'THE RESURGAM PROJECT': FEASIBILITY STUDY BRIEF FOR A PILOT COMMERCIAL OFFSHORE TIDAL ENERGY STORAGE AND RELEASE (TESAR) SCHEME AND EXHIBITION CENTRE ON THE NORTH WALES COAST

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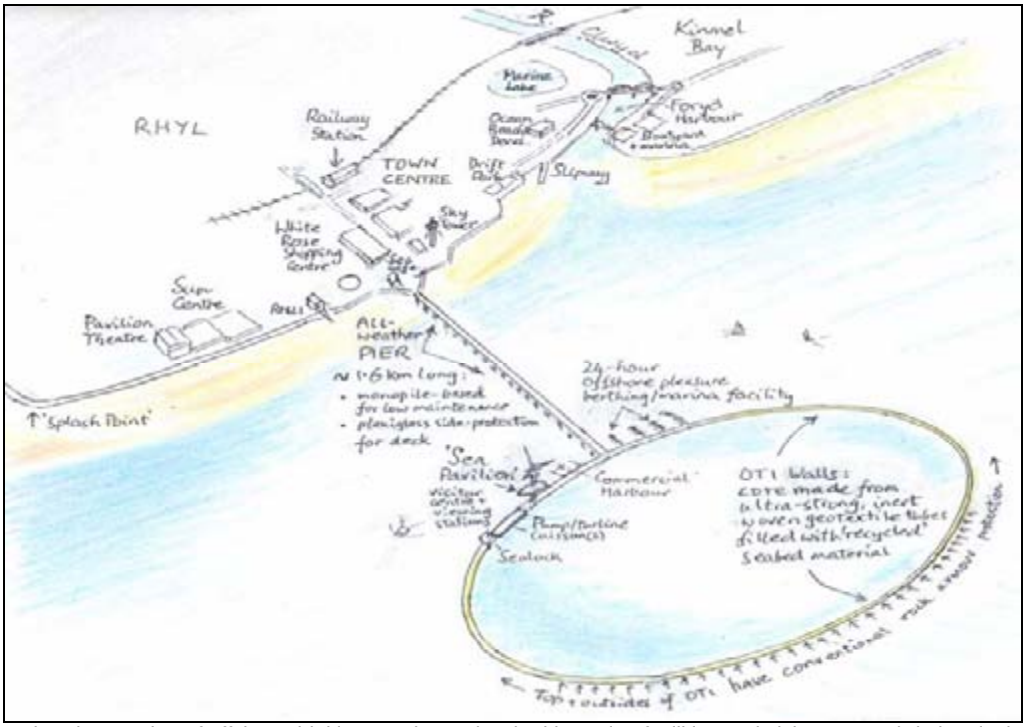


Artist's impression of offshore tidal impoundment (OTI) with marine facilities and visitor centre (Rhyl option)

1. SUMMARY

This outline brief proposes that North Wales - with its strong existing grid infrastructure backed by an expanding base of offshore renewables expertise, its regional economic and maritime development and regeneration needs, and its central position within the British Isles – is uniquely placed to offer the site for a commercial-scale pilot offshore tidal energy storage and release (TESAR) scheme, in the process filling two big strategic gaps, viz:-

(i) An innovative testbed function for TESAR schemes of all sorts analogous to that of Blyth for the UK's offshore windfarm programme.

(ii) Under the 'Resurgam Project' heading, a unique educational role aiming to help unite world public opinion behind all honest and appropriate ways and means to halt and reverse destructively rising trends in greenhouse gas concentrations.

2. THE OUTLINE PROPOSAL

The scheme would involve a 3-6 sq km offshore tidal impoundment (OTI) situated below the line of lowest tides and suitably linked to the coast by a low-maintenance, monopile-based pier protected from side-winds by plexi-glass panels or equivalent. Bulb pump/turbines would be located within prefabricated, multi-chamber caissons to be floated into their design position. Any necessary seabed sculpting would be carefully managed so that, wherever possible, excavated material would be recompacted back into the core of the OTI's walls inside geotextile tubes. The OTI would have conventional rock armour cover, consideration being given to the whole structure's parallel functions as a breakwater to shelter separate facilties for commercial and pleasure boating, both with round-the-clock access.

Meanwhile the pier would also provide access to the harbour and an educational visitor centre. The latter would include a single full-scale wind turbine similar to those in use further offshore, with a specially designed-in observation platform just below nacelle level as at Swaffham's Eco-Centre. The tidal scheme's access and switchgear gallery would also be on view, with underwater cameras showing one or more turbines in operation if possible. Further examples of offshore marine engineering would be demonstrated in working model or other form. However, 'Big is Necessary' ideas will be balanced against the emphasising of eco-fragility and demonstration of the responsibility for active co-operation at all levels in demand management ('Small is Beautiful').

Three seaside locations associated presently or historically with traditional pier structures (Colwyn Bay, Llanddulas and Rhyl) are proposed for preliminary evaluation against each other in the study. Factors influencing eventual choice may include (i) scope for negotiation with owners of existing working pier structures, or remains thereof in the case of Colwyn Bay; (ii) depth and area of seabed accessible in relation to the submergence requirements for the pump/turbines; and (iii) modelling of effects on beach protection and nourishment processes both immediately opposite the OTI and elsewhere along the coast to either side of it.

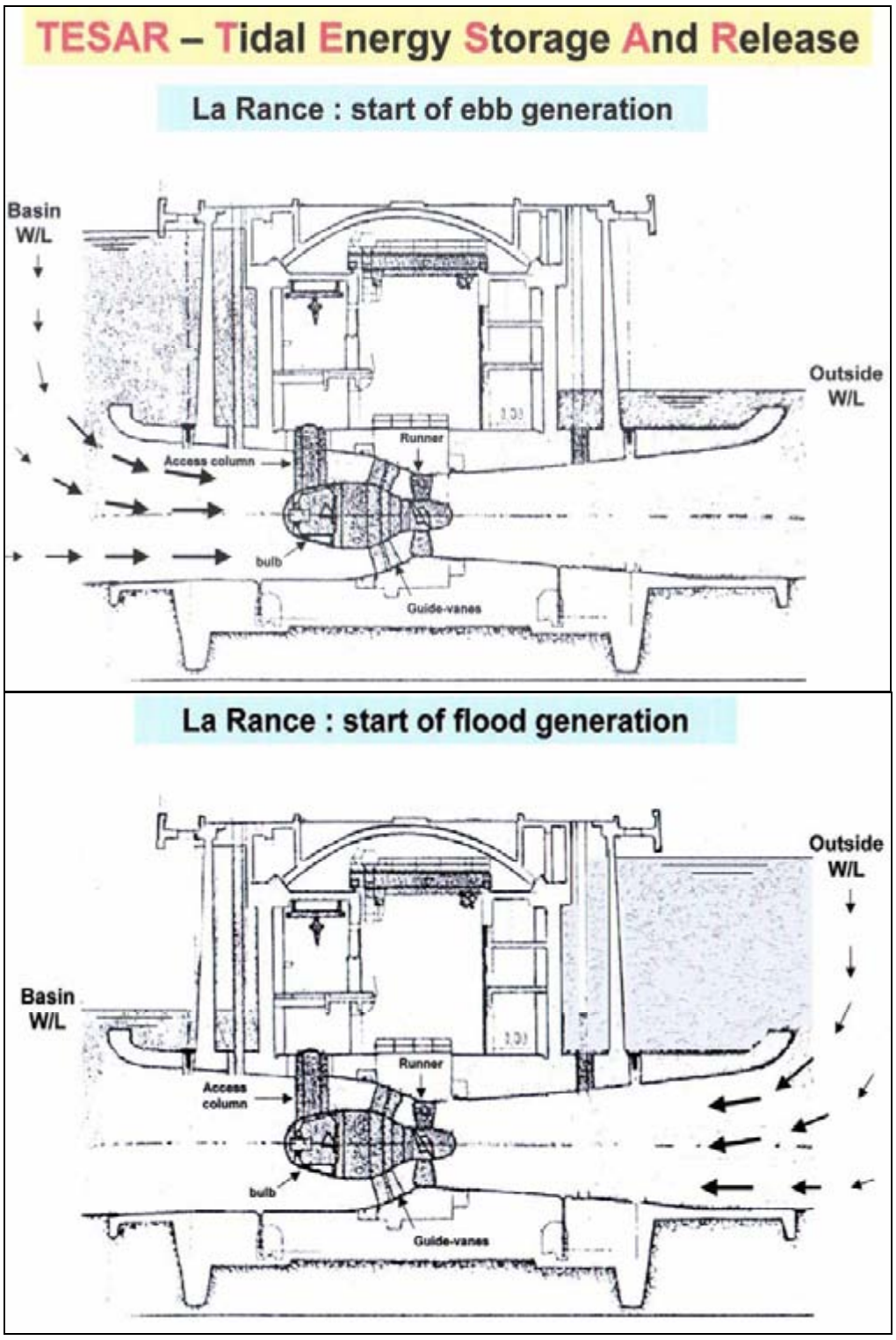
3. BACKGROUND HISTORY AND STUDY BASE

This proposal broadly follows the lines of the former WDA's offer for a feasibility study for a pilot OTI on the Rhyl Flats made to, but turned down by, Peter Ullman of Tidal Electric Ltd (TEL) in June 2001. Since then TEL's attention has turned to Swansea Bay, where a pre-feasibility study by Atkins was heavily criticised by a DTI-funded study by AEA Ltd published in 2005.

