MESA REDONDA

El coste de una energía limpia a gran escala

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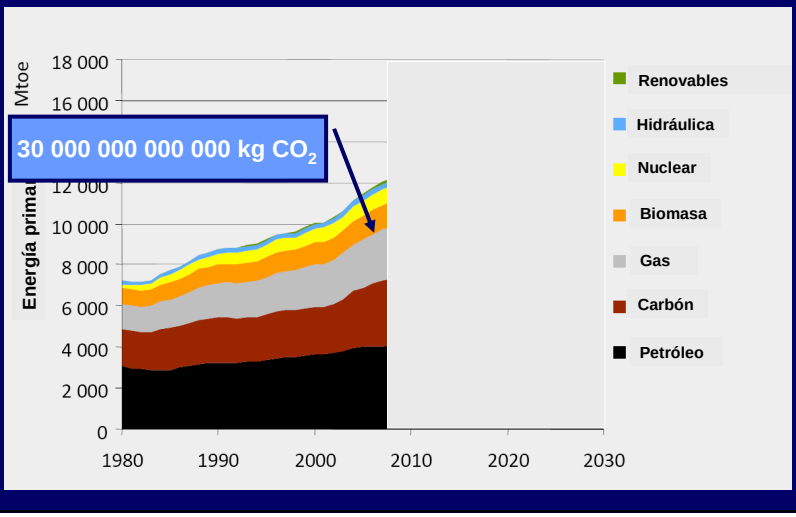
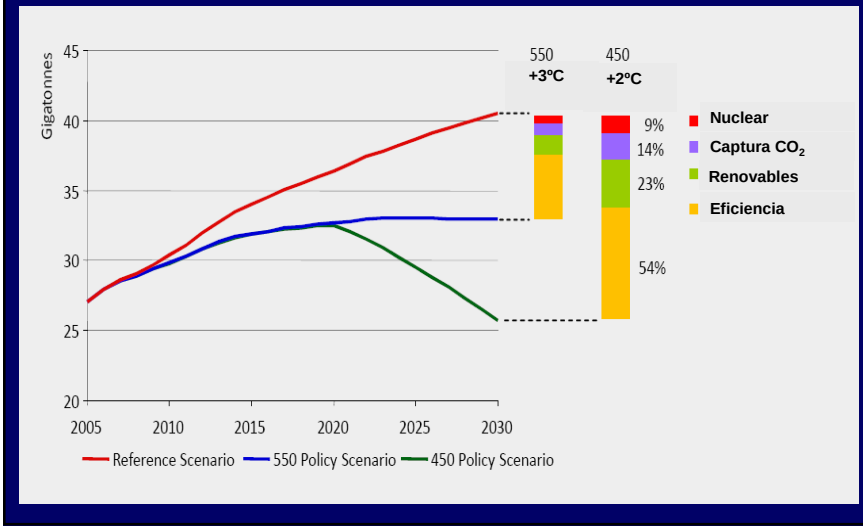
Fronteras de la Energía, Benasque 5-10 Julio 2009

