Welfare Analysis of Offshore Wind by Julian Silk: A Comment

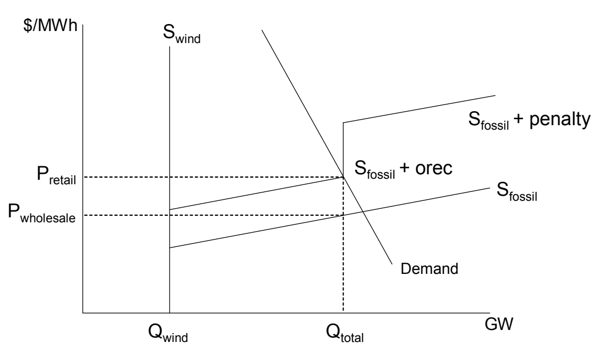
By Richard Green*

In the I*AEE Energy Forum* for the 2nd Quarter of 2012, Julian Silk offered an analysis of the welfare economics of offshore wind power, motivated by Maryland's proposed scheme and inspired by the tools used to analyse the impact of an import quota on a domestic market. Unfortunately, those tools do not easily transfer from the trade-relevant case of a maximum supply from a cheap source to the energy case of a minimum supply from an expensive one. In the case of trade, once the quota of cheap imports is used up, all other demand must be met from domestic sources, and the price must rise to their marginal cost (if that market is otherwise competitive). This price is also received by importers, despite their lower costs.

The governor of Maryland is currently proposing to source 20% of its electricity from renewable sources, and Dr. Silk argues that the marginal cost of these sources will set the price for all the power sold in the state. "The price going to the wind suppliers will be [the cost of offshore wind]. If the price is higher, more wind supply will come into the market to drive it down. If it is lower, wind suppliers will exit the market … the last, marginal, fossil supplier has a supply price equal to [the cost of offshore wind]. If this fossil supply price is higher, more wind will be purchased, and the price will be driven back down. If it is lower, the electricity market will attempt to purchase more fossil energy, and come upon the binding quota restriction, which will drive the price back up." This is represented by a leftwards shift of their supply curve, and Dr. Silk comments that "[the area between the old and new supply curves] can be considered to be costs for fossil fuel producers." Is the effect on prices the equivalent to the standard analysis of an import quota, in which the ability to sell at a price raised by the quota leads to higher profits for the importing firms? I will argue that neither wholesale nor retail prices will be affected in the way that Dr. Silk suggests. Furthermore, I cannot conceive of a way in which, as in Dr Silk's world, the presence of a quota of high-cost generators somehow raises the costs of every other generator on the system.

To analyse the price impacts, we need to know how the renewable generators will be supported – in Maryland, this is to be through Offshore Renewable Energy Certificates (ORECs). The owner of an offshore wind farm is entitled to sell one OREC (at an administered price) for each MWh it generates, giving up all the energy market (and other) revenues it receives in return. The ORECs are then bought by electricity retailers, in proportion to their sales, and the cost is offset by redistributing the wind farm's energy revenues to the OREC holders. The net cost is thus the difference between the OREC price and the market price for the station's output. A retailer that does not hold enough ORECs pays an (administratively set) penalty.

Figure 1: A market with a wind quota: short-run equilibrium



Dr. Silk discusses these certificates and suggests that "it would be reasonable for generators to purchase the [O] REC, and immediately sell 1 MWH of their own generation." This somehow leads him to conclude that the fossil generators would now have a higher marginal cost than the wind farms and would, therefore, require a subsidy if they were to continue to operate.

I am not quite sure how fossil-fuel generators could purchase an OREC and immediately sell their own power, since the OREC is only given for output actually delivered. But rather than struggle further with Dr. Silk's article, I thought it might be helpful to present some analysis that reflects the way in which electricity markets actually operate. In the short run, the output from wind farms can be taken as completely inelastic – absent transmission or other constraints, the entire available output will be sold, given its zero marginal cost. Once wind farms have been added to an electricity system, we, therefore, need to shift the supply curve of the fossil-fuelled stations to the right, by the amount of wind production. This can reduce wholesale market prices in the short run, as observed in Germany (Sensfuß et al, 2008) and in Spain (Sáenz de Miera et al, 2008). Figure 1 shows a short-run market equilibrium with the supply curve shifted in this way. The fossil stations produce the difference be-