Meanwhile lessons from the successful first decade of two-way generation with two-way pumping at the 240 MW La Rance Barrage scheme near St Malo seem almost to have been forgotten. Desk-top studies suggest that it is largely due to inadequate installed capacity that this scheme was (and remains) such an odd combination of genuinely successful technical innovation but serious and hitherto unrecognised, yet potentially remediable, shortcomings in deployment. The results are little short of dramatic. For example, when (by contrast with the 1989 Severn Barrage studies, which stopped at a 20% increase in installed capacity (IC) relative to extant tidal sine wave parameters) increases in IC of 2, 3 or even 4x are simulated, it appears that the corresponding potential for increases in net output rises in direct linear proportion with IC. Moreover the artificial rise-and-fall in the area impounded, though delayed by a quarter-cycle, can potentially be 'naturalised' into matching up with even the highest spring tide rise-and-fall outside (see diagrams on p.7).

Subject to consultation with turbine manufacturers, RWE/npower's own pre-feasibility studies of an OTI are understood to agree that a potentially big point of divergence from the 1981 and 1989 Severn Barrage Studies is the idea that dividends might be paid out by reverting to the original, two-way La Rance model, this time being prepared to put in a significantly higher proportion of investment into 'active' pump/turbine hardware than (for example) 'passive' sluices.

The series of diagrams on the next five pages is intended to help summarise the potential way forward as to how a pilot OTI scheme could help push away barriers to the scoping out of a new generation of efficient and powerfully effective TESAR schemes that may be planned strategically also to meet coastal defence needs.



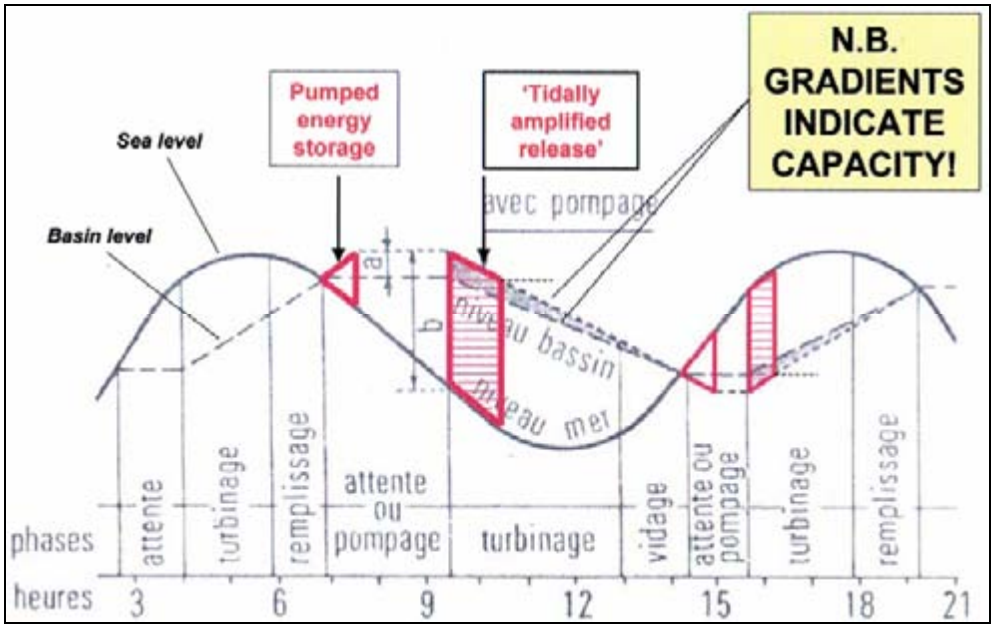
The above pair of diagrams help clarify two important lessons:-

1. Great strides were made at La Rance towards effective two-way generation. However the project also had its innate frustrations, arising from compromises needed to adapt and install machinery designed originally for river use. E.g. though with long intake and draft tubes both of the scenarios shown above (ebb and flood generation) were theoretically workable, in practice nothing like sufficient installed capacity was built in to permit the basin behind the barrage both to fill and empty in the way shown – or at least not during one and the same tidal cycle (see also flow diagram on p. 5, lower).

2. As a concept, the 'Energy Extraction Quotient' (EEQ) for any tidal barrage or impoundment scheme enclosing a given area with tide of a given range is made understandable by imagining the above (albeit in practice 'impossible') composite scenario whereby for EEQ value of 100% *ALL* the stored energy from high tide is released repeatedly for electricity generation purposes at the moment of low tide (ebb generation) and - in addition - *ALL* the energy stored outside the basin at low tide is likewise repeatedly released back for electricity generation at the moment of high tide (flood generation). NB. the EEQ concept takes no account of the bulb turbine generator's own innate efficiency within its operating head range, which at La Rance peaks smoothly at around 90% for ebb generation and 76% for flood generation.

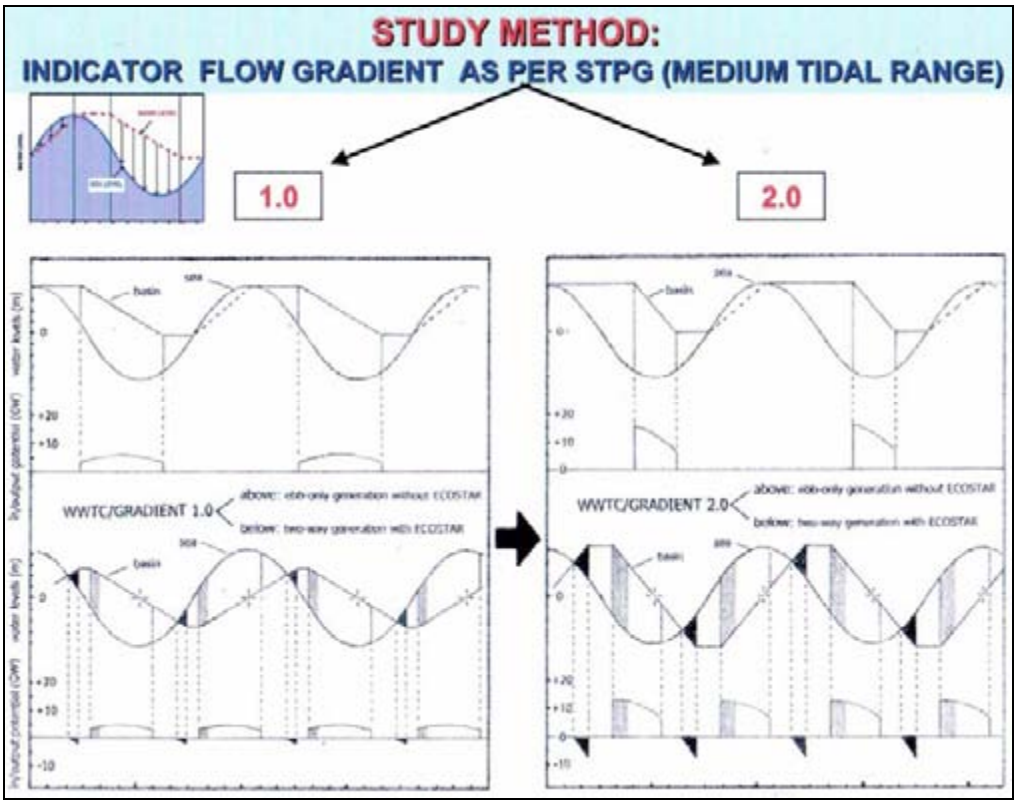
La Rance: how inadequate installed capacity marred success

Above: The Rance barrage was built 'in the dry' (i.e. using a coffer dam to drain the entire estuary for 3 yrs, while diverting river water through sluices) at a pinch-point in the estuary measuring 665m across, not counting further lost width from the midstream rock upon which the 'usine maremotrice' is built. Sluices (R) and a boatlock (L) occupy further parts of width that might otherwise have been usable. To either side of the chosen barrage location the estuary is at least one kilometre wide. A functional conflict of interest may have arisen from the use of now-outdated civil engineering techniques, perhaps chosen partly to facilitate the building of a roadway, and designers' inability at the same time to optimise the output potential of the tidal scheme (see 'Ecostar' paper).

