Do cost fall faster than revenues?

Dynamics of renewable entry into electricity markets

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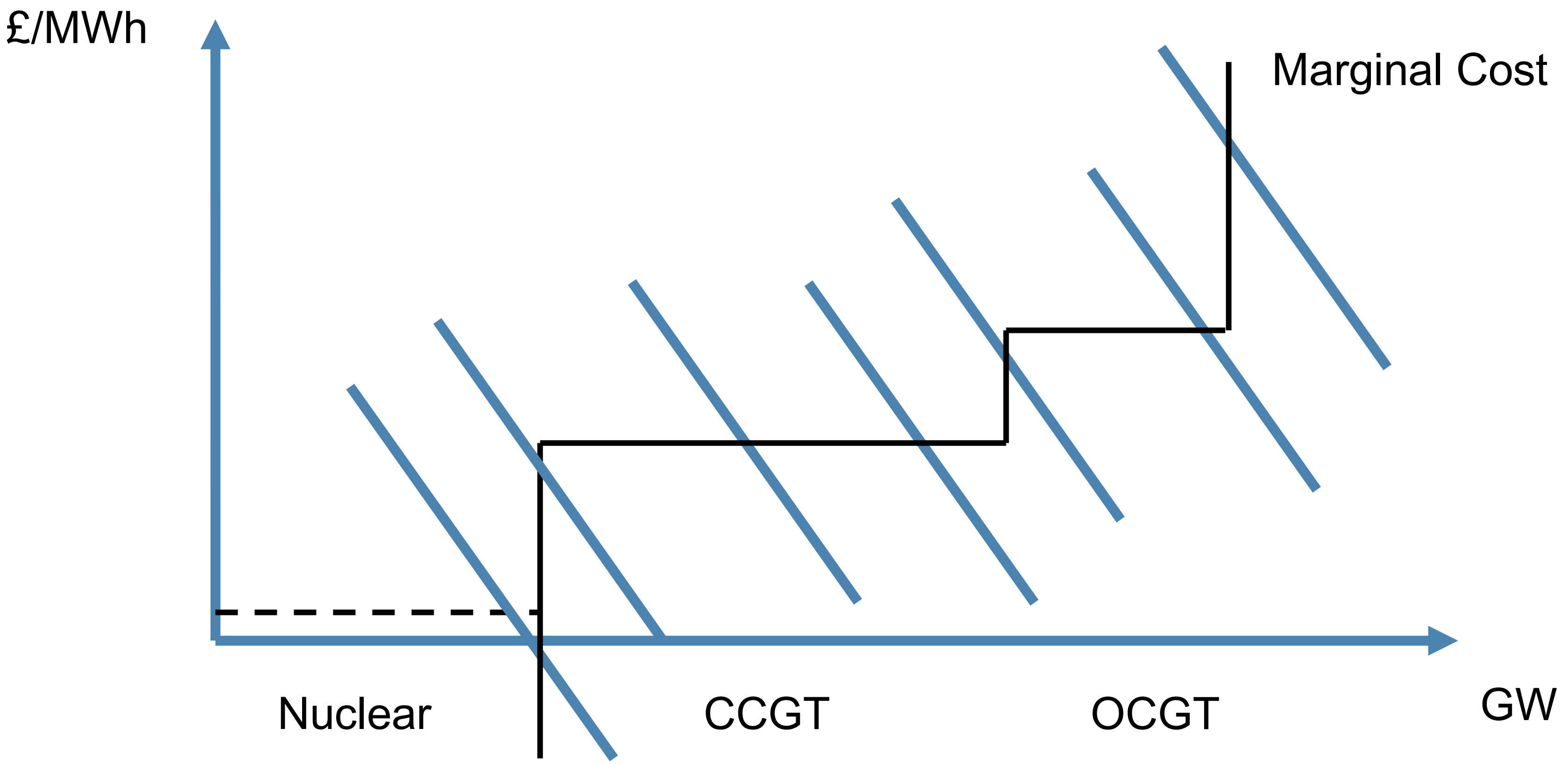
Renewable integration and subsidies

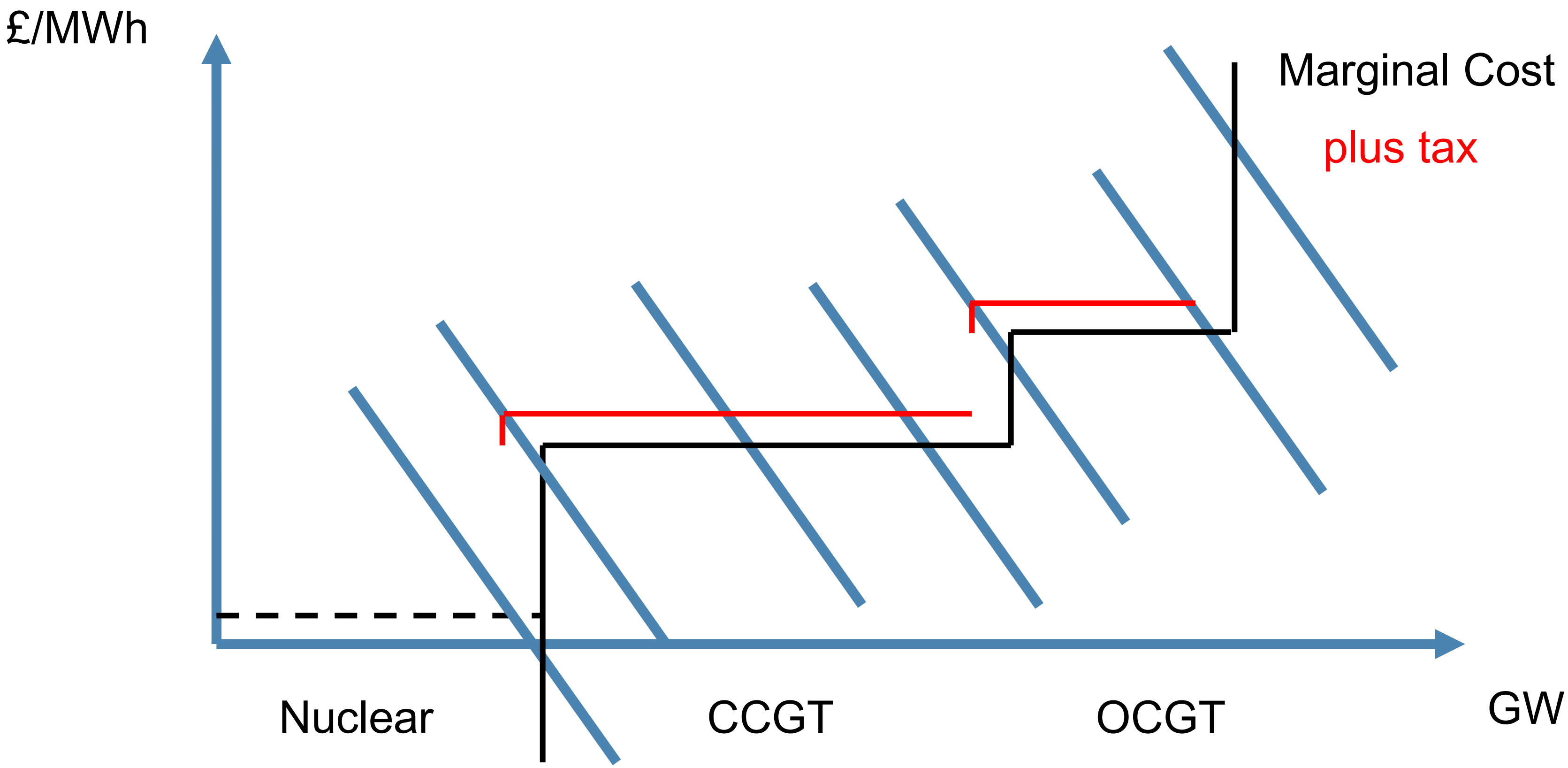
- Renewable entry has already had a profound impact on the generation mix and led to a high tax in Germany, and soon in other European countries
- This research project
  1. determines analytically the "laws of motion" of renewable entry, i.e., the dynamics of the generation mix, subsidy, and tax
  2. illustrates the analysis on the case of Great Britain
- It finds that
  1. massive wind entry in the UK under the current physical dispatch priority rule would push inflexible nuclear out of the market, and lead to a significant increase in the subsidy and tax
  2. replacing physical dispatch priority by financial dispatch priority would mitigate these negative effects without altering renewable economics

Long-term generation mix: Marcel Boiteux forever



Source: Green and Léautier, 2015

Generation mix evolution as renewables enter



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Source: Green and Léautier, 2015