Una visión posible y **negativa** del futuro energético

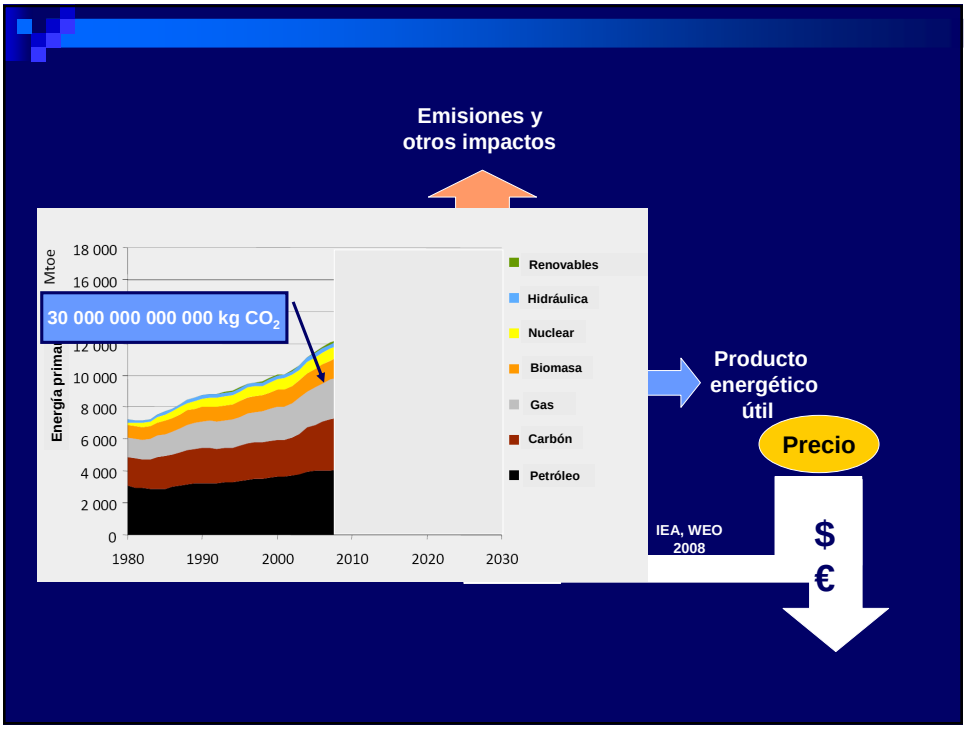


IEA, WEO 2008

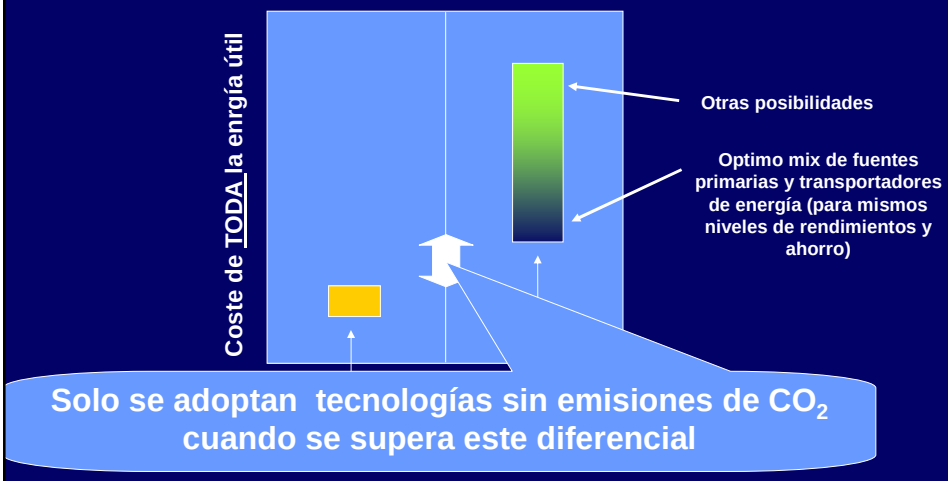
Una visión posible y positiva del futuro energético