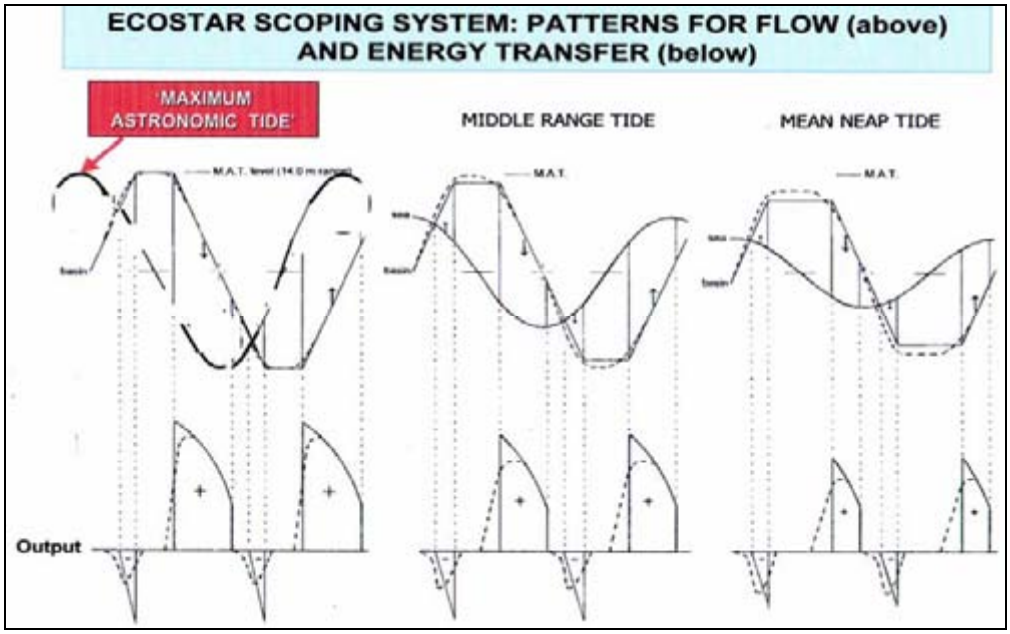


The above diagram comes from a paper in IEEE's 1976 archive by the EDF engineer, H André, in charge at La Rance during the first ten, experimental years. An accompanying table confirms that two-way pumping with generation – as shown - was the ONLY usage mode during that period. In effect, two parallels cycles are seen – the natural sine tidal wave outside the basin, and a linearly shaped artificial cycle inside it. Note that pumped energy transfer is used at BOTH ends of the 'basin cycle' - sharply linear 'intersections' with the tidal sine wave also meaning that engineers cannot have relied just on sluices for negative-head ('pre-intersection') filling and emptying. Overall, about half of the ebb generation output comes from pumped energy transfer. (Since the gradients in question are similar, it might be thought that coefficients of performance [COP] for 'tidally amplified release' of energy could be derived just from the ratios in area between cross-hatched rhomboids and preceding triangles. However there is further energy gain within each 'turbinage' area from fuller use of generating capacity, and any overall COP must also allow for pumping losses). Meanwhile, a potent reason for the upward bias of the mean basin level is that both reverse generation and reverse pumping are somewhat less efficient than forward generation and pumping, doubly affecting COP on flood generation. Alternating alignments of pump/turbines could 'even out' this problem – except that in most estuaries extra ebb generation capacity is needed to cope with times of high freshwater flows. The offshore tidal impoundment situation, where freshwater input is confined to direct rainfall, would seem experimentally ideal in order to free thinking from this and other constraints.

How simulated increases in installed capacity can be modelled

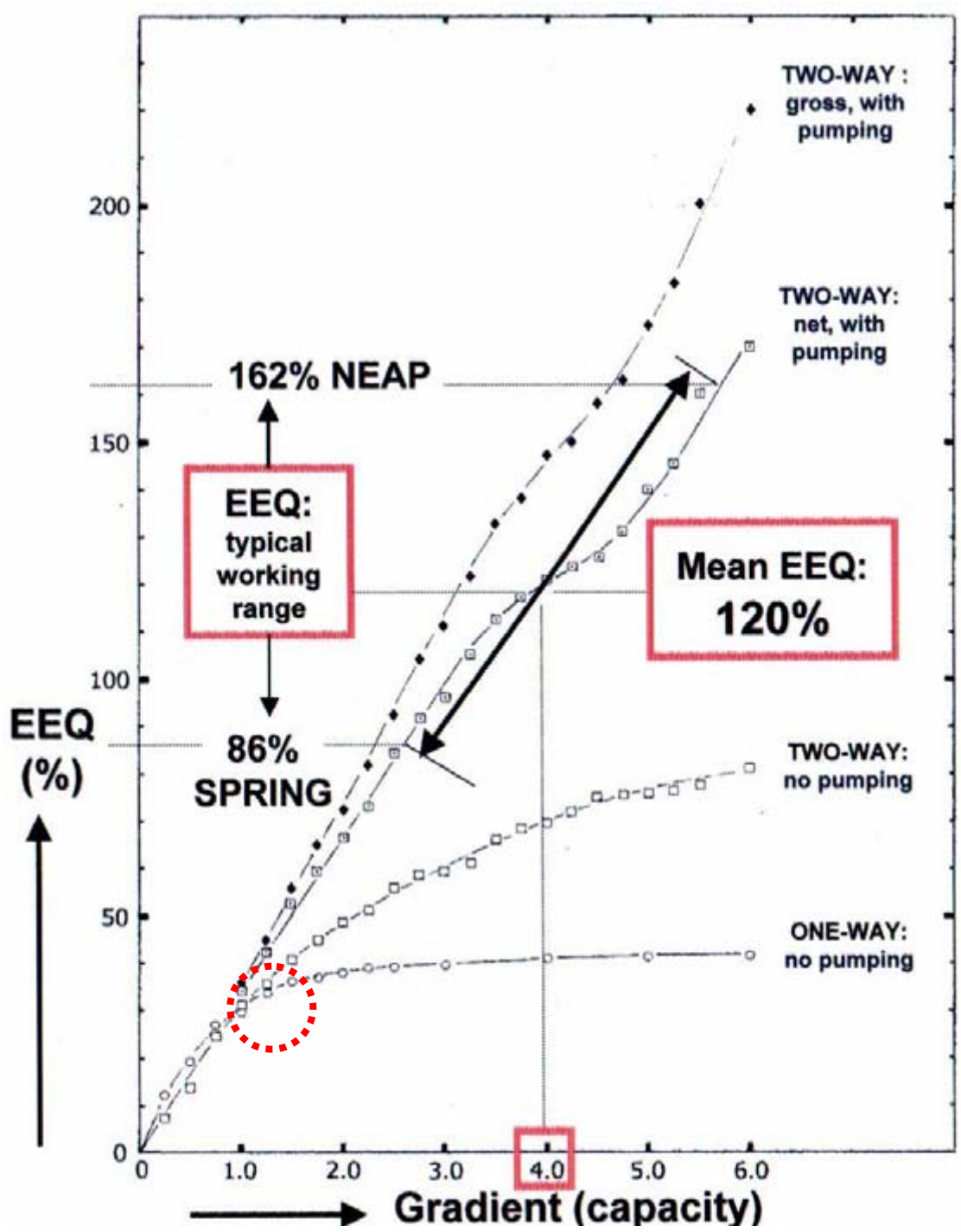


Above: the working gradient of 1.0 is derived from the 1981 Severn Barrage studies (top L), also following the same working water throughput capacity (WWTC) as at La Rance in proportion to the sine waves of extant 'medium range tides'. With two-way generation (lower subdiagrams), a doubling of capacity is needed to allow the basin flow chart's height and depth just to reach those of a medium range tide. Black triangles represent pumped energy transfer, and ensuing shaded rhomboids corresponding periods of 'tidally amplified release'. Dynamic symmetry is assumed in this standard, vertically sided, flat-basin model - so that basin level fluctuations are delayed by exactly one-quarter of a tidal cycle. In the lower power generation projections (and in desk-top calculations feeding into the diagram on p.7) an arbitrary weighting of 25% was added into the triangular pumping areas to allow for inevitable energy losses. Furthermore the cut-off pumping head was set at exactly half the head for the start of the following generation period.



Above: a further doubling of pump/turbine throughflow capacity – i.e. an operating gradient of 4.0 relative to La Rance and the 1981 Severn Barrage studies - is needed for the basin flow pattern to be able to approximate to that of the max. astronomic tide. Graphs for respective output potentials are shown below, with pumping areas again augmented by a factor of 25% to allow for extra energy loss. While sharply intersecting lines of the sort shown were used for desktop calculations, the dotted lines may represent more probable and desirable flow patterns in usage. NB. even during neap tide the artificial rise-and-fall can approach that of an average spring tide. Lesser capacities (e.g. 3.0) might reasonably be used – but would such restriction help to anticipate future generations' needs? (see pp. 20-22).