A bit of notation

- K_n cumulative capacity of first *n* technologies (ordered by MC), K^i_0 installed capacity of renewable technology *i*
- *θ is the state of the world*
- $\alpha_i(\theta)$ is the availability of renewable technology *i* in state *θ*
- *Inverse demand is linear with constant slope*

$$P(Q,\theta) = a(\theta) - bQ$$

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Free entry in generation

- Wholesale spot price is $p(\mathbf{K}_0,\theta)$

- Expected marginal operating profit is equal to marginal capacity cost for every technology

$$\mathbb{E}\left[\left(p\left(\mathbf{K}_0,\theta\right)-c_n\right)u_n\left(\theta\right)\right]=r_n,\ \ for\ n\geq 1$$

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Subsidy and tax

- Marginal subsidy for renewable technology *i* with marginal investment cost $r_0(K_0^i)$

$$\varphi^i(\mathbf{K}_0) = \max\left(r_0^i\left(K_0^i\right) - \mathbb{E}\left[\alpha^i(\theta)\, p(\mathbf{K}_0, \theta)\right], 0\right)$$

- Cumulative aggregate subsidy

$$\Phi(\mathbf{K}_0) = R_0(\mathbf{K}_0) - \sum_{i=1}^{I} \mathbb{E}\left[\alpha^i(\theta)\, p(\mathbf{K}_0, \theta)\right] K_0^i$$

- Retail price is $(p(K_0,\theta)+\tau)$ where τ is the unit tax to finance renewables
- Total tax revenues

$$\tau(\mathbf{K}_0)\, \mathbb{E}\left[D\left(p(\mathbf{K}_0, \theta) + \tau(\mathbf{K}_0), \theta\right)\right] = \Phi(\mathbf{K}_0)$$

Dynamics of generation mix

- v_n is the vertical portion of the supply curve where technology *n* produces at capacity

- Long term equilibrium: conventional installed capacity is reduced as renewables capacity increases

$$\frac{\partial K_n}{\partial K_0^i} = -\frac{1}{b}\frac{\partial \tau}{\partial K_0^i} - \mathbb{E}\left[\alpha^i(\theta)\,|v_n\right]$$

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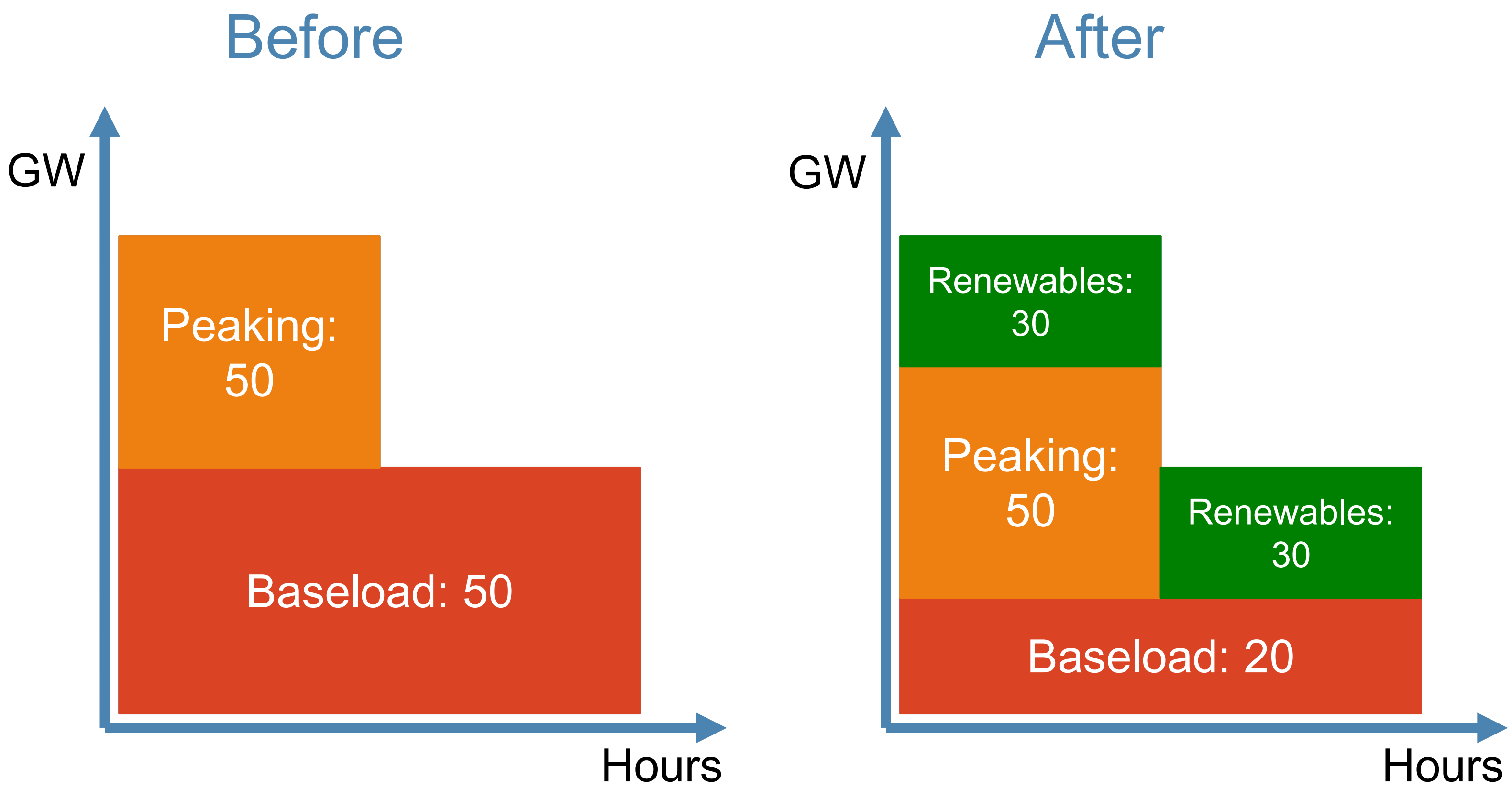
Impact of renewables: no correlation with demand