IEA, WEO 2008

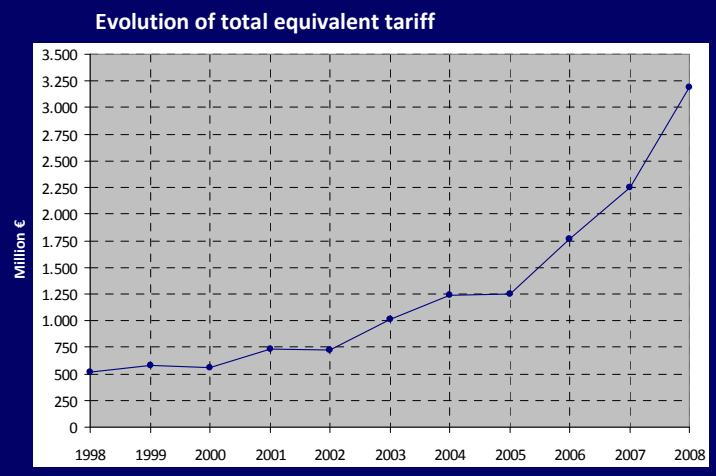


Coste de la energía útil



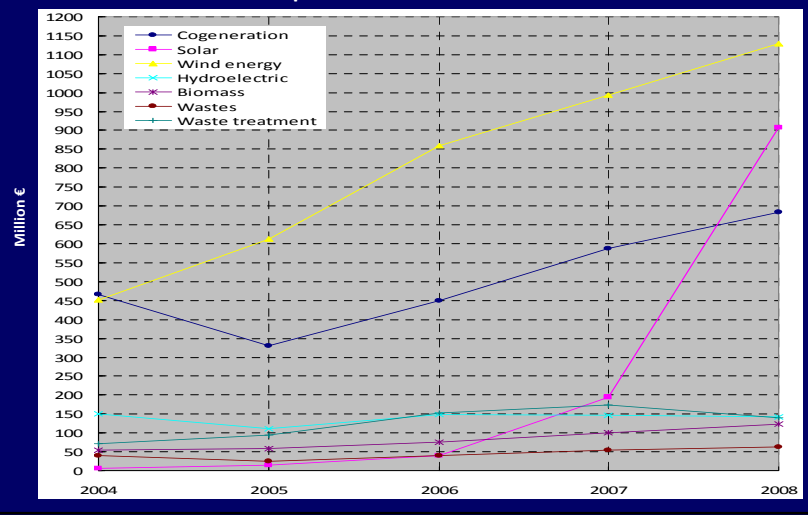
Solo se adoptan tecnologías sin emisiones de CO_2 cuando se supera este diferencial

Cost of feed-in tariffs in Spain



Cost of feed-in tariffs in Spain

Evolution of total equivalent tariff



¿Qué factores determinan las emisiones de CO_2?

$$\text{Emisiones de } CO_2 = \text{Población} \left(\frac{\text{PIB}}{\text{Población}}\right)\left(\frac{\text{Energía}}{\text{PIB}}\right)\left(\frac{\text{Emisiones}}{\text{Energía}}\right)$$

Población (2007) =	6.610.300.000	(www.worldbank.org)
PIB (mundo 2007) =	54.583.800.000.000 $	(www.worldbank.org)
Emisiones CO2 (2007) =	29.469.000.000 t CO_2	(www.cdiac.ornl.gov)

GENERAMOS aprox 1900 $ PIB por tonelada emitida de CO_2

¿Qué factores determinan las emisiones de CO_2?

ESPAÑA

$$\text{Emisiones de } CO_2 = \text{Población} \left(\frac{\text{PIB}}{\text{Población}}\right)\left(\frac{\text{Energía}}{\text{PIB}}\right)\left(\frac{\text{Emisiones}}{\text{Energía}}\right)$$

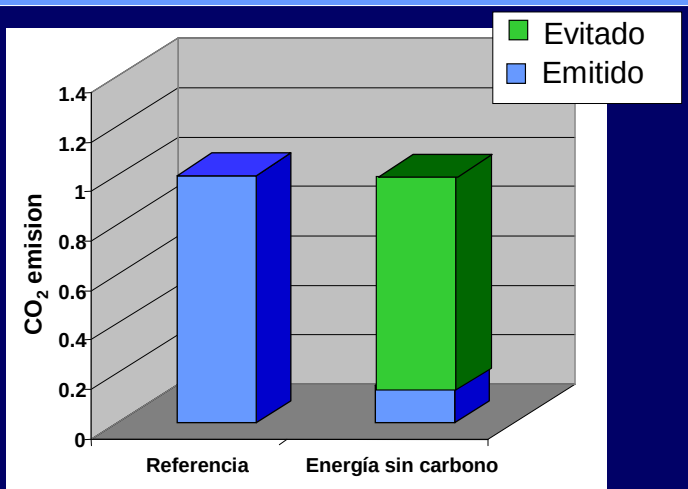
Población (2007) = 44.900.000 (www.worldbank.org)