What such modelling shows ('the Ecostar hypothesis')

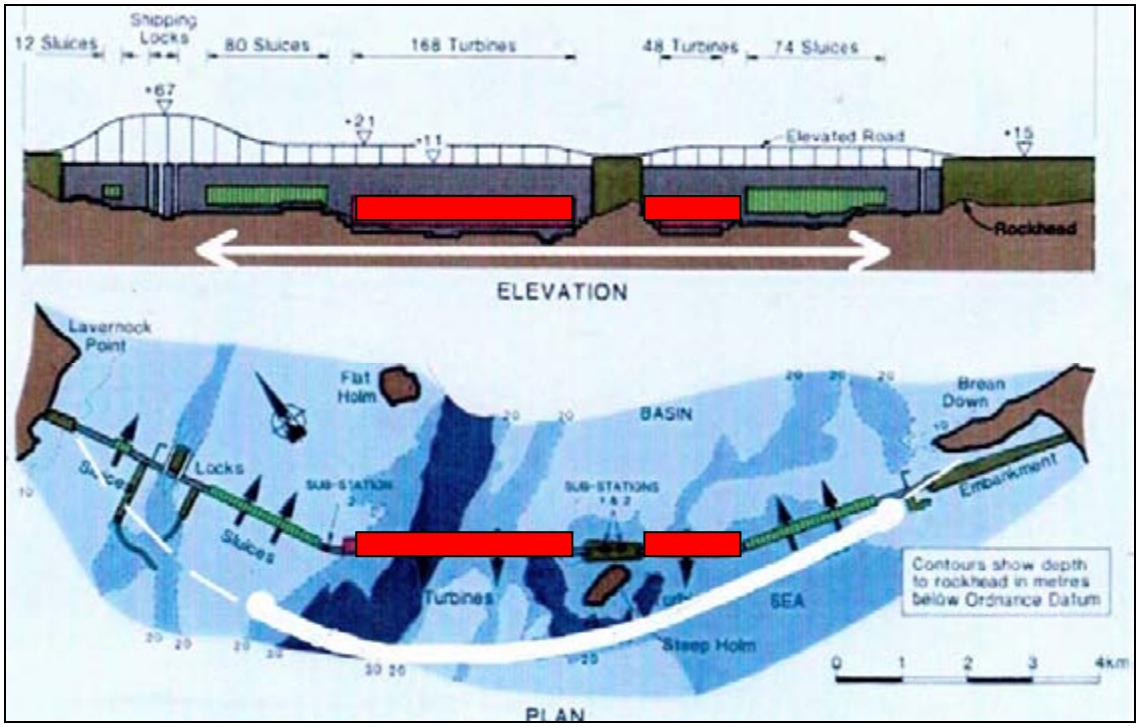


The above graph represents the core of the 'Ecostar hypothesis' for TESAR - viz. that radical re-examination of pump/turbine capacity issues may allow increased potential for net energy capture from timed energy storage for tidally amplified release, especially with two-way generation. There is no evidence that the Severn Barrage studies ever looked outside the dotted red circle, where one-way generation more or less matches two-way generation and may even outperform it when top-end pumping is added in. In practice, basin shape means that capacity widens out as with altitude above OD – a factor increasing the relative potential for ebb generation, further compounded by turbine orientation if this is set to build in the approx. 15% efficiency bias disadvantaging reverse generation. At La Rance practical issues (e.g. wear-and-tear of electrical equipment from frequent start-ups) also pushed practice towards ebb-only generation. The above graph presupposes assumptions that merit case-by-case examination, nevertheless two general points stand out:-

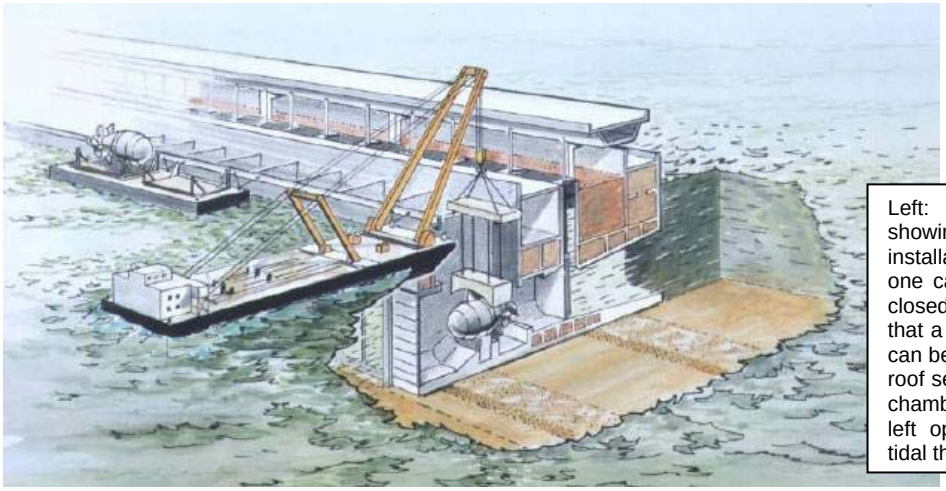
1. Given certain assumptions, an EEQ in excess of 100% is theoretically obtainable for two-way generation-with-pumping. This 'trick' is analogous to the performance of a heat-pump and relates to the paradox that a tidal barrage or impoundment can act as a partially *OPEN* energy-collection system – gravitational rather than heat energy being exchanged in the present case. Unlike conventional pumped storage, timing of both pumping *and* generation is crucial to net efficiency of such energy exchange. (The manoeuvre also has parallels with hedge-fund management - but is likely to offer more predictable results!)

2. The doubling of net EEQ as between spring and neap conditions shown ref. a mean gradient/capacity value of 4.0 for middle range tides should apply equally to lesser such gradient/capacity values, e.g. in range 2-4, with corresponding potential benefits in terms of tending to flatten-out the inequality in net outputs as between neap and spring conditions.

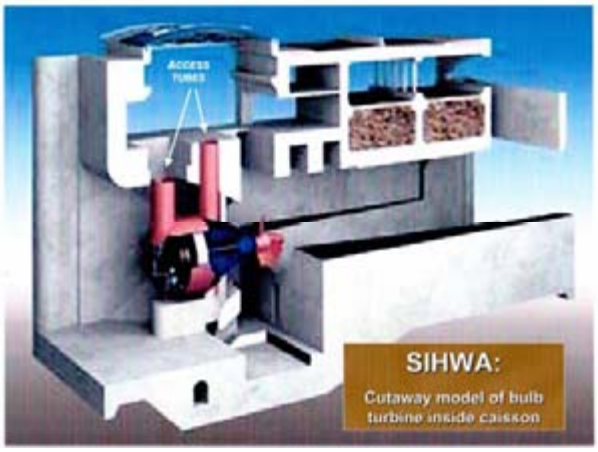
Illustrations of possible wider application of 'Ecostar' scoping



Above: schematic elevation and plan diagrams of Severn Tidal Power Group (1989 Energy White Paper). Proposed locations for pump/turbine arrays are shown in red. In total these occupy only one-third of the barrage's width. An alternative alignment would allow a 2.2x increase in width available for pump/turbines (bold, curved white line in plan) at the same time putting the functionally most important part of the barrage over somewhat deeper water & eliminating most or all of the need for sluices. The arch-shape in plan would allow the designing-in of greater tsunami resistance.



Left: cutaway STPG drawing showing the accepted turbine installation method. Essentially, one caisson section at a time is closed off and pumped out dry so that a complete turbine assembly can be dropped in, followed by its roof section. Meanwhile adjacent chambers have their sluice doors left open to allow unobstructed tidal through-flow.