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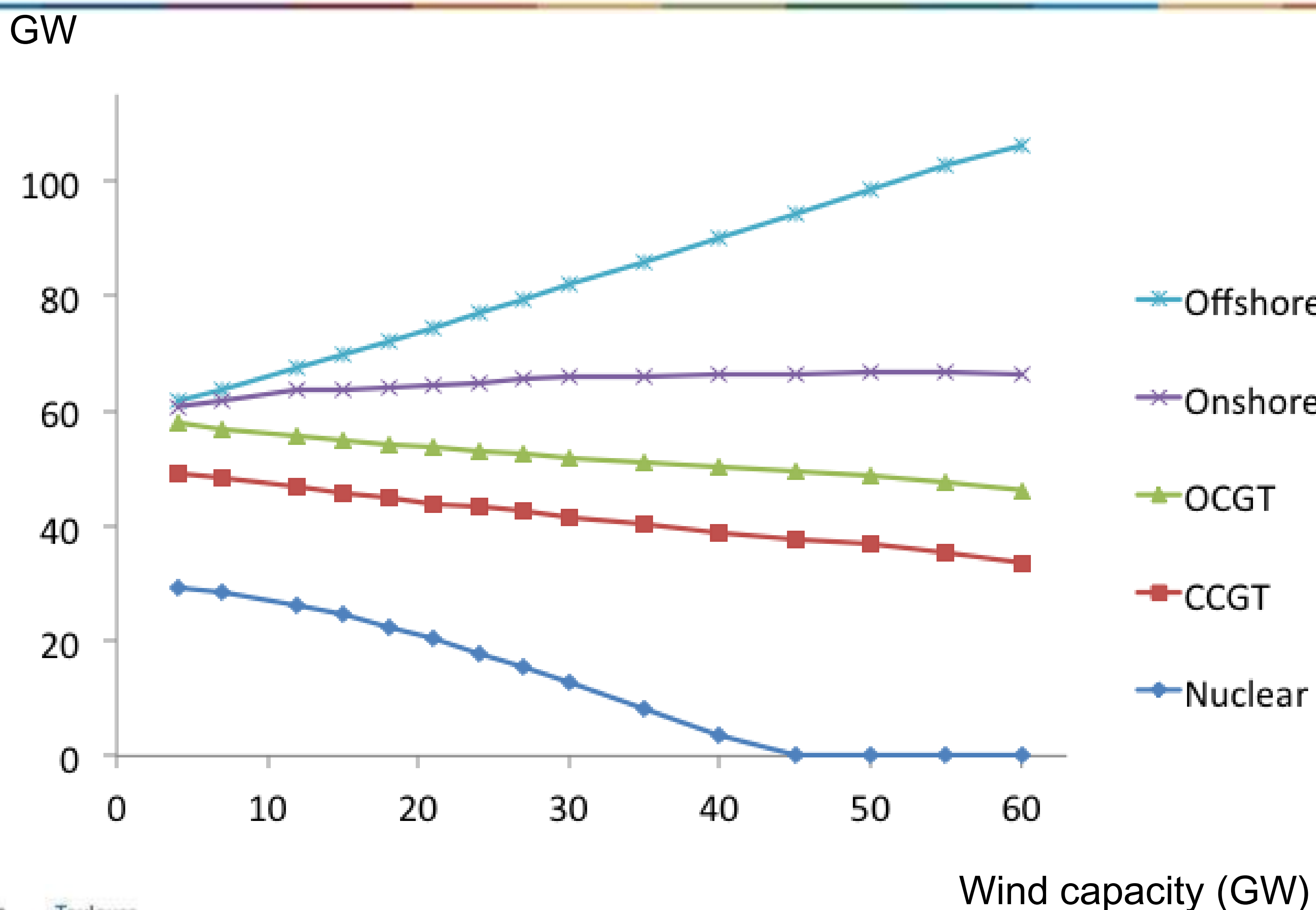
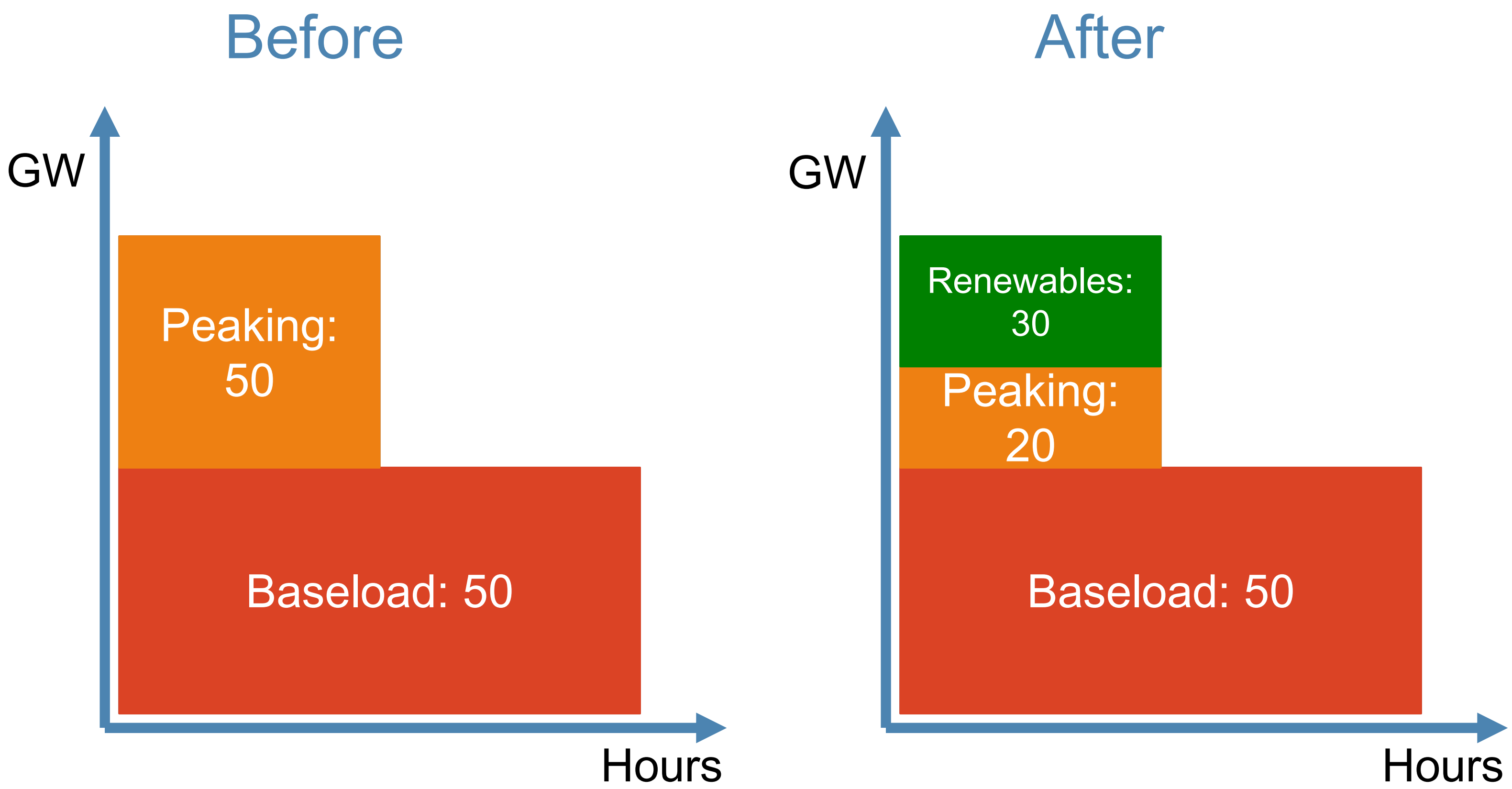
Resulting capacity mix in Great Britain



Source: Green and Léautier, 2015

Impact of renewables: strong correlation with demand



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Dynamics of the marginal value of renewable capacity

The marginal impact of renewable technology *i* on the value of technology *j* is proportional to the covariance of availabilities

$$\mathbb{E}\left[\alpha^j(\theta)\frac{\partial p}{\partial K_0^i}\right] = -b\widehat{cov}_{\mathbf{K}_0}\left[\alpha^i(\theta),\alpha^j(\theta)\right]$$