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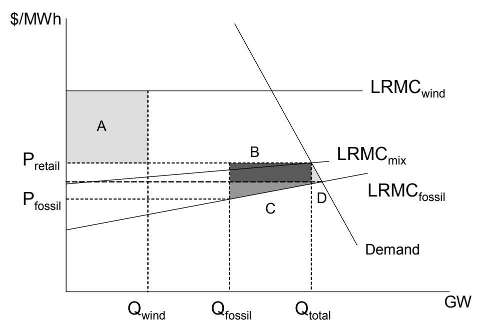
tween the total demand for power, Q_{total}, and the amount supplied by wind stations, Q_{wind}. They are paid a wholesale market price ($P_{wholesale}$) equal to the marginal cost of the most expensive unit in operation. In Maryland, this price is actually set on the basis of supply and demand across the entire PJM market (subject to the effects of transmission constraints), making it inconceivable that a renewable policy in one state could raise the price received by all generators to the cost of offshore wind.

The state's policy will affect the retail price in that state, however, and it is this that determines the level of demand. Maryland consumers have to pay the wholesale price plus a charge for the renewable power. If demand is low enough, the wind output will equal or exceed the proportion of demand required by the policy, and the retailer must just pay the OREC price, multiplied by that proportion, per MWh of retail power sold. The figures are drawn with a required proportion of one-third, so that if the OREC price was $30, the addition per MWh of retail sales (labelled "orec" to distinguish it from the price per certificate) would be $10. I assume that certificates in periods of low demand would be banked for future use, and so the price adder would never fall below this level. If retail demand is high, however, then the number of ORECs available will be too low, and retailers will have to pay a buy-out price instead, here labelled as "penalty". The diagram is drawn with a proportion of wind power exactly equal to the requirement, and so the line giving the retailer's marginal cost jumps upwards at the actual level of demand. This is given by the intersection of the retailer's marginal cost with the demand curve, at a price equal to P_{retail}, and the quantity of Q_{total}.

Figure 2: A market with a wind quota: long-run equilibrium



What about the long run, and the calculation of deadweight losses? Figure 2 shows the position, this time measuring both wind and fossil generation from the vertical axis. In the absence of a renewable support policy, the demand for power would be given by the intersection of the demand curve and the long-run marginal cost of fossil power ($LRMC_{fossil}$), just to the left of Q_{total}. As in Dr. Silk's article, the LRMC of wind power is high and constant, while that of fossil energy is lower and upwards-sloping. If retailers are required to source one-third of their power from offshore wind, then the LRMC of this mix will start one-third of the way between the origins of the two LRMC curves, and will have a slope two-thirds of that of $LRMC_{fossil}$. In the equilibrium shown, the total output is equal to demand at the price P_{retail}, with fossil output equal to two-thirds of this, and wind to one-third. This retail price is equal to a 2:1 weighted average of the LRMC of fossil power and that of wind, since the retailer will have to buy one MWh of wind power for every two MWh of (cheaper) fossil energy. In the wholesale market, the fossil energy would earn the price P_{fossil} (equal to $P_{wholesale}$ in Figure 1), its marginal cost.

The deadweight losses from supporting offshore wind are given by the sum of four areas. Three of these (A, B and C) represent the extra costs incurred in producing one-third of the delivered power from offshore wind rather than from fossil energy. They cover the vertical distance between the cost of offshore wind and the cost of an equivalent amount of fossil energy from the stations displaced. Area B and the two rectangles to its left represent the amount of this cost borne by consumers, whereas Area C and the lower two rectangles represent the amount borne by fossil generators. (The four rectangles together have the same area as A.) The remaining deadweight loss, Area D, comes from the lower overall demand for electricity. It is relatively small, given that the demand curve has been drawn to be inelastic, and that the price increase is based on the excess cost of offshore wind, but multiplied only by the proportion of power which it is required to meet. Almost all of this loss comes from consumers – the producer surplus from a small increment of generation with a relatively flat supply curve is tiny. Any other effects, such as employment in the renewable industry, visual disamenity, emissions savings or the costs of dealing with intermittency, should be added to these deadweight losses.