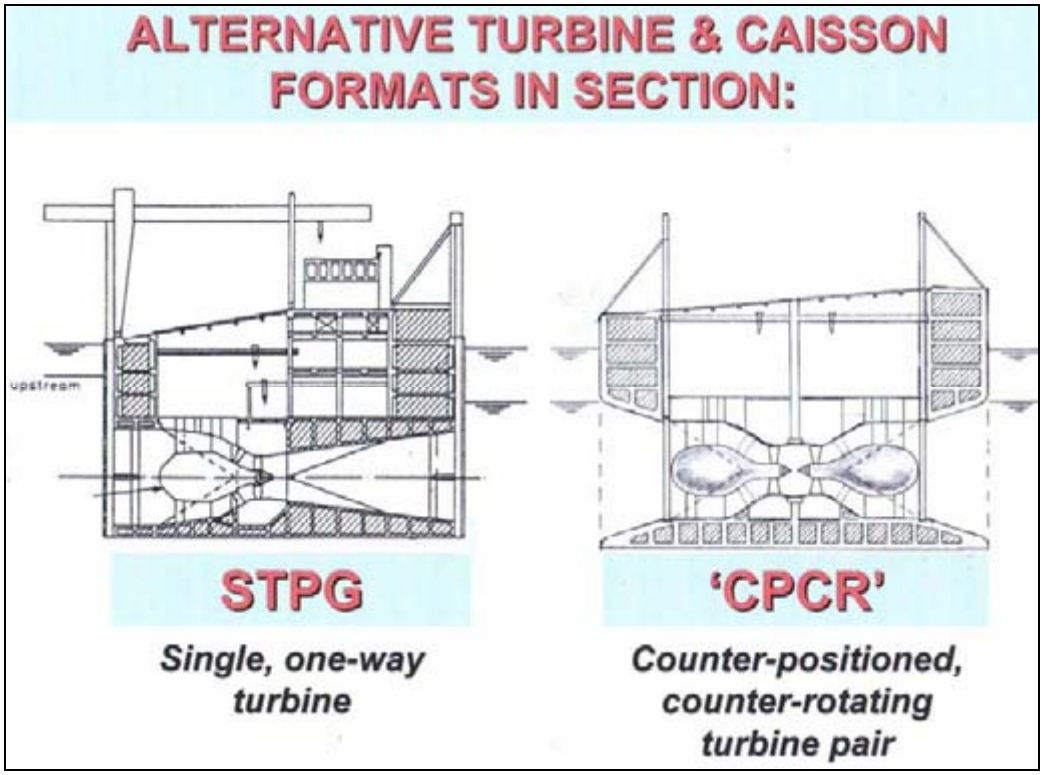
Left: 25 years after the abortive last round of planning for a Severn Barrage, very much the same pump/turbine and caisson layout is planned at the flood-generation-only plant at Sihwa, near Seoul in South Korea, due for completion in 2009 - the only significant difference being reversal of the turbines' orientation. Of interest is Sihwa's history as a 'land reclamation project gone wrong', with accumulated pollution from industrial rivers having forced a rethink. Now, a seawall originally built to keep the sea out is being rebuilt to contain pump/turbines that can intermittently let it back in again. Installed capacity at the Sihwa tidal station is to be similar to La Rance's (265MW vs. 240MW).

4. ENGINEERING, MARITIME/REGIONAL, EDUCATIONAL AND LOCAL DEVELOPMENT AND REGENERATION POTENTIAL

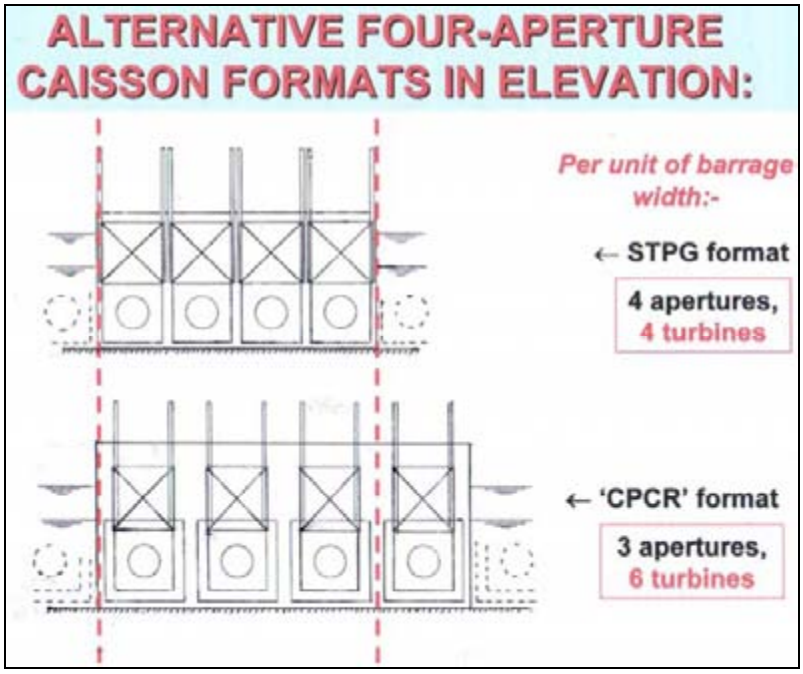
4.1 Engineering

The Sustainable Development Commission's recent, otherwise extremely cautious, report 'Turning the Tide' does concur that serious studies on a UK pilot TESAR scheme of some sort is long overdue for testing possibly outdated assumptions - as do former senior STPG members when approached individually.

Although the preliminary study may look first at how the present project would deploy existing single-turbine technology, manufacturers will also be asked to study an idea for deploying paired CPCR (counter-positioned, counter-rotating) pump/turbines, the main aim being to increase capacity by up to 50% per unit of barrage/impoundment width in elevation while increasing sectional width of caissons by of order 10-30%:



Above: counter-rotation, since the 1940's usually with coaxially mounted engines, has long been an established principle in propeller-driven aircraft, similar principles applying to modern turbofan/jet engines and steam turbines. Efficiency add-ons of around 30% through hydraulic swirl containment can also be shown to apply experimentally to the coaxial pairing of wind turbines as against single turbines of the same sweep, in the Wells air turbine, and in the Kaplan-type water turbine. The above, inward-facing CPCR arrangement allows sharing of a suitably wider water channel by two separately mounted in-series bulb turbines equal in size to the single turbine shown L (from STPG drawings) but with adjustments made primarily to size and specific speed rather than rpm. While each runner when upstream would, so far as possible, act as guide-vane for its downstream counterpart, the CPCR arrangement also makes for two-way symmetry as regards the purpose-built inlet guide-vanes that seem likely also to be desirable for use at times (see 'further issues to study', p.10).



LEFT: a 'unit of barrage width' is taken as the length of the STPG 4-chamber caisson format. This unit, traced down via the dotted vertical red lines onto the CPCR format below, shows potential for 6 rather than 4 pump/turbines of equivalent O/P – a 50% increase.

THE RELEVANT COST ISSUE: the key is ability to build in more capacity per unit of barrage width while minimising civil engineering cost increase. E.g. pump/turbines represent a 29% share of the current £15bn estimate for an ebb-generation Severn Barrage. If pump/turbines made up a 50% share of doubled overall costs (£30bn) for a two-way generation scheme tripling or even quadrupling the net output, the project's overall economics could be transformed by the cost of electricity falling from around 7p to perhaps ~4-5 p/KWhr.

In a pilot OTI scheme, the minimum case is that of looking somewhat 'outside the box' – e.g. by incorporating an experimental chamber in which to try out such new ideas. However, the time interval between a preliminary study and the later, detailed one should allow completion of basic research proving any seriously worthwhile idea aiming at more effective redeployment of existing, mature technology:-

CPCR TWIN-TURBINE FORMAT: PROVISIONAL LIST OF ISSUES TO STUDY

1. 'Both-turbines-in-use' hydrodynamic performance during pumping and generating: (main issues are head, submergence, cavitation risk, intake & draft tube shapes – aim is for improved whole-cycle efficiency, plus perhaps some modest widening of useful head at upper end)

2. 'One-turbine-in- use' hydrodynamic performance: (aim for widening of useful head range at lower end)

3. Issues related to both above: (e.g. guide-vane positions and usage/non-usage, shaping of conduits and runners)

4. External/environmental hydrodynamic performance (changes will be linked to all-round efficiency changes)

5. Cost, installation & maintenance in relation to caisson shape and size (aim for corresponding cost savings)

Above list serves to show extent to which the CPCR format is a 'different animal' to the single-turbine one.

