

# The Cost of Nuclear Electricity

## France after Fukushima

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- Focus on Second Generation starting 1970s



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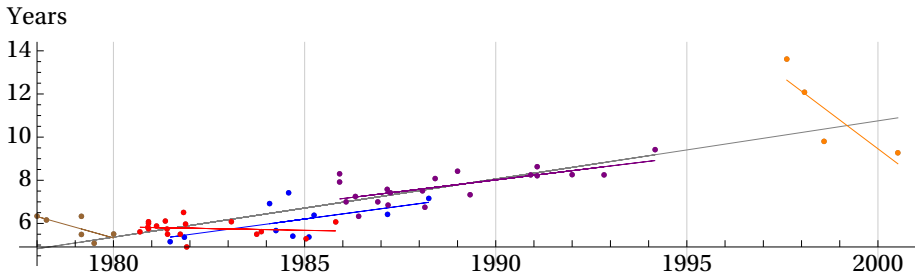


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- Long lasting investments: *Steam Trains* alongside *TGVs*

## French Second Generation Nuclear Reactors

- Construction duration of 58 French nuclear reactors
- Function of the date of commercial operation
- Distinct colors and linear fittings for the five batches
- Source: PRIS database, International Atomic Energy Agency



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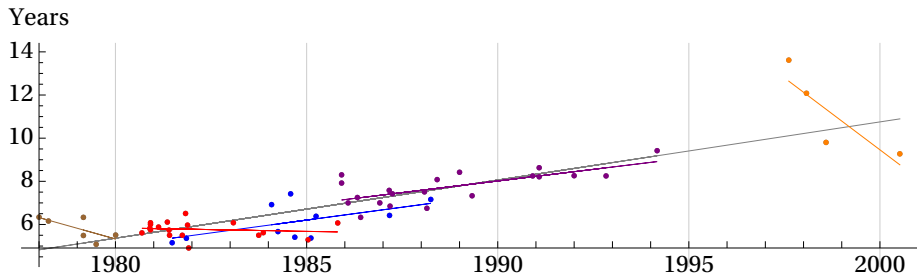
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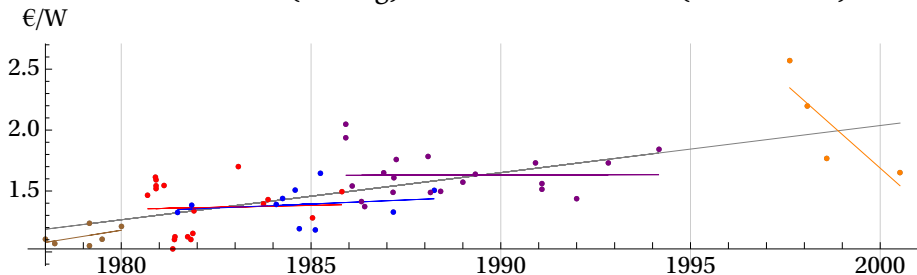
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- Estimate reactor capital cost using duration and plant cost

# Construction Cost of Second Generation French Nuclear Reactors



Old information (Timing) vs. New information (2010€ cost)



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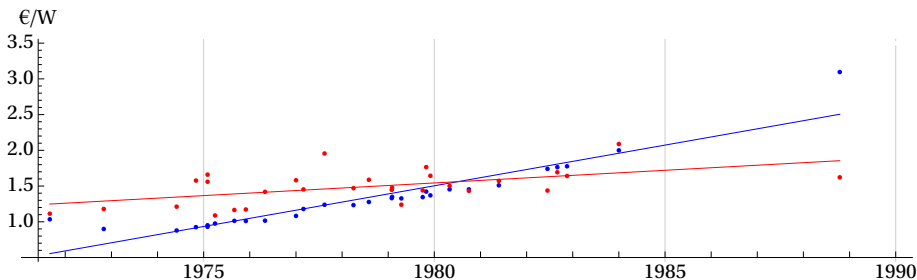