Per MWh of output, low-carbon electricity can cost much more than the pre-externality cost of fossil power. The impact on consumers' bills and welfare, however, depends on the product of the cost per MWh and the proportion of power receiving support. In the UK, the Committee on Climate Change (2011) has shown that this impact is currently low, and I am confident that an appropriate analysis of the Maryland scheme would produce a similar result.

References

Committee on Climate Change (2011) Household energy bills –impacts of meeting carbon budgets, London:

Committee on Climate Change

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Sensfuß, F.; M. Ragwitz and M. Genoese (2008) "The Merit-order effect: A detailed analysis of the price effect of renewable electricity generation on spot market prices in Germany" Energy Policy, vol. 36, no. 8, pp. 3076-3084

Response to Professor Green's Comment

I thank Professor Green for his comment on my analysis. My impression, in working through the comment, is that we are making different assumptions. That the short-run supply of wind is absolutely inelastic with respect to price is certainly a different assumption than I was making. That the wind suppliers will enter the market regardless of their receipts is different as well. If the wind suppliers lower the wholesale prices over what they would otherwise be, as in the examples of Spain and Germany that are cited, well and good, but I wonder if there are not some other costs that are being disguised or not counted.

My understanding, which I will be delighted to correct if it is mistaken, is that the wind producers must receive payment to cover their all fixed costs and marginal costs each year, or they will not enter the system at all. Yes, the marginal costs are zero for wind. But the fixed costs in annualized terms are not. In looking at Figure 1, the wind producers just get what they get. But implicitly, it would seem that the marginal cost for the wind producers is as in Figure 2, much higher than the market equilibrium price. If this is the case, and the price is only p_{fossil}, how do we know that p_{fossil} + orec covers the payment for the fixed costs of the wind suppliers? Either the wind suppliers are given a long-term guarantee that their costs will be covered later, which has market value now, or the fossil fuel generators pay for it, or the consumers pay for it. If the wind suppliers were willing to accept less, why would Delaware's offshore wind farm, so similar (almost in swimming distance) to the one proposed for Maryland, be facing the financing difficulties detailed in "Offshore wind 'backbone' still a plus for Delaware", online at http://www.delawareonline.com/article/20120517/BUSINESS09/305170027/Offshore-wind-backbone-still-plus-Delaware? Professor Green accepts a discontinuity at the intersection between supply and demand in Figure 1; I am much more skeptical. My renewable energy certificates are much more expensive than Professor Green's, it seems.

Something similar seems to apply for Figure 2. The wind producers are receiving a much higher payment for the power they produce than are the fossil fuel producers. The wind producers are making an economic profit of zero, yes. But the fossil fuel producers are paying Area C plus the lower two rectangles, as Professor Green rightly notes. Why should they do this in the long run? It was always an implicit assumption in my argument that there was an electricity market as an alternative to PJM to which electricity generators could turn if PJM did not provide at least as much profits as the alternate market. As the fossil fuel producers close up shop, retire plants, or more likely, never build them at all, $LRMC_{fossil}$ moves up. If it moves up until it meets $LRMC_{wind}$, then these payments stop, and that's what I think will be the equilibrium result.

Actual wind production is plagued by the need for spinning reserve, periods of negative pricing and loop flow, in addition to the constant high annualized cost. I have tried to go into this in my "Wind Problems" submission for the IAEE Blog. To cite from there, "There have been various attempts to use batteries as spinning reserve. The latest and most efficient of these is being conducted in Chile (see http://generationhub.com/2012/05/03/aes-combines-advanced-battery-based-energy-storage)." If batteries (as in Chile), can be used as backup for wind, then perhaps we can have an empirical test to see who is right.

Trying to seriously discuss wind on a large scale for the U.S. has an air of unreality now, in the wake of the success of Governor Scott Walker (R-Wisconsin) in the recall election called to replace him. This bodes very well for the success of Governor Mitt Romney, who has made renewable energy a favorite target, in the November U.S. Presidential election. My object is not to generically oppose wind or any renewable energy, far from it. It is to make absolutely sure it delivers on its promises, especially for cost, without special pleading, so as to escape the backlash that is threatening it, and become a significant part of the world's energy supply.

Julian Silk