'ECOSTAR' SCOPING METHOD APPLIED ILLUSTRATIVELY TO NORTH WALES PILOT OTI

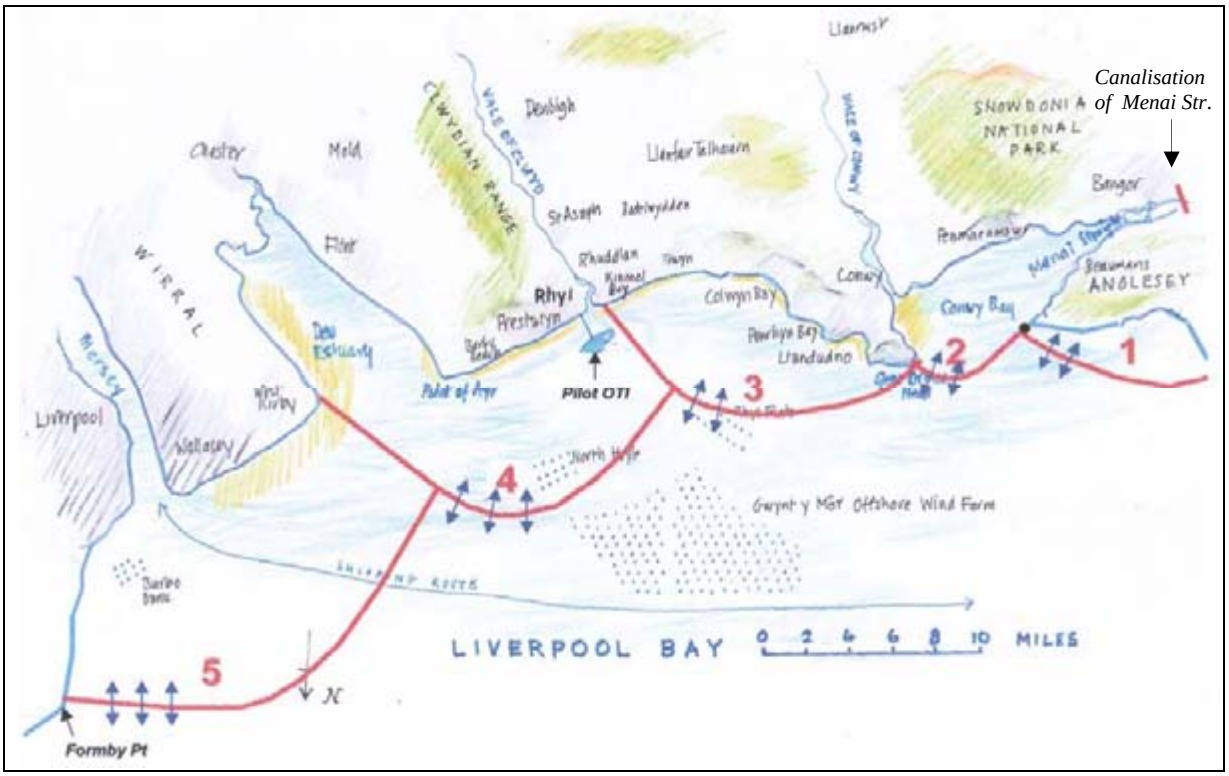
Area of OTI	3 sq km
EEQ rating (range for mean)	60-120%
Mean net output (range)	11-22 MW
Installed capacity (range, MW)	36-72 MW
Turbine capacity (MW)	~2 MW
No of turbines (range)	18-36
No of caisson apertures* (range)	4-8
No of caissons (range)	1-2

** assumes CPCR format, otherwise double this no.*

PROVISIONAL COSTING OF OTI

£2m per installed MW is reasonable to expect

Freeboard allowances, maintenance, and decommissioning may be assessed in terms of the usual 100 yr+ life of hydro-electric schemes. But it is also proposed (Section 5) that a successful scheme looks beyond the scoping limit of a 1 m sea level rise defining present coastal policies, to anticipate a situation - perhaps as early as 2030 - where the pilot OTI is left behind one of a working line of five CATI's (fig 1) each with an inbuilt ship- or boat-lock. In this situation the OTI's pump-turbines may be removed for use elsewhere, or their in-situ function change, but the need for a pier and round-the-clock offshore docking facility seems likely to remain:-



Above: the red lines 1-5 indicate a proposed sequence of five Irish Sea coastally-attached tidal impoundments, envisaged approx. along the -10.0m seabed contour and in total enclosing 1000+ sq km of seabed. Advantages of a sequential approach include basing first experience in more sheltered waters, also spreading cost while bringing forward pay-back. The blue arrows indicate probable optimally sheltered positioning of turbines and sea-locks. Costing would be greatly helped by the pilot OTI scheme, whose strategic purpose needs to be widely understood as preparing the way for such TESAR projects

4.2 Maritime/Regional

The pier/sheltered offshore harbour complex will present a unique opportunity for shared practical and prestige development not just for the seaside town hosting the OTI itself but also regionally around the whole Irish Sea perimeter – i.e. the Celtic Sea at the heart of the British Isles and from antiquity linking its peoples.

4.3 Educational

The name ‘Resurgam’ (Latin for ‘I shall rise up again’) will be internationally understood to have moral overtones, reflecting (for example) the call at the end of Al Gore’s film ‘An Inconvenient Truth’ for each and every person now living to see climate change as an opportunity to rise above circumstance. The exhibition centre will explain most if not all of the various forms of offshore renewable energy, either by direct experience (wind and TESAR) or by appropriate modelling (see p.2).

The fact that threats from sea level rise can be turned into opportunities to mitigate that threat is itself a powerful educational theme - the Resurgam Project having realistic prospects of coming to embody an ideal venue from which to feature and publicise the UK-wide TESAR strategy as it emerges.

In this connection, the fact that CO_2 levels inside *Resurgam* were in 1879 already recognised as the main determinant of human survival inside her is itself a powerful lesson that can be used to focus attention back onto the world’s present atmospheric challenges (‘the world is now our submarine’).

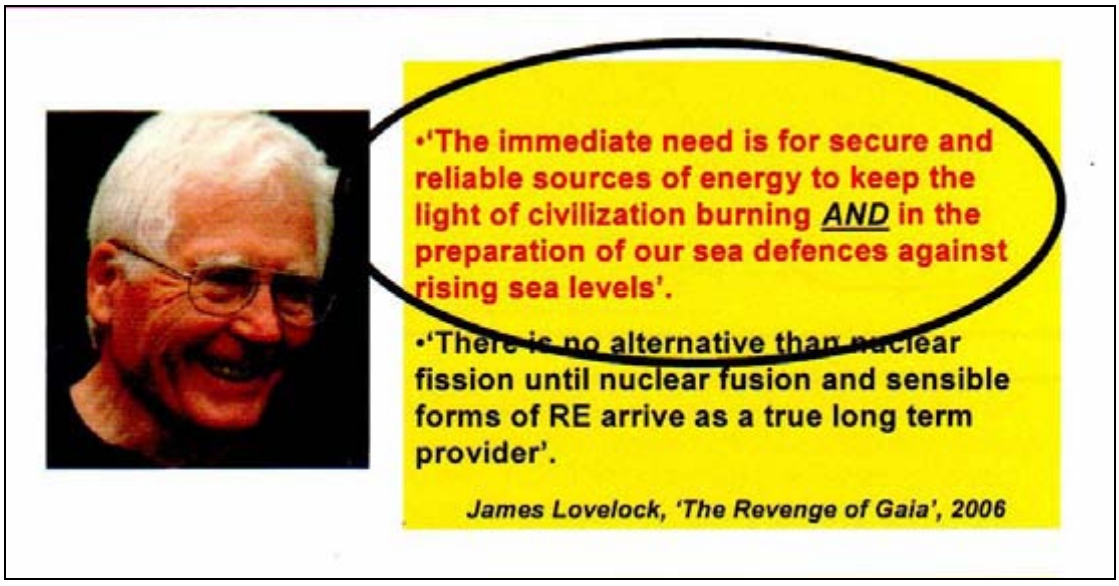
Meanwhile, relevant regional models in terms of creating an all-weather family and educational visitor focus of world-class quality include Cornwall’s Eden Project and mid-Scotland’s Falkirk Wheel. Like the latter, the Resurgam Project will provide a key missing link for pleasure boating that should afford the opportunity to provide one or more engineering items with unique visual and architectural ‘draw’ (see p.14).

Moreover, while Eden’s biodomes exhibit land-based habitats, the pilot OTI may offer the opportunity to shelter, exhibit and/or farm particular forms of marine life, especially shellfish, in significant numbers*.

*Worries about possible risk to fish passing through bulb pump/turbines may be put into context from the story that at La Rance a yachtsman who got himself sucked through a turbine there came through alive on the other side. Such a remarkable feat can be explained by the fact that water ‘flows’ past the blades of a reaction turbine somewhat after the manner of air-flow over and around an aircraft’s wings. However, the rotation of bulb turbines is remarkably slow (of order 60-90 rpm). Since living creatures of all sorts have a similar density to that of water the most likely thing for a medium-sized, highly streamlined fish to ‘notice’ on passing through them is sudden pressure change. Larger underwater creatures e.g. cetaceans might be excluded by grates. (Floating booms are now used at La Rance to exclude boats and yachtsmen).

'The Resurgam Project':
WHAT'S IN THE NAME?