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- Full economic benefit requires European output market

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## Comparison with Grubler

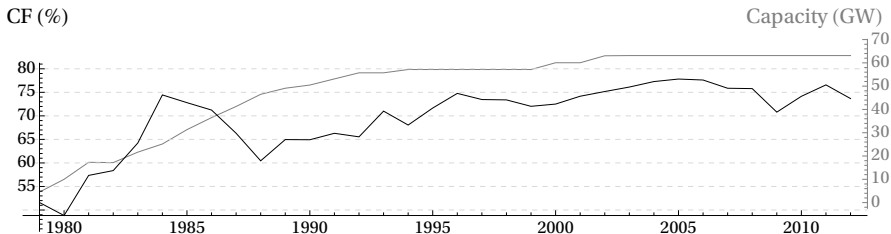
- Grubler vs. Court of Audit (timing is construction start)
- Plant Unit Cost escalation increasingly off the mark
- Mean cost 1.4 €/W, growth 8.4%
- Real: 1.5 €/W, growth 2.1%



- Capacity Factor: ratio of actual output to theoretical maximum

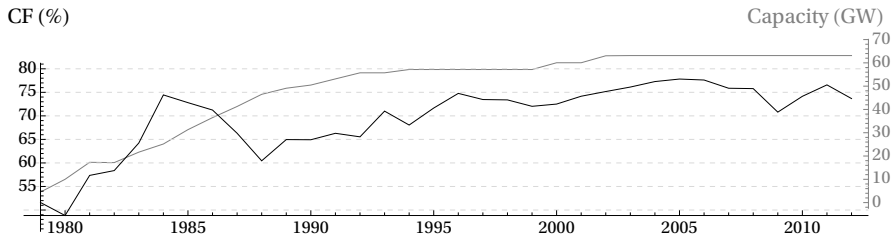
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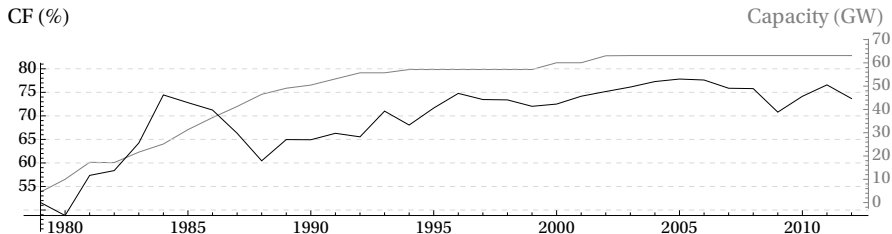
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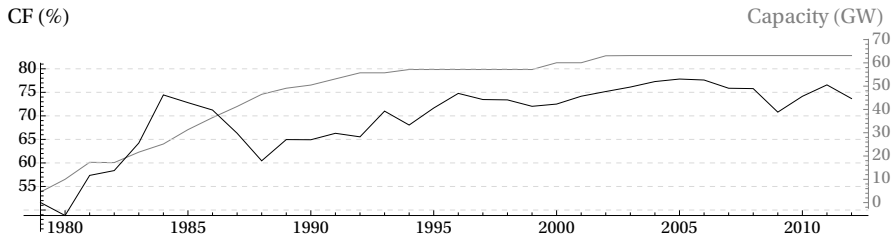
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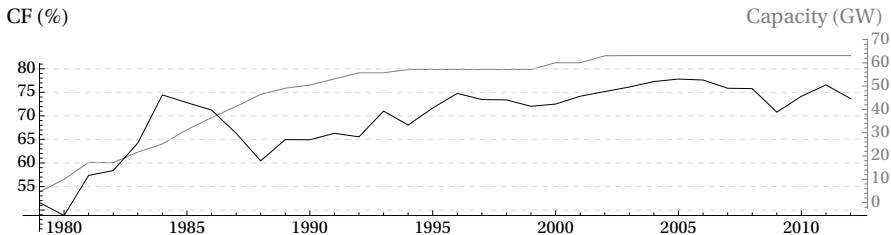