PIB (2007) = 1.436.900.000.000 $ (www.worldbank.org)

Emisiones CO2 (2007) = 349.700.000 t CO_2 (www.cdiac.ornl.gov)

GENERAMOS aprox 4100$ PIB por tonelada emitida de CO_2

$$\text{Coste } CO_2 \text{ evitado} = \frac{\text{Coste}_{\text{sincarbono}} - \text{Coste}_{\text{referencia}}}{t\ CO_2/\text{Energía}_{\text{referencia}} - t\ CO_2/\text{Energía}_{\text{sincarbono}}}$$



Muchas tecnologías de bajas emisiones se comparan con centrales de carbón de referencia emitiendo aprox 1 kgCO2/kWhe

Ejemplo ecuaciones de costes de un producto energético (1 kWhe)

- **Capital cost of the energy system** ($/kwe)

  CC

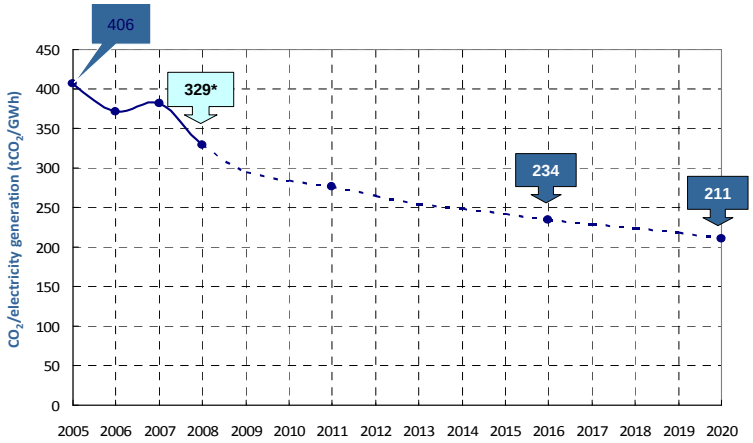
- **Cost of electricity** ($/kwhe)

$$COE = \frac{(CC * Chargefactor) + O\&M_{fix}}{kW * Capacityfactor * 8766} + O\&M_{var} + FuelCost / Efficiency$$

- **Avoided cost of CO_2**

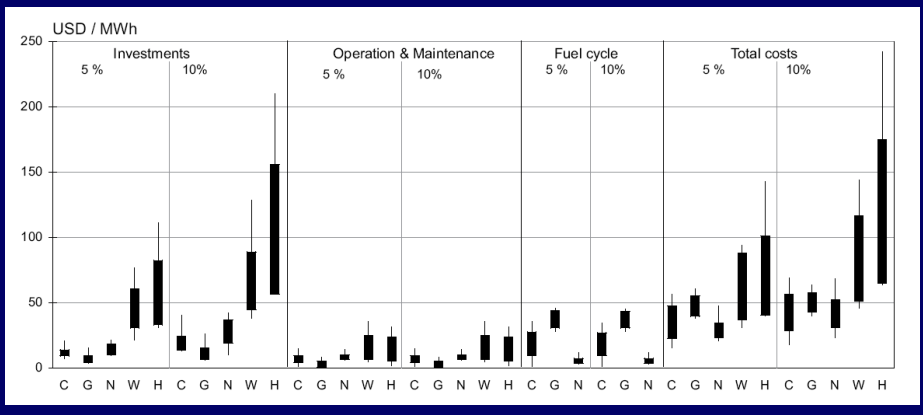
$$\$/t\ CO_2\ avoided = \frac{COE_{lowcarbon} - COE_{reference}}{t\ CO_2/kWhe_{reference} - t\ CO_2/kWhe_{lowcarbon}}$$