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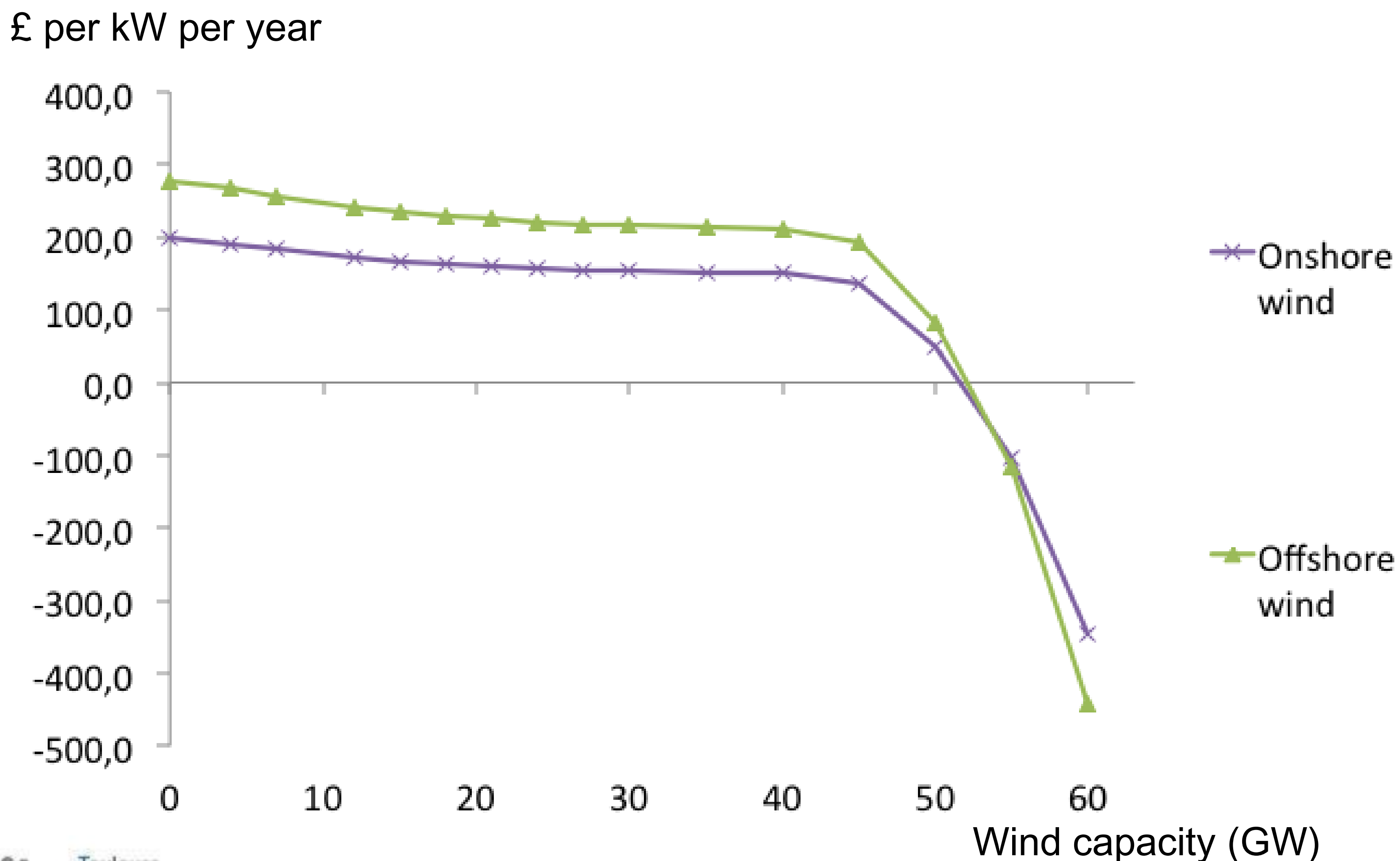
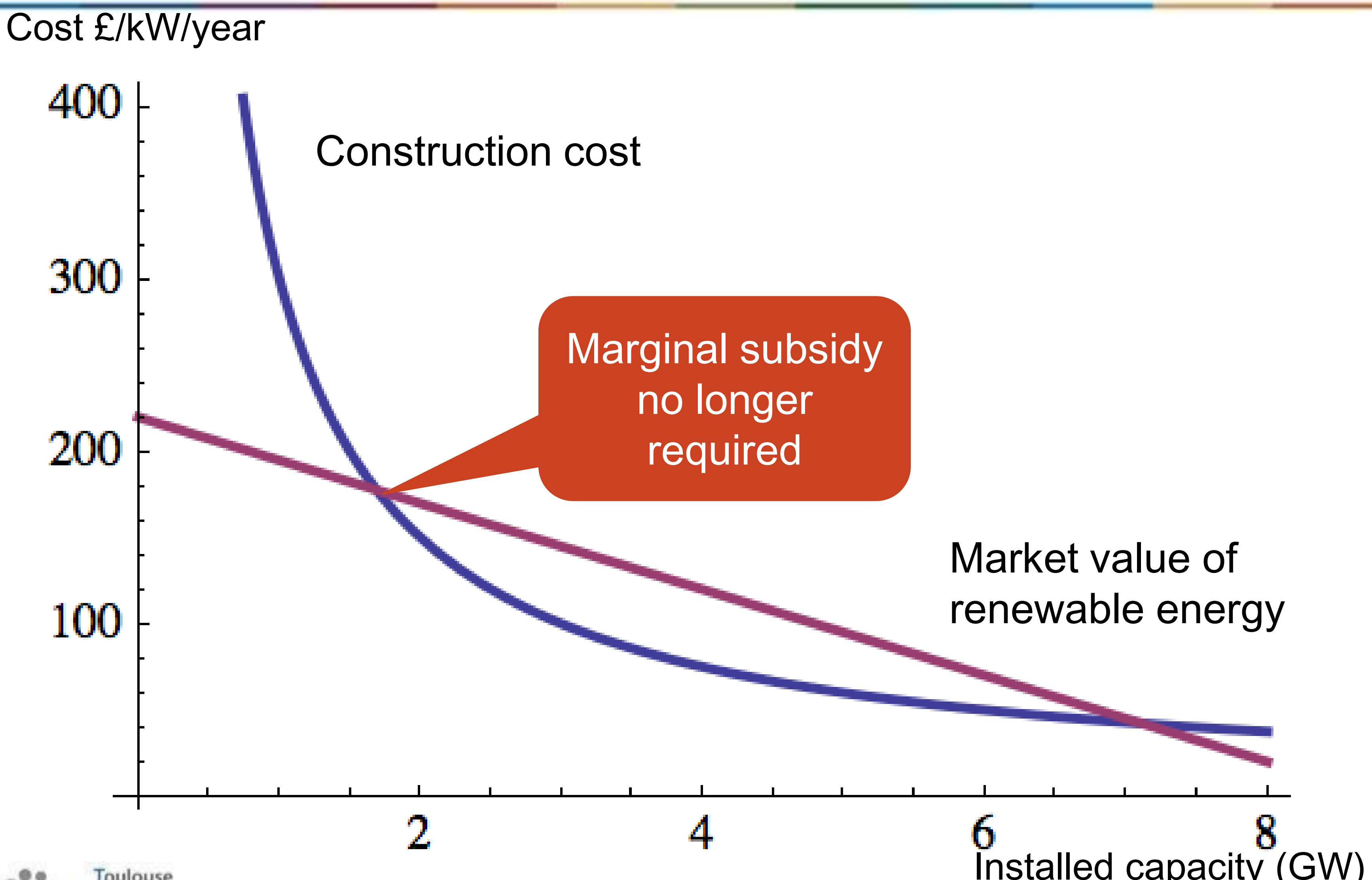
Marginal value of wind turbines (status quo)



Source: Green and Léautier, 2015