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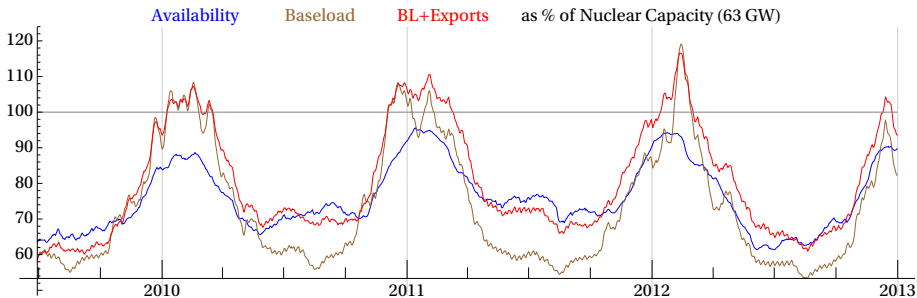


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- What about 1990s with young “problem-proof” fleet ?

- Could lack of demand forces EDF to keep idle capacity ?

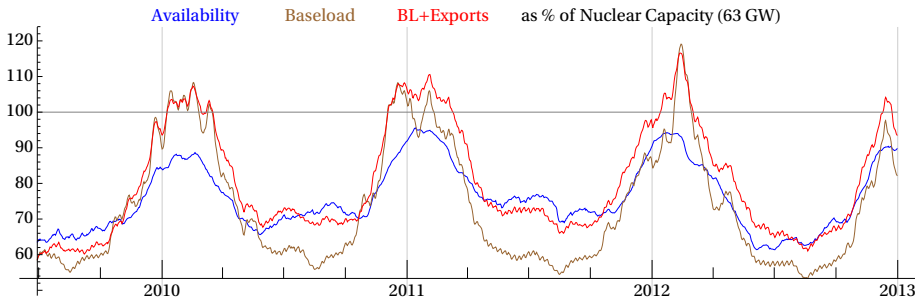
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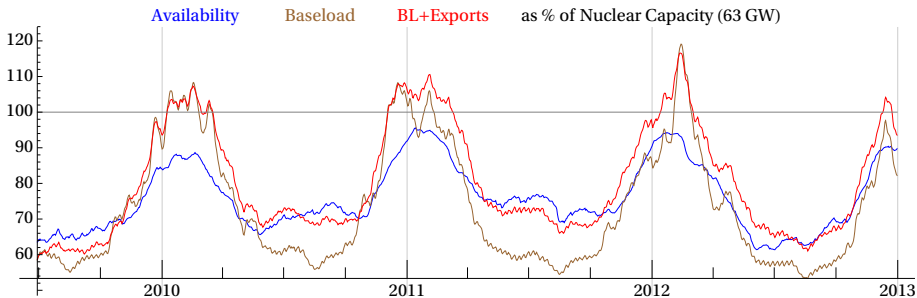
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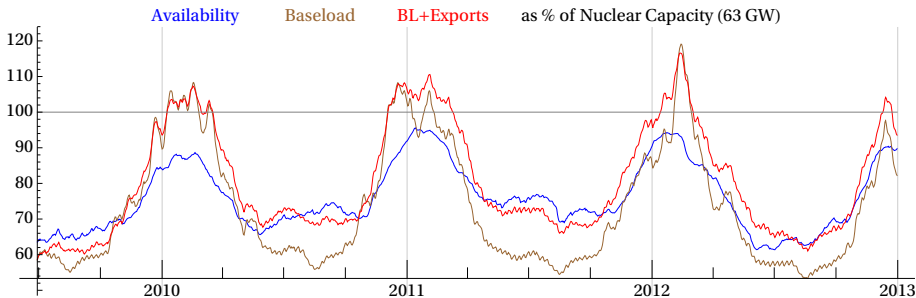
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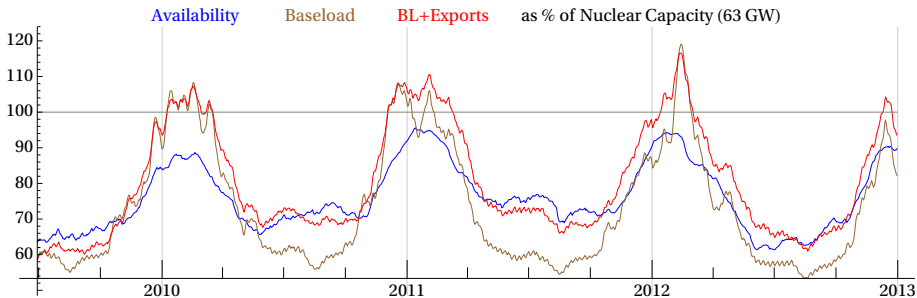
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- Total Plant Investment for French Second Generation Nuclear Plants