Reducción de emisiones específicas en el sector eléctrico En ESPAÑA



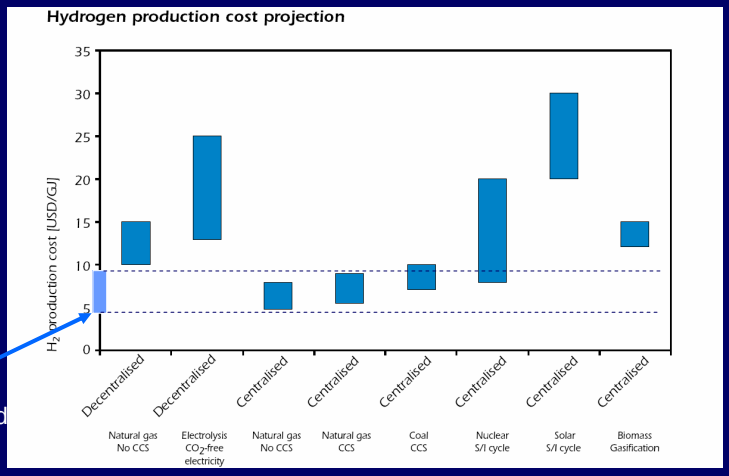
** Estimated value*

Costes de electricidad



IPCC, AR4, WGIII, 2007

Costes de producción de hidrógeno

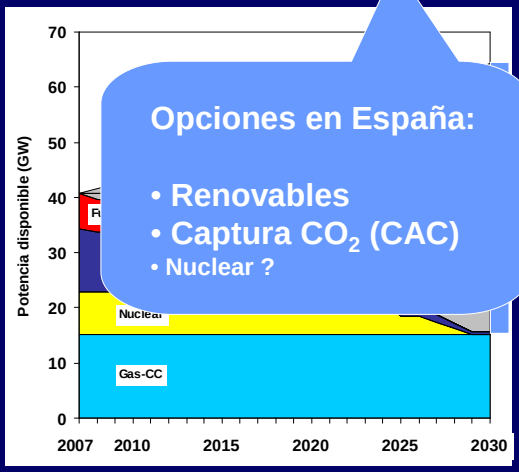


Coste electricidad

Prospects for Hydrogen and Fuel Cells (IEA, 2005)

LAS DECISIONES HOY COMPROMETEN DURANTE DECADAS

¿Cómo se va a renovar el parque de generación en España?



Opciones en España:

- **Renovables**
- **Captura CO_2 (CAC)**
- **Nuclear ?**

49 GW de potencia "disponible"

Esto supone renovar en su totalidad el parque actual de generación antes del 2030

Second Strategic Energy Review

AN EU ENERGY SECURITY AND SOLIDARITY ACTION PLAN

Energy Sources, Production Costs and Performance of Technologies for Power Generation, Heating and Transport

Table 2-5: Energy Sources for Road Transport – Moderate and High Fuel Price Scenario

Energy source for road transport	Cost of Fuels to the EU				Lifecycle GHG emissions [a]
	Moder				
Petrol and diesel					
Natural gas (CNG) [d]					
Domestic biofuel [e]					
Tropical bio-ethanol					
Second-generation biofuel [e]					

[a] Values are given for 2013, assuming oil price of 57.9$_{2005}$/b
[b] Values are given for 2013, assuming oil price of 88.3$_{2005}$/b
[c] Data subject to revision pending on an agreement on an app
[d] Requires a specially adapted vehicle, which is not accounte
[e] Ranges is between cheapest wheat-ethanol and biodiesel
[f] Values are based on an assumed competitive market price q

Table 3-3: Construction time and life time of facility, current and future global installed capacity, learning rate and lifecycle GHG emissions