Cost falls faster than the price: marginal subsidy ends



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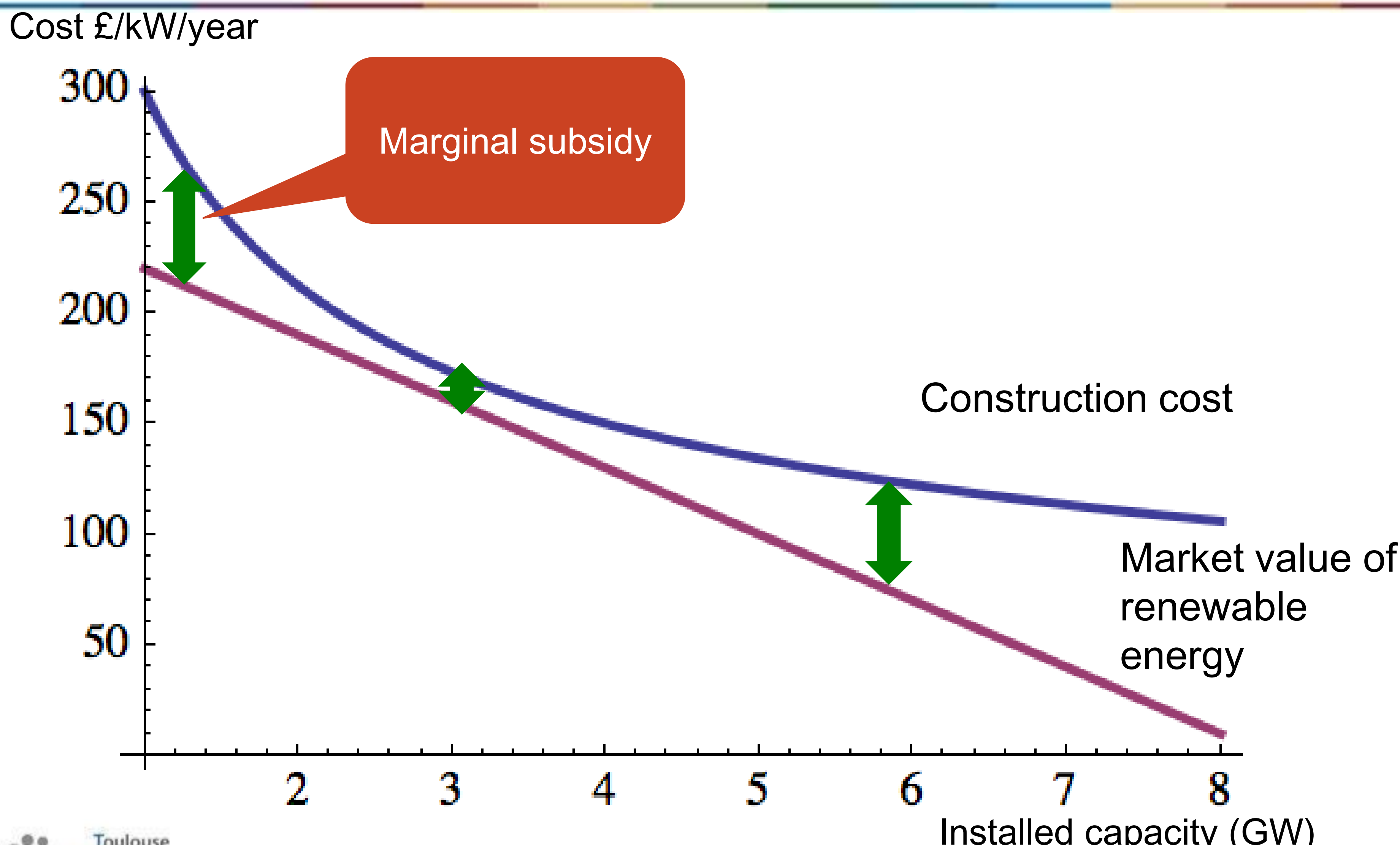
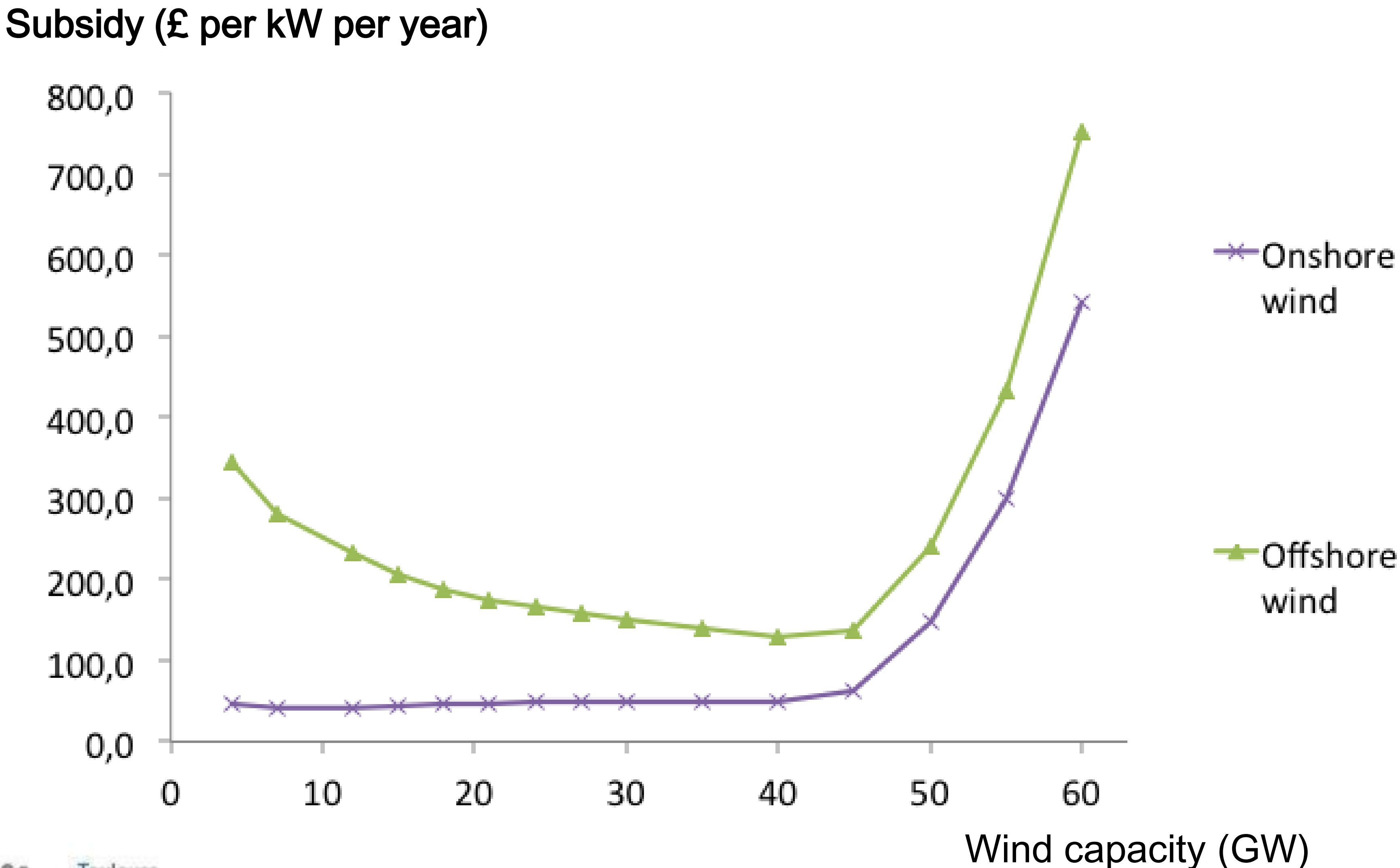
Price falls faster than the cost: marginal subsidy required

