Case study for a small scale installation in UK waters

Background

The new requirements for carbon reduction and energy security are forcing a rethink of the way in which energy is produced. In the past, production of electricity was centralized and then electricity was distributed through a high voltage grid. It was simpler to bring the fuel to a single location, and one could also benefit from the economies of scale of large power plants. By switching to renewable and sustainable energy sources, the "fuel" is distributed on the territory, and therefore there is no need to move the produced electricity around, except for a percentage of it for buffering and stabilization purposes. The new paradigm of distributed generation, which comes hand in hand with the switch to renewable sources, forces also a rethink of the economics of energy production. While only big financial entities can finance the construction and operation of a 1000MW Coal power plant and guarantee the necessary power purchase agreements and fuel sale agreements, almost anyone can provide the capital necessary to set up his/her own "personal power plant". The totally distributed model, adopted for phpotovoltaics in Germany, Italy, Spain and many other countries, is at the opposite end of the spectrum with respect to centralized energy production: everybody produces energy, with no intermediary (the energy is produced for consumption, not for distribution through a grid, except for buffering and stabilization purposes).

Of course, also in Renewables there is room for concentrated production plus distribution through a grid, possibly a small one, for example because:

- the are places where the renewable source is particularly abundant or easy to harvest, so that the energy produced has a cost advantage large enough to offset the distribution cost
- installation, O&M and removal are easier and cheaper if performed at a single location
- above a minimum plant size threshold, a stable O&M base, with local personnel and standardized support, becomes economically viable

- spare parts can be shared among the devices, if the machines are installed in arrays, thus reducing costs and downtime

This intermediate model is already in place to some extent for wind turbines, although the wind parks tend to be large and far from inhabited areas due to the very high environmental impact of turbines. Moreover, in wind, to have an economically viable solution the size of the park cannot be too small. In this situation Utilities enter the equation with their capital and with their distribution grids.

Wave energy will adopt the same intermediate model, with the advantage that, in many locations, already 900kW-1MW of installed power may be enough to reap the benefits of centralized production, without the large capital requirements. Moreover, wave energy devices are completely submerged 1-2 NM from shore, in areas which are often already prohibited to fishing boats and to the navigation of large commercial boats, and in any case they do not impact on navigation; this makes it possible to have megawatt sized wave parks (6-7 machines rated at 150kW each) off most of the minor ports along the coast. In this scenario the Utilities do not need to enter: almost any municipality can afford the 4-6 M£ capital expenditure needed, in view of the advantages coming from the production of renewable electricity at a cost only marginally superior to their current electricity cost. Utilities can concentrate on deep offshore wave parks in highly energetic areas, made with megawatt scale machines.

Case study: 900kW installation near shore

We describe a scenario in which the installation of wave machines is done inside a “Wave Park”, like Wave Hub in Cornwall. The difference with respect to Wave Hub is that such a Wave Park will be initially tailored for 6 machines of type F6-150, for a total output of 900kW, and positioned within 2 Nautical Miles from shore. This reduces the installation cost of the cable and of the associated infrastructure. Having 6 machines (ore more) concentrated in a small area 2NM from shore insures also a low maintenance cost.

Ordinary maintenance can be carried out by local personnel, with a small support boat (no barges or special purpose boats are needed). The machine is monitored remotely by 40South Energy 24/7. The area occupied is a rectangle of sizes approximately 100m x 600m, with only the four signaling buoys on the outer perimeter.

Installation requires three main steps:

- cable installation
- mooring points installation
- machines installation

The most onerous part is the cable installation, which is however significantly easier than the cable necessary for offshore wind parks. This installation procedure is generally carried out in a few days (for the 2NM length and 900kW of power assumed in this scenario)

A Wave energy park installation will incur the following main costs:

- Capital cost of project development: £112,000 (3% of CAPEX)
- Capital cost (CAPEX) of installation: 4.05 M£ (4.5£/Watt)
- Capital cost of cable (including installation): £810,000 (20% of CAPEX)
- Operation and maintenance costs: £182,000 per year (4.5% of CAPEX)

All the above costs depend on the specific site of installation, and are therefore difficult to quantify in general. We will very generally assume the above, which are reasonable assumptions for a location where 35 meters of depth are achievable within 2NM from shore, and where the trenching of the electrical cable does not have any special requirements (especially on the shore side). We are considering an installation of 6 F6-150 machines, for a total power of the installation of 900kW and a CAPEX (excluding the cable) of 4.05M£. The final Levelized Cost of Energy LCOE) is estimated to be £107/MWh, with a capacity factor of 50%. This capacity factor is estimated to be achievable in many UK coastal sites, but will need to be validated case by case.

The resulting LCOE should be compared with the retail cost of energy, NOT with the market (wholesale) price, as the electricity goes directly to offset consumption, not to grid distribution: this is the main difference between centralized and distributed generation. In this sense it is important to tailor the size of the wave park to the actual consumption level on the local grid where the energy lands: if there is a surplus of energy which needs to be sold on the grid at wholesale price, then the economics of the project deteriorate, unless there are government incentives offsetting the gap between retail and wholesale price. Ideally, a few large users will commit to a power purchase agreement (PPA) for the energy produced, and may even own directly the wave park. Alternatively a "municipal utility" (maybe participated by a few large users) will own the wave park and handle the sale of the energy to the community. The local (medium voltage) grid operator will charge a transmission fee, which needs to be negotiated in advance.

The detailed assumptions used as inputs in the economic model (produced by Bloomberg BNEF) to come up with the 107£/MWh LCOE are the following:

LCOE	**107£/MWh**
Operating life	25y
Development time/cost	1y/£112000
Construction time/cost+capital cost	1y/5M£
% Debt/Debt spread over LIBOR	50% / 700bps
Loan	10y
Operating and Maintenance	£182,000 per year

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