Technology	Construct. time [year]	Life-time [year]	Global installed capacity C_0 [GW]	Global installed capacity C_{2005} [GW]	Learning rate, LR [%]	References	Lifecycle GHG emission t_{CO2}/GWh	References
Open Cycle Gas Turbine (GT)	1	25	225	1110	5.0%	[6],[7],[87]	520 ÷ 600	[95],[104]
Combined Cycle Gas Turbine (CCGT)	3	25	350	790	5.0%	[6],[7],[96]	385 ÷ 495	[95],[103-104]
Combined Cycle Gas Turbine with CCS	4	25	1	61	2.3%	[7],[6]	80 ÷ 235	[95],[103-104]
Internal Combustion Diesel Engine	1	25	200	930	3.0%	[87]	670 ÷ 690	[95],[104]
Combined Cycle Oil-fired Turbine	3	25	350	790	3.0%	[6],[7],[96]	570 ÷ 590	[95],[104]
Pulverised Coal Combustion (PCC)	3	40	300	790	6.0%	[6],[7],[95]	800 ÷ 860	[95],[103-104]
Pulverised Coal Combustion with CCS	4	40	10	235	2.1%	[7],[6]	240 ÷ 290	[95],[103-104]
Circulating Fluidised Bed Combustion (CFBC)	3	40	70	230	6.0%	[101],[101]	950 ÷ 980	[95],[103-104]
Integrated Gasification Combined Cycle (IGCC)	3	40	1	3	11.0%	[7]	830 ÷ 860	[95],[103-104]
Integrated Gasification Combined Cycle with CCS	4	40	10	235	5.0%	[6],[7]	240 ÷ 290	[95],[103-104]
Nuclear fission	6	40	3 [aa]	100 [aa]	3.0%	[26],[40],[6]	3 ÷ 40	[95],[129-131],[103-104]
Biomass combustion steam cycle – small scale	2	30	62	125	12.5%	[6],[41]	42	[119]
Biomass combustion steam cycle – large scale	2	30			12.5%	[6],[41]	21	[119]
Biogas plant	1	25	4	11	12.5%	[6],[41],[46],[47]	245	[119]
Landfill Gas	1	25			11.0%	[6],[41],[46],[47]	6	[119]
On-shore Wind	1	20	95	660	8.0%	[6],[64],[65],[73-76]	7 ÷ 30	[95],[40],[103-104]
Off-shore Wind	2	20	12	210	8.0%	[6],[64],[65],[73-76]	9 ÷ 22	[95],[40],[103-104]
Hydropower – large scale	4	50	770	n/a	-0.5% per year	[6],[41],[73]	3.5 ÷ 40	[95],[119]
	4	50						
	4	50						
Hydropower – small scale	3	50	75	n/a	-1.2% per year	[41],[73]	3.5 ÷ 10	[59],[119],[95]
	3	50					3.5 ÷ 32	[59],[119],[95]
Photovoltaics	0	25	8	150	23.0%	[94],[93],[6],[93]	40 ÷ 110	[40],[95],[103]
Concentrating Solar Power	2	40	0.4	60	10.0%	[6],[138],[144-145]	135 [bb]	[40]

[aa] Values represent the global installed capacity of Generation III and 3+) nuclear reactors only, and not the total installed nuclear capacity operating worldwide (370 GW in 2007).
[bb] This includes 13 t_{CO2}/GWh of indirect emissions and the direct combustion emissions from natural gas use.

Hydro	Large	-	35 ÷ 145	30 ÷ 140	30 ÷ 130	-	0	6	6	nil
	Small	-	60 ÷ 185	55 ÷ 160	50 ÷ 145	-	0	6	6	
Solar	Photovoltaic	-	520 ÷ 880	270 ÷ 460	170 ÷ 300	-	0	45	45	nil
	Concentrating Solar Power (CSP)	-	170 ÷ 250 [dd]	130 ÷ 180 [dd]	120 ÷ 160 [dd]	-	120 [dd]	15	135 [dd]	Low

[aa] Assuming fuel prices as in DG TREN 'Scenarios on high oil and gas prices' (barrel of oil 54.5$_{2005}$ in 2007, 106$_{2005}$ in 2020 and 119$_{2005}$ in 2030)
[bb] Calculated assuming base load operation
[cc] Reported efficiencies for carbon capture plants refer to first-of-a-kind demonstration installations that start operating in 2015
[dd] Assuming the use of natural gas for backup heat production