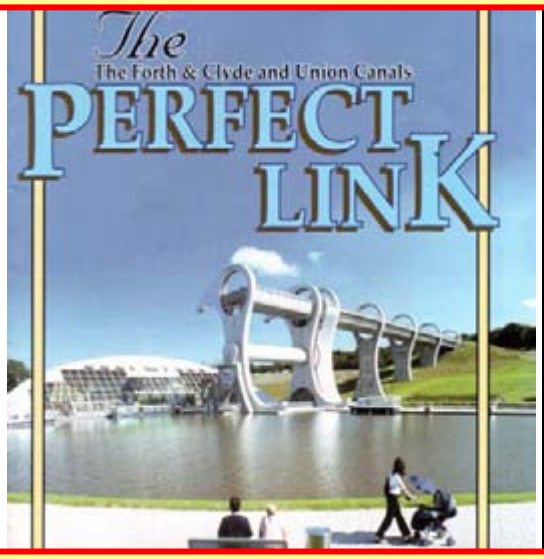
Educationally, *Resurgam*'s association with North Wales is arguably the kind of gift of that no region seriously interested in regeneration should be prepared to ignore. However, using it is about finding the confidence required for leadership - firstly in facing up to the magnitude of the coastal threat, and secondly in turning that threat into a unique opportunity of matching size. The world sketchmap shown above is taken from a Cold War era textbook on submarines, ironically showing the range of action of a Polaris missile as fired from Liverpool Bay. *Resurgam* herself presaged nuclear submarines in that the latter, though nuclear-powered, are still steam-driven. Now the battle in which Britain is uniquely placed to take a lead within Europe, and by extension elsewhere around the world, is that of mobilising attitudes to global warming as a coastal survival issue. However, positive practical example is the *sine qua non.*



Just as the two pictures above tell different aspects of one life-and-death disaster and rescue story, so it is vital that coastal defence and the quest for reliable, adequately scaled sources of renewable energy come to be seen as having the same strategic implications for survival. In the words of the Stern Review, 'strong action is necessary and urgent – uncertainty is an argument for a more, not less, demanding goal because of the size of the adverse climate change impacts in the worst-case scenarios'. Or again, as said by the 20th Century master-strategist Winston Churchill, 'advantage is gained by selecting from many unattractive or unpleasant alternatives the dominating point…failure to adhere to this simple principle produces confusion and futility of action, and nearly always makes things much worse later on'. Sir Nicholas Stern has recently gone on to advocate an 80% cut in emissions of CO_2 equivalent from the developed world by 2050, saying that 'we risk damage on a scale larger than the two world wars of the last century'. Recognition is long overdue for coastal tidal energy's structural role as part of the urgently needed 'rescue vessel'……..

BELOW AND RIGHT…

are two images suggesting how the 'Resurgam Project' offers the strategic middle of Wales' north-facing coastline iconic architectural opportunities inviting visitors to understand and identify directly with the practical needs of the 21st Century & beyond (see also p.12).



'A clear idea of where we are going as a world will make action at the individual, community and country level much easier & more coherent'

Sir Nicholas Stern referring to the forthcoming Bali talks in 'The Guardian', 30.11.07

4.4 Local & Regional

The potential for employment benefits, direct and indirect, to the locality nearest the OTI/pier complex should qualify for study under convergence funding. For each of the possible towns in question, the opportunities for the project to contribute to the critical mass and quality of attractions to visitors (and residents) seem positive bearing in mind the 'waterfront factor' (q.v. Rhos-on-Sea). However, increased visitor numbers may mean that optimal benefits cannot be assumed without close and targeted attention to transport issues in particular. In the past Rhyl, for example, has proved attractive as a trial destination for novel transport modes such as the hovercraft. The challenge here is to see if this can once more be true in North Wales e.g. for small electric or hydrogen driven vehicles or trams using the proposed pier. Ideally, such key onshore developments as are 'on show' in this way should from the start reflect the novel nature of offshore ones – using any opportunity to start the community switching to the hydrogen economy, e.g. using power made available for this on a demonstration basis.

Good mainline railway and road connections mean that indirect benefits to the town and hinterland opposite the OTI should be another area of opportunity. For example, attracting in value to the general business and higher education environment via upgraded local identity and self-esteem seems likely. Should Colwyn Bay or Llanddulas wish to compete for the project, these towns would need to be prepared to look at their needs, in so doing not suffering from the disadvantage of a divided local authority base. However, whichever town succeeded in attracting The Resurgam Project, the fact that there are regional benefits means that the neighbouring coast should not feel left out – particularly bearing in mind the project's parallel, fundamental leitmotif of wider long term security against coastal erosion and flood disaster.

To face up to all such challenges, in 2000 the notion of a forward-thinking 'Integrated Development Concept' was suggested by Mark Bostock of Ove Arup (masterplanners of the Eden Project, Shanghai's Dongtan eco-city, and London's successful Olympics bid) as being necessary.

5. STRATEGIC ENVIRONMENTAL & TWO-WAY IMPACT ASSESSMENTS : A BEACON PROJECT FOR 'ONE-PLANET WALES' TO ADOPT FOR 2012?

This pitch for a pilot OTI emphatically does NOT aim to set up the 'tidal lagoon' format for TESAR in a false dichotomy with the barrage, as some supporters of the Swansea Bay scheme might be understood to suggest. Instead, it acknowledges and develops the principle that impoundments and barrages are all-but-identical from a functional viewpoint. It also bears in mind, however, that in view of longstanding and apparently intractable controversies over ebb-only generation schemes for tidal barrages, a two-way generation OTI may be needed to break the deadlock and give practically based generic 'proof of concept'. Perhaps only in this way can everyone concerned move on from La Rance's muddled legacy. Furthermore, with a North Wales scheme as the generic UK pilot for TESAR, mental and political space may open up to allow needed consideration of a vitally important third type of setting for TESAR, the coastally-attached tidal impoundment (CATI).

For N Wales and Liverpool Bay a series of five CATI's (p.11) seems the only long term idea in prospect for protecting the whole coastline from Anglesey to Formby Pt against sea level rises exceeding 1m, in the process affording a net output matching and complementing that of the Severn Barrage. Part of the Stern Review's call for 'strong action in view of the size of climate change uncertainties' is that timely intervention towards large scale low-carbon energy systems, where feasible, is likely to turn out many times better both practically and financially than even one further decade of unnecessary delay - or mere adaptation that passively follows such sea level changes rather than actively helping to prevent them via *anticipation*.

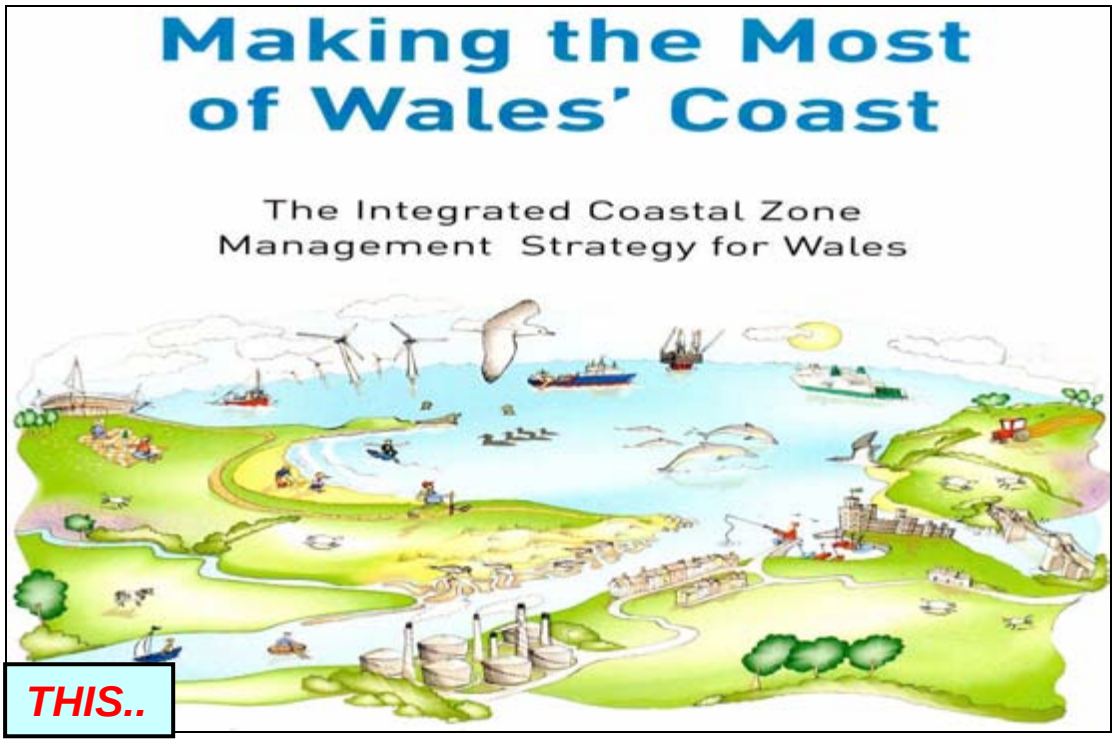
With these issues in mind, a completely integrated strategy for TESAR has been outlined as being in prospect, allowing renewables to penetrate and take over most the UK *base-load* electrical supply by 2030. Such a strategy could come to include E coast projects such as Thames Estuary, The Wash, Humber, Forth and St Andrews Bay – putting the UK as a whole, and Wales in particular, centre-stage in the worldwide 21st century battle for coastal survival. The challenge to a devolved Wales is thus whether and how - without, as matters stand, any direct control over

offshore renewables policy - to use encouragement of this pilot project to match words with deeds in her bid to lead with sustainable development. The fact is that mental, as against merely physical, spatial planning (i.e. preferably a major input that can capture and win over the public imagination) is essential in order to permit official thought to go beyond the threshold of a 1m rise in sea levels. As Ministers have anxiously tried to point out recently, there is a paradoxical danger that The Assembly´s present well-meaning notions of a Spatial Plan and of Integrated Coastal Zone Management, limited as they are to a 20-year horizon, become counter-productive. Paradoxically this is because, by definition, such unintentionally short planning horizons can come dangerously near to ***contradicting*** the need for any honest notion of sustainable development (like the one adopted by Conwy) that aims actively to promote longer term intergenerational equity.