<i>Investment</i>	bn€	€/kW
Construction	72.9	1154
Engineering	10.3	163
Financing Costs	13.0	207
<b>Total</b>	<b>96.2</b>	<b>1524</b>

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- Continuous flow of spent fuel = operating expense

<i>Fuel</i>	bn€/year
Acquisition	1.5
Spent fuel	0.9
Stock	0.6
<b>Total</b>	<b>3.0</b>

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<i>O&amp;M</i>	bn€/year
Maintenance	3.8
Labour	2.7
Support	3.4
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- O&M cost  $\approx 4 \times$  fuel cost (similar to RES)

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- Back-end Cycle cost decomposition

<i>Back-end</i>	bn€	€/kW
Dismantling EDF	18.4	291
Dismantling CEA	1.9	30
Last cores	3.8	60
Waste EDF	23	365
Waste CEA	2.4	38
<b>Total</b>	<b>49.5</b>	<b>784</b>

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R&D 1st gen	14.4
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R&D 3rd gen	21.0
SuperPhénix	12.0
Old Reactors	6.1
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- Levelized Cost of Second Generation French Nuclear Power

<i>French PWR</i>	<i>Best</i>			<i>Worst</i>		
	bn€/y.	€/kW/y	€/MWh	bn€/y.	€/y./kW	€/MWh
Capital	5.6	89	13.4	10.9	172	26.0
O&M	11.9	188	28.5	11.9	188	28.5
Fuel	3.0	48	7.3	3.0	48	7.3
Back-end	0.8	13	1.9	1.6	25	3.8
Insurance				4.0	63	9.6
Development			7.7			7.7
<b>Total</b>	<b>21</b>	<b>338</b>	<b>59</b>	<b>31</b>	<b>497</b>	<b>83</b>

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- Court of Audit information double previous levelized cost estimate

Item	Capital	O&M	Fuel	Back-end	Development	Total
Grubler	12.5	6.0	6.3	2.5	3	30
Auditors	13.4	28.5	7.3	1.9	7.7	59

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<i>EPR</i>	<i>Best</i>			<i>Worst</i>		
	bn€/y.	€/kW/y	€/MWh	bn€/y.	€/y./kW	€/MWh
Capital	19.5	310	41.6	34.3	543	73.0
O&M	11.9	188	25.3	11.9	188	25.3
Fuel	3.0	48	7.3	3.0	48	7.3
Back-end	0.8	13	1.7	1.6	25	3.4
Insurance				4.0	63	8.5
<b>Total</b>	<b>35</b>	<b>559</b>	<b>76</b>	<b>55</b>	<b>869</b>	<b>117</b>

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- 2013 UK EPR deal: 108 €/MWh for 35 years to EDF

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<i>US</i>	bn\$/y	\$/kW/y	\$/MWh
Capital	22.7	227	33.4
O&M	15.1	151	22.2
Fuel	5.5	55	8.1
Back-end	0.9	9	1.4
Development			9.5
<b>Total</b>	<b>44</b>	<b>443</b>	<b>75</b>