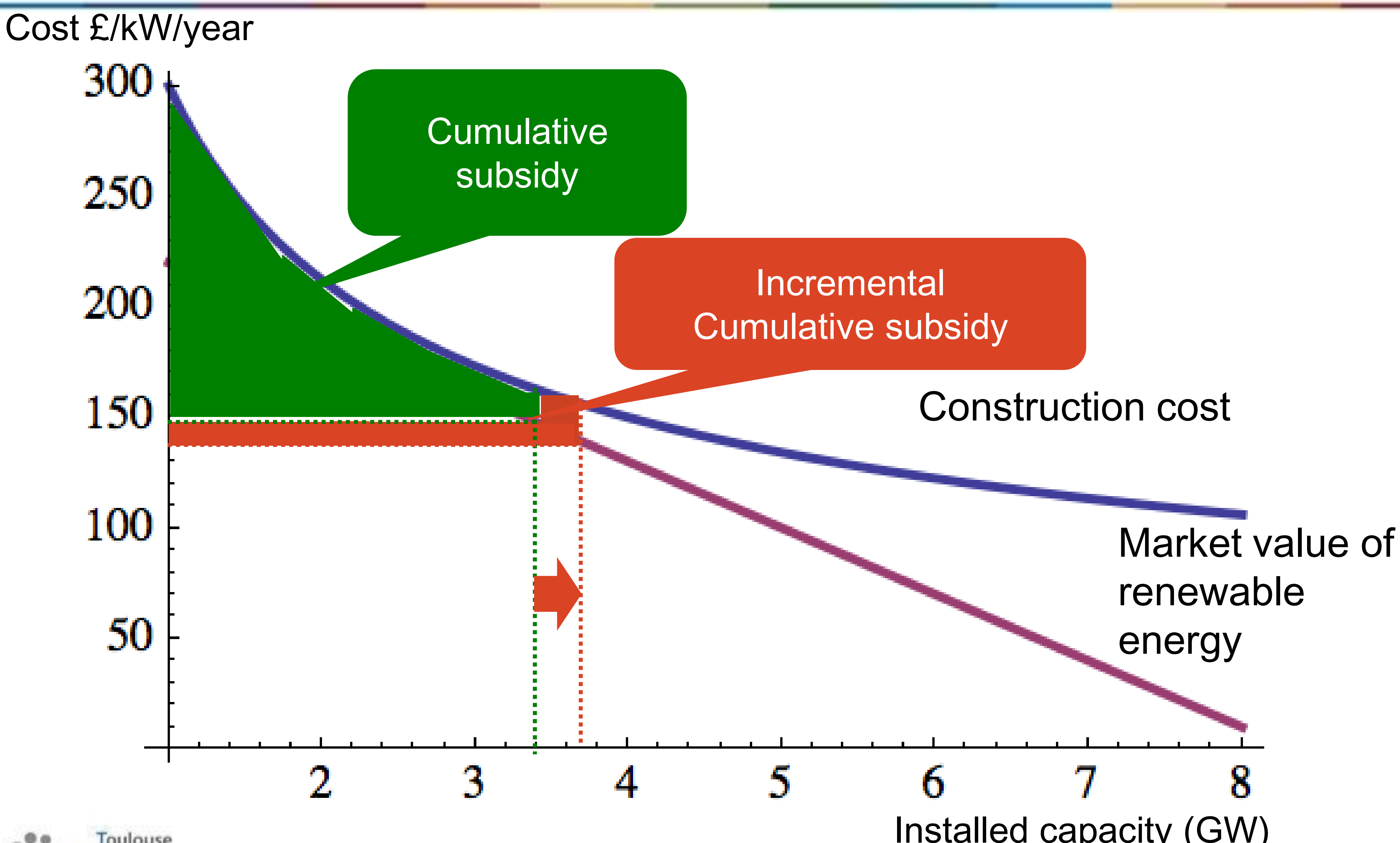


Marginal subsidy to wind turbines

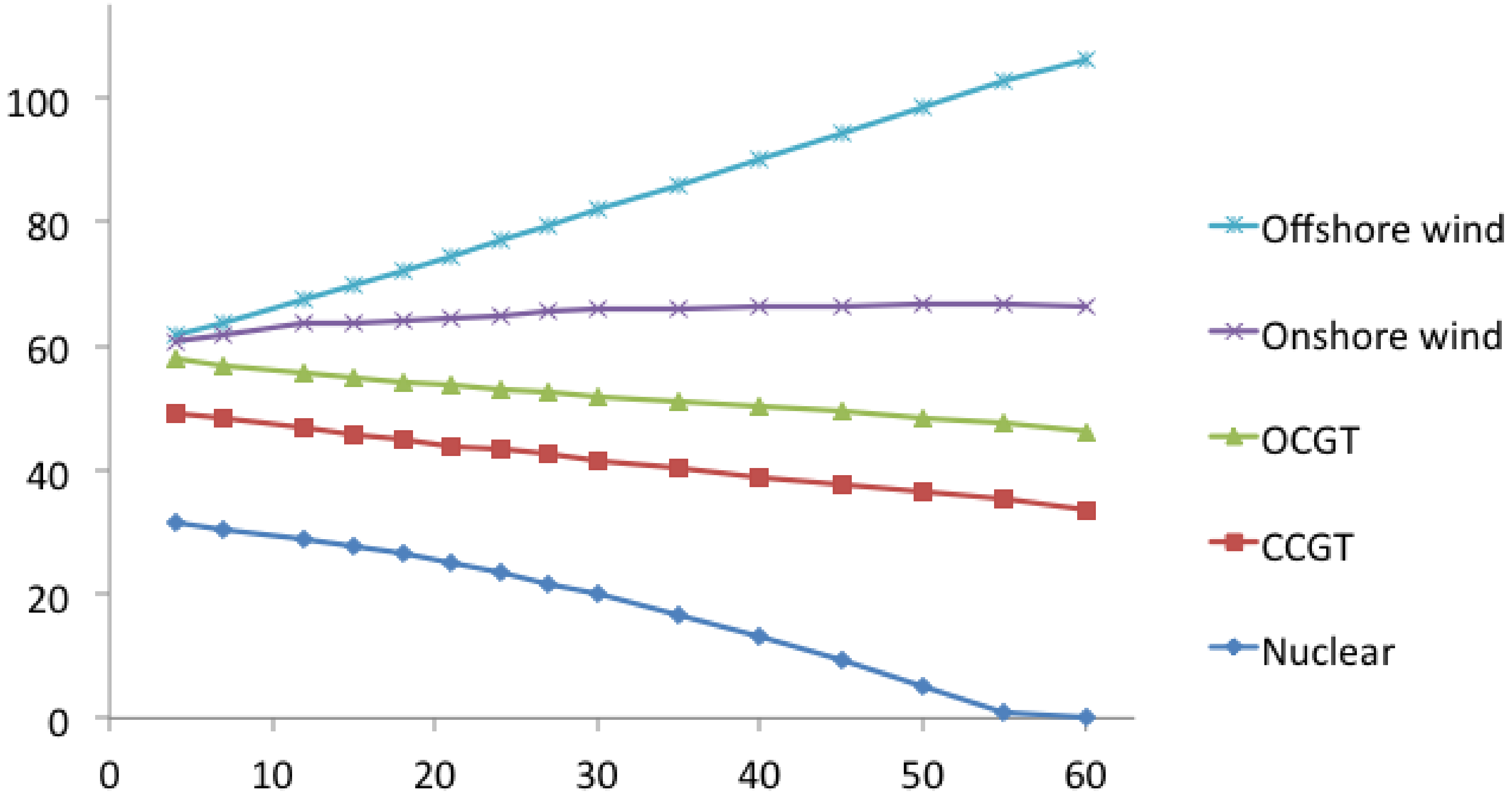


Source: Green and Léautier, 2015

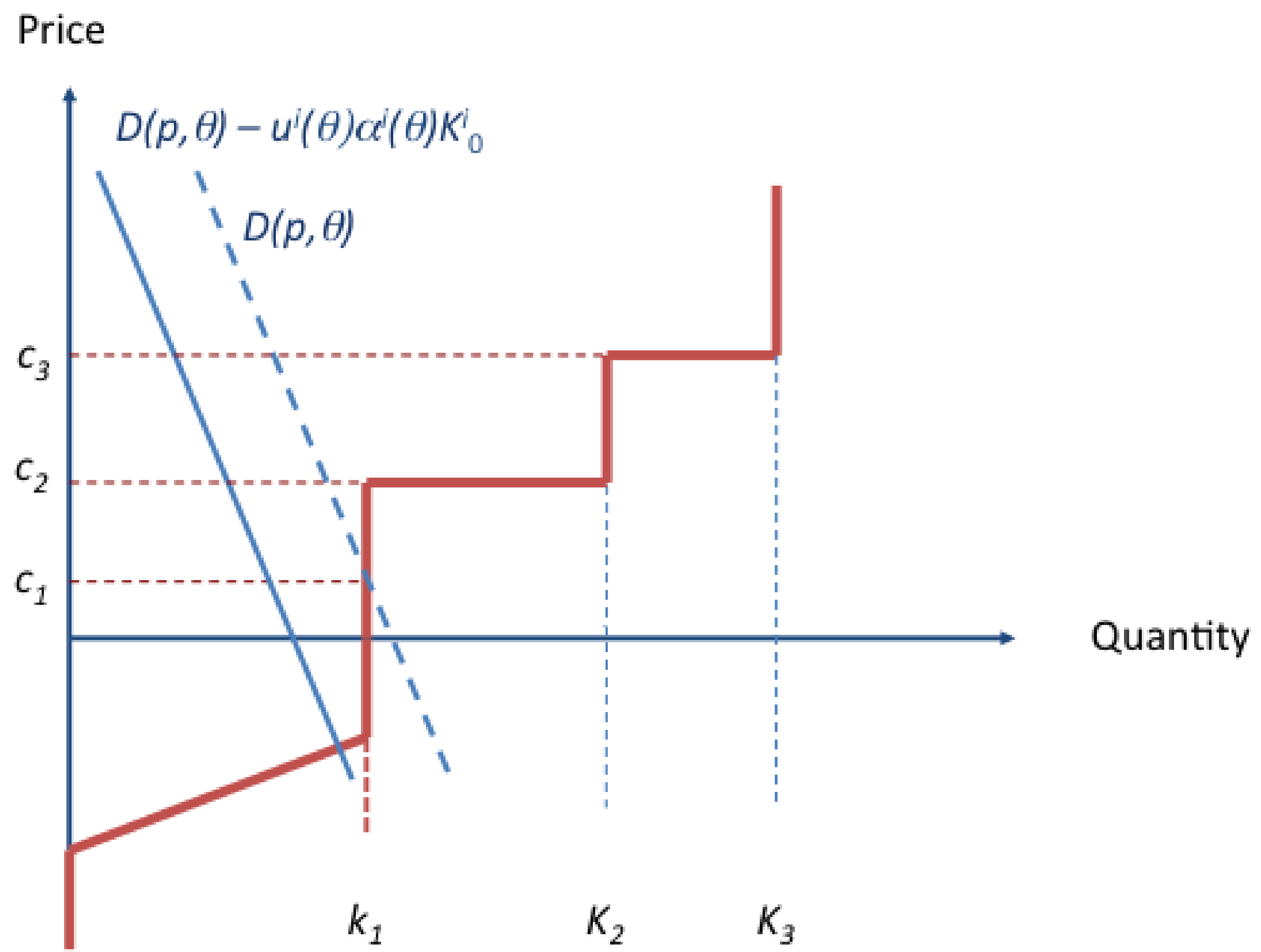
Evolution of cumulative subsidy



What if nuclear was flexible?

