050**	**2050**
Scenario		**Base**	**a)**	**b)**	**c)**
		Present	**Business**	**Nuclear**	**Optimal**
			as usual	**expansion**	**Power system**
Total costs	(1000 M€)	1 559	3 658	3 415	3 642
Generation	(TWh)	19 062	44 926	44 925	44 934
Costs	**(€/MWh)**	**82**	**81**	**76**	**81**
Index	%	100 %	100 %	93 %	99 %

Summary

CO2-emissions in 2050

Year		**2005**	**2050**	**2050**	**2050**
Scenario		**Base**	**a)**	**b)**	**c)**
		Present	**Business**	**Nuclear**	**Optimal**
			as usual	**expansion**	**Power System**
Emissions	(Mt CO_2)	8666	13956	3929	3794
Index	(%)	100 %	161 %	45 %	44 %
Generation	(TWh)	19 062	44 926	44 925	44 934
Specific	(gCO_2/kWh)	**455**	**311**	**87**	**84**
Index	(%)	100 %	68 %	19 %	19 %

Summary and conclusions

- The consumption of electricity in 2050 will be more than two times of the 2008 level
- If the present trend of construction of power plants continues, the CO2-emissions will increase by 70 % (Scenario A)
- In scenario C) CO2-emissions can be reduced by 50 % from the present level
- This can be achieved by stopping building coal and gas fired base load plants and by building of wind, nuclear and CHP-plants insteadt

For details see reference text book ”Planning of Optimal Power Systems”

Author:
Asko Vuorinen

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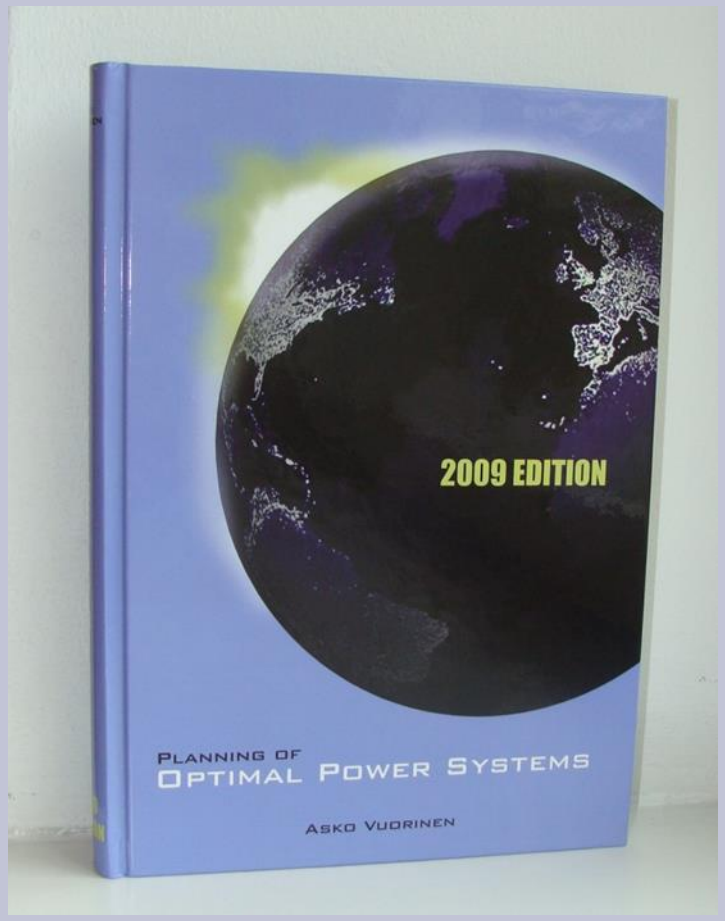
Book and programs are available at



https://www.booky.fi/tuote/vuorinen_asko/planning_of_optimal_power_systems/9789526705712