<i>US</i>	
€/kW/y	€/MWh
198	29.0
131	19.3
48	7.1
8	1.2
	8.3
<b>385</b>	<b>65</b>

<i>FR</i>	
€/kW/y	€/MWh
89	13.4
188	28.5
48	7.3
13	1.9
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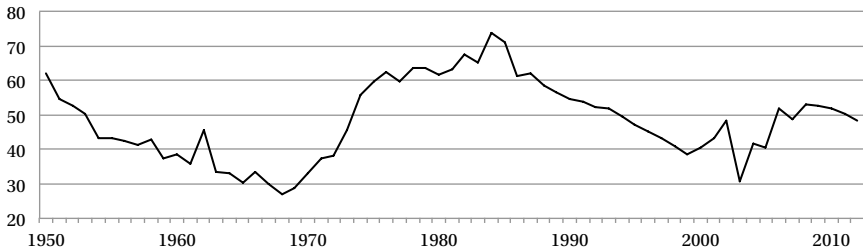
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## Comparisons: Nuclear vs. Coal

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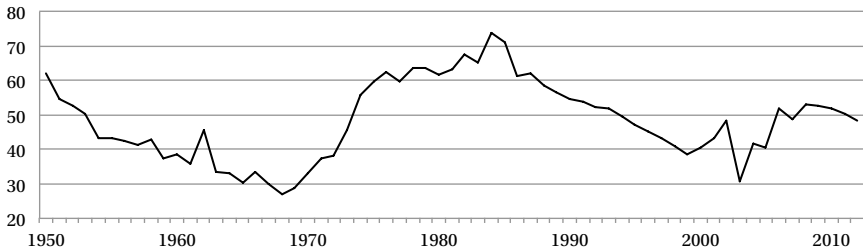
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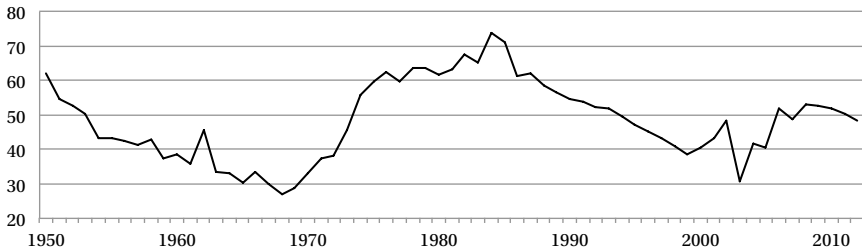
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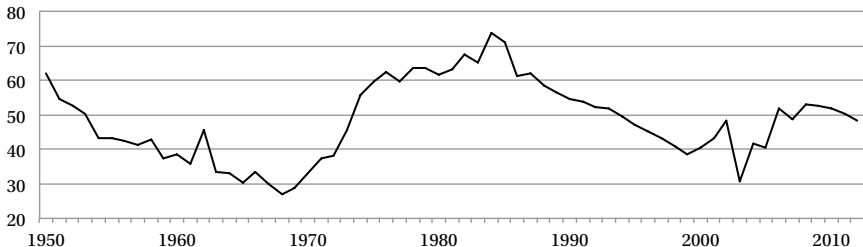
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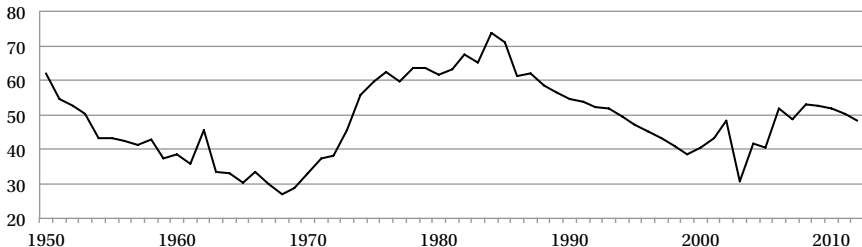
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- Clean energy drive: cost of carbon capture



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