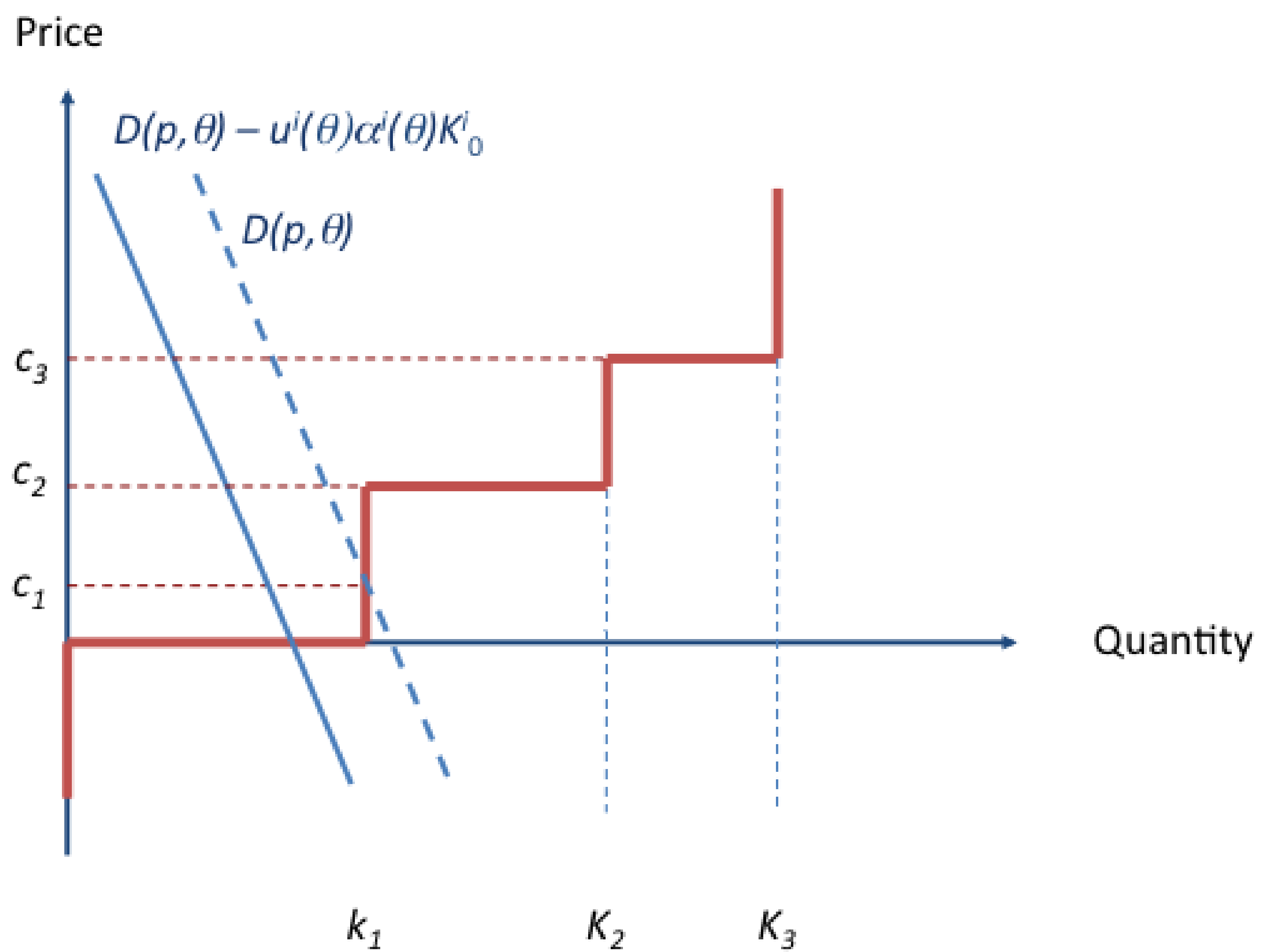


What about a feed-in premium?

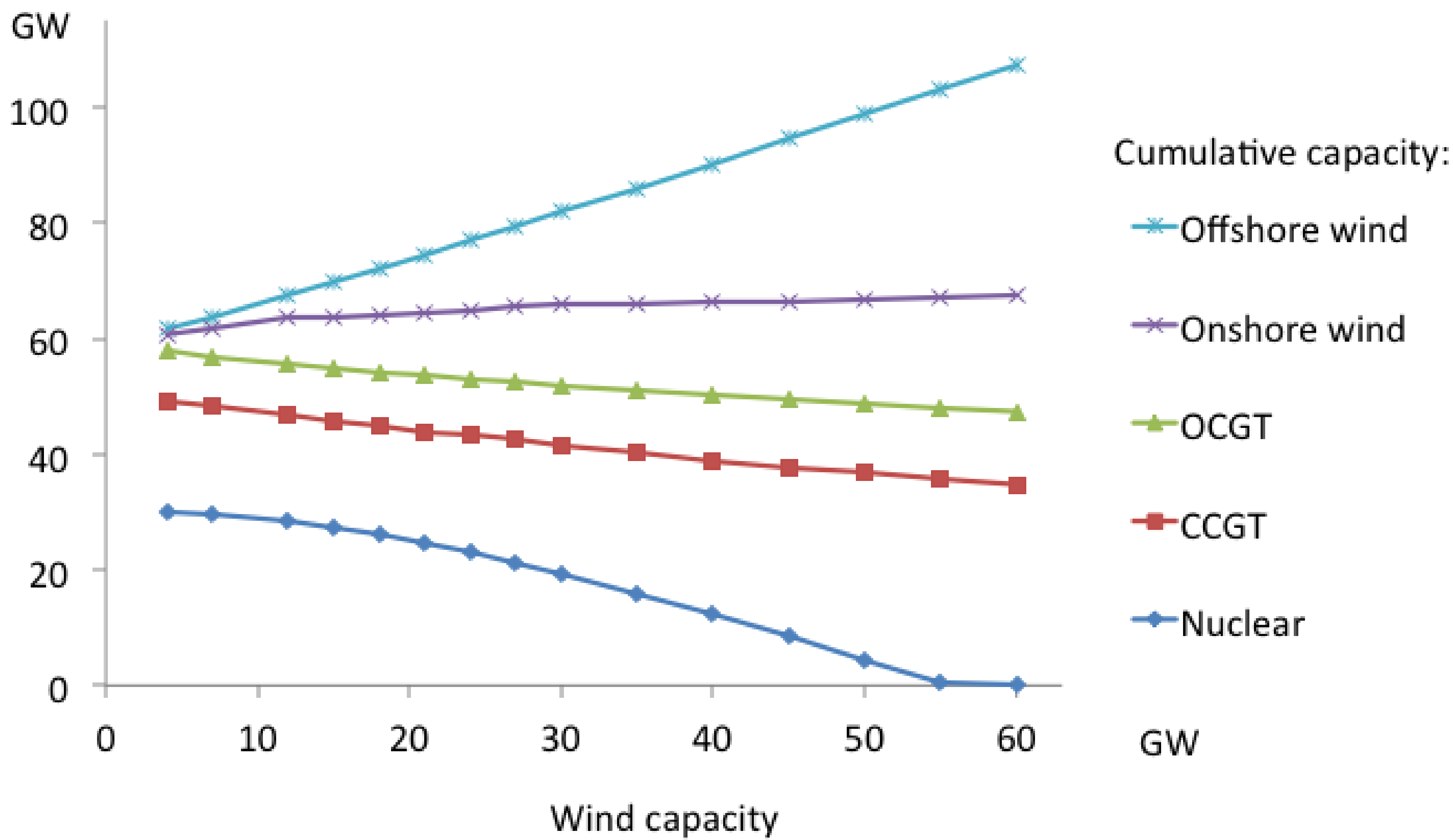


Nuclear stations fully inflexible; Physical dispatch insurance

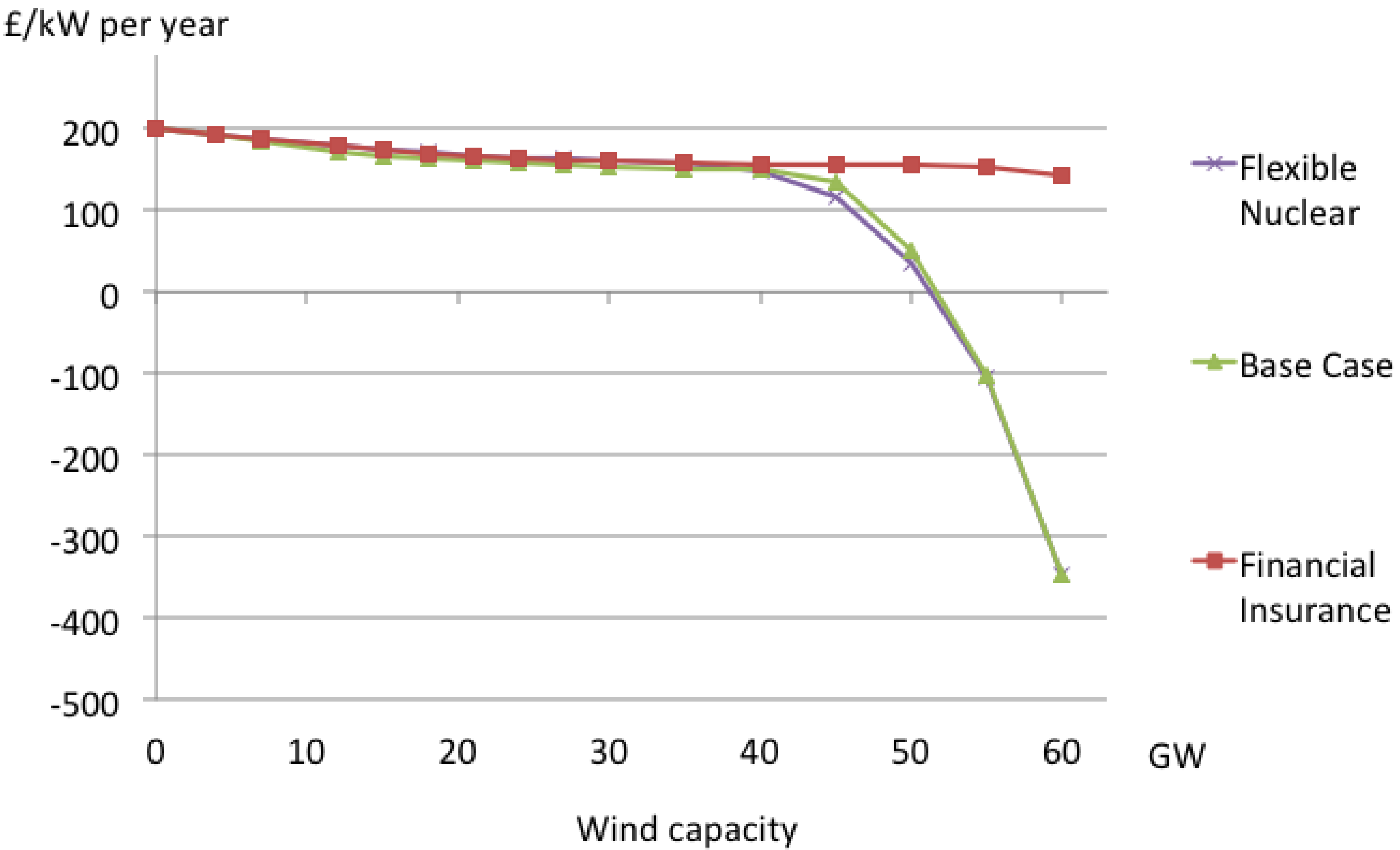
What about financial distpatch insurance?



Generation mix evolution under financial dispatch insurance



Marginal value of on-shore wind for different scenarii



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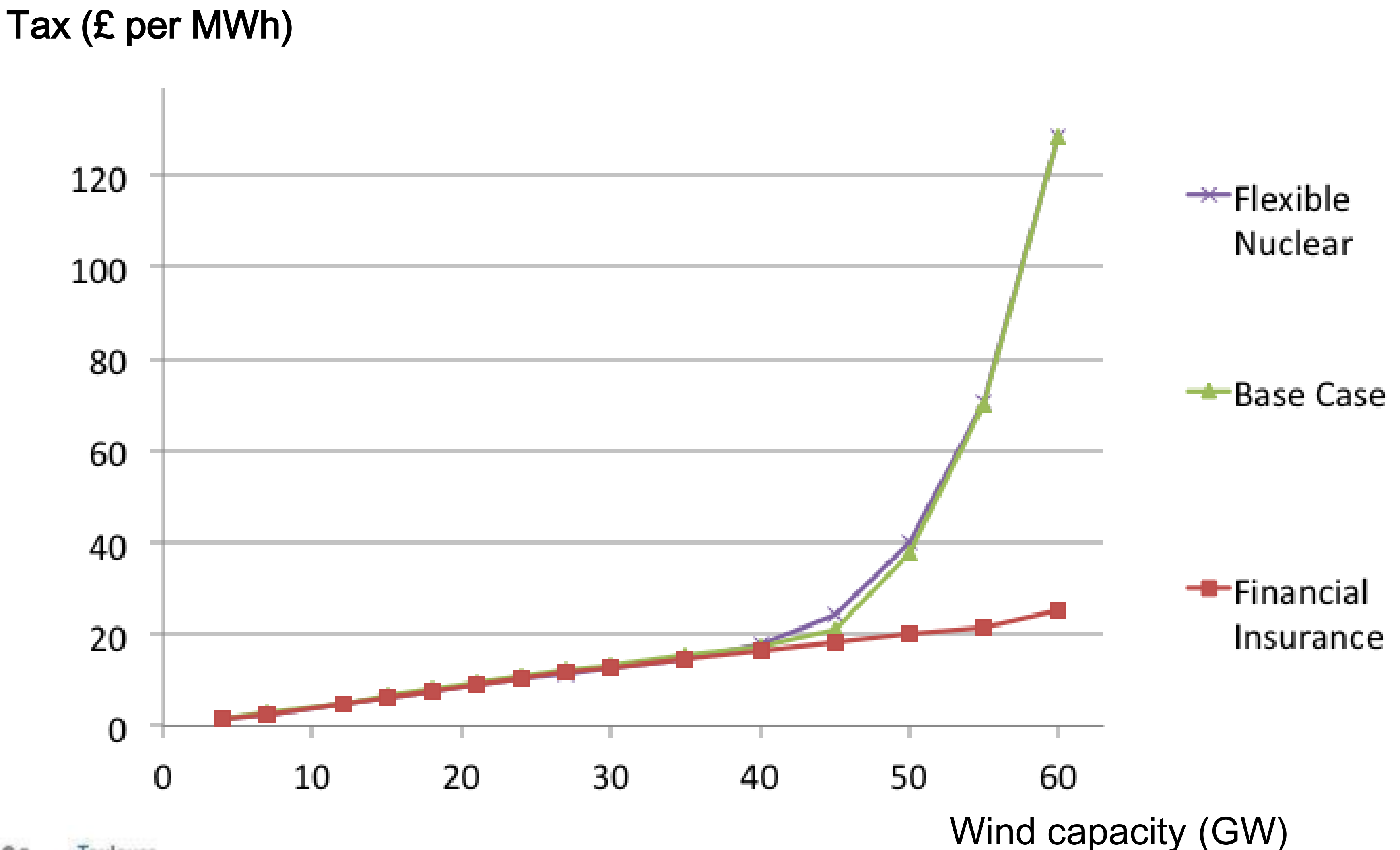
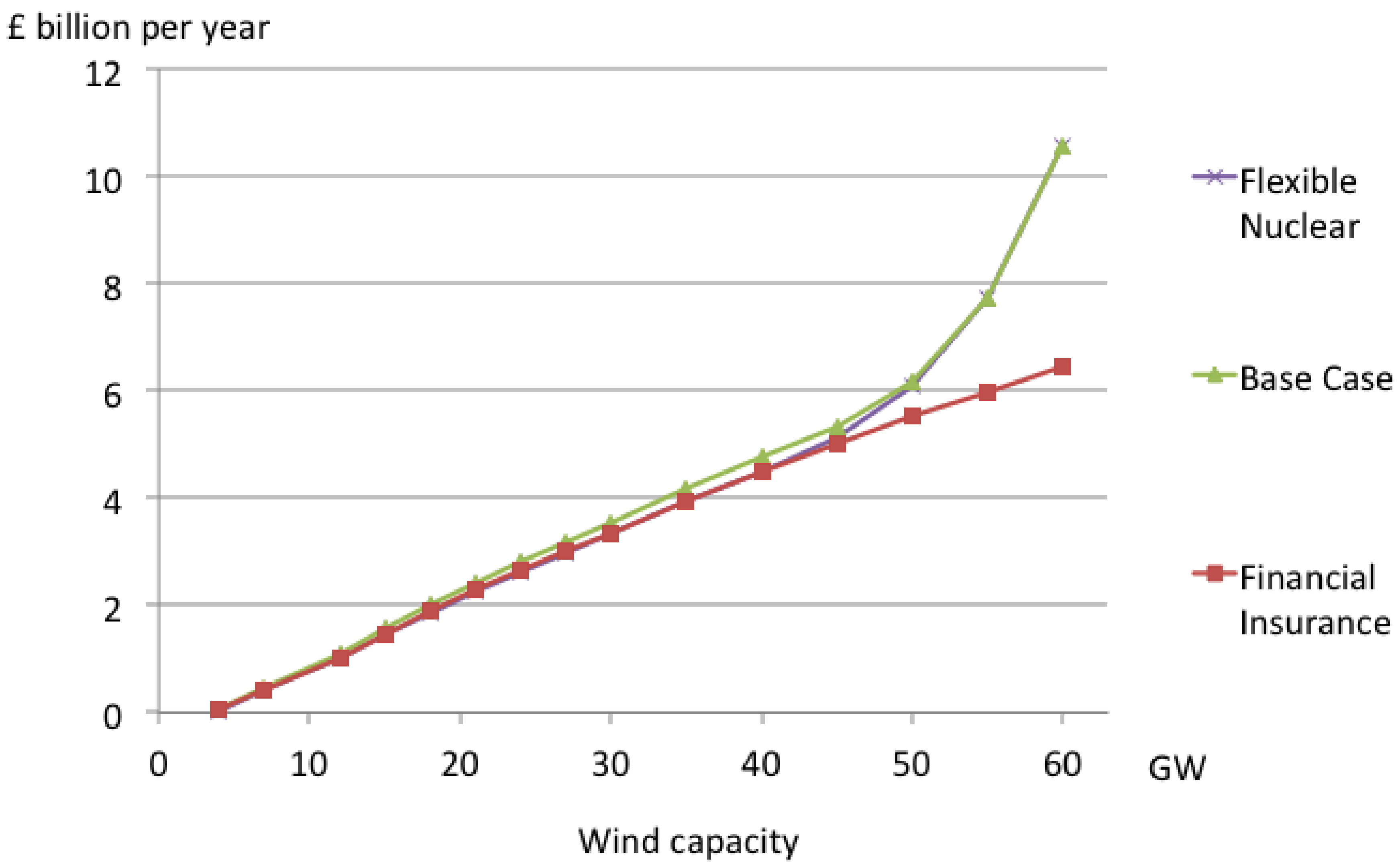
Evolution of the unit tax



Source: Green and Léautier, 2015

Net surplus loss under different scenarii



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