Clearly, attempts to see how TESAR might be used to ***anticipate*** on the scale here suggested – especially if repeated on the same scale elsewhere around the world, as seems technically possible off France, N and S America, European and Asian Russia, China and Korea, and Australia for example – could be a major spur towards the supreme effort that one US commentator, Ross Gelbspan, has aptly described as being needed to 'rewire the globe with clean energy'. Concentrating Solar Power (CSP), though equal in predictability and maybe with greater long term quantitative potential than TESAR, is arguably less immediately accessible - and less powerful as a public wake-up call. As in wartime, full use of ***every*** useful defensive weapon is surely required if the aim is to redirect comfortably-off Western countries away from the slippery path of present 'business-as-usual' practice - which we set out for the world to tread, and along which it is steadily sleep-walking towards the precipice.

The challenge of using renewable energy in a ***concerted*** drive towards contraction and convergence (see *TREC* map, p. 20) is described as equivalent to a second industrial revolution – giving Britain, once again, the chance to show leadership as she did with the first. With this in mind, and with the *One Planet Wales* notion clearly meant to reflect successful identification with the 2012 *One Planet Olympics*, it is hoped that urgent political support can be brought to bear to help initiate feasibility studies setting a target date of 2012 for completion of The Resurgam Project.

WHICH COVER HONESTLY SHOWS WALES' STRATEGIC 'ELEPHANT'?



THIS..

....or THIS?

The above two front pages encapsulate The Assembly's well-meaning day-dream and local government's more realistically based nightmare. At BURA's Sept 2007 seaside regeneration conference in Rhyl, Rt Hon Peter Hain MP was challenged about the effects on coastal regeneration of climate change. His verbatim reply was to admit honestly that though sea level rise was the 'elephant in the room', it was not something he had an answer to. NB: R. of the lower picture, TWO elephants are shown - the point being that once correctly recognised and harnessed they become one and the same animal! The Resurgam Project will help local and central government work together to get this understood. But a necessary precondition is that threats and opportunities must be dealt with equitably together (i.e. that sustainable development means 'meeting present needs while striving equally to allow for those of future generations' - Conwy CBC's chosen definition). In face of the present man-made 'shadow our future throws'*, it is arguable that everything less than this represents denial and delusion.

*Title of second chapter in Al Gore's 1992 book 'Earth in the balance: forging a new common purpose' (Earthscan)

'GOING ELECTRIFYINGLY DUTCH' ...what it could mean for the UK as a whole

*The UK's strategic direction **MUST** turn towards marriage of her coastal defence and renewable energy agendas. The alternative is (for example) for Thames and Severn Barrages to go on living in separate administrative 'silos' when both have the same parallel functions. This is clearly absurd - and lethal to both agendas' potentially creative future outputs together……*

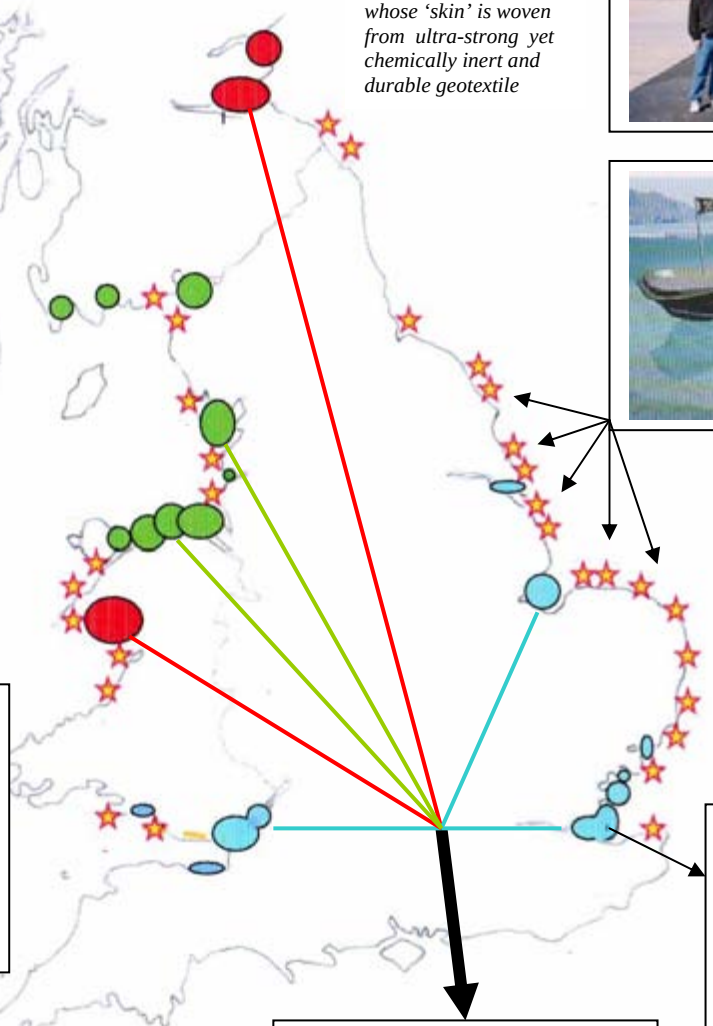
The building of one TESAR scheme will have knock-on effects further round the coast (e.g. building a Severn Barrage would raise high tide levels by up to 10 cms in Liverpool Bay). The only responsible answer is to start as soon as possible to develop a coherent, pan-UK strategy for ALL such reasonably possible schemes

As sea levels rise the relationships between coastal and fluvial flooding risks are set to become much more complex and fraught. Clearly, a UK-wide strategy for TESAR schemes built primarily for electricity generation must have usage codes allowing emergency prioritisation of flood defence. Such a prospect is, in effect, an extension of present DEFRA and EA policies on 'making space for water' (a phrase that is Dutch in origin).

Picture R shows scale of a single 'geotube', whose 'skin' is woven from ultra-strong yet chemically inert and durable geotextile

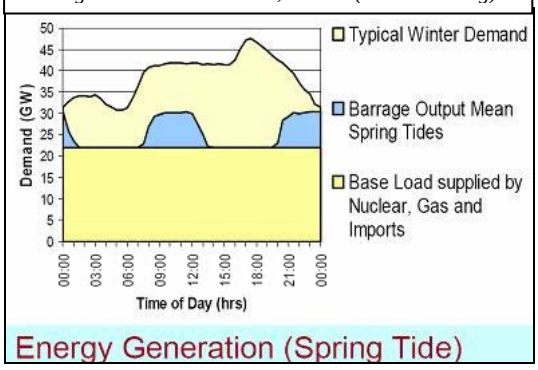
Dutch techniques e.g. dropping in geotextile tubes (see above) filled with dredged material to create underwater breakwaters planned to 'trip up' waves before they reach the coast may mean that many coastal areas need no longer be managed passively (see below)

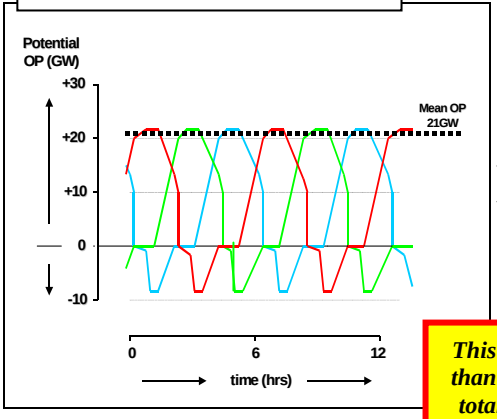
The idea is that, once tidal energy generating structures such as a new Thames'Active Barrier' are in place, their flood generation capacity may be enhanced by the dredging-up of surplus sandbank material, and shipping this round to help protect vulnerable neighbouring stretches of coastline (qv 'stars' on sketchmap).



ABOVE & BELOW: the same blue, red and green colour-coding is used to show positions of, and electrical inputs to/outputs from, TESAR schemes whose 'tidal timetable' from the viewpoint of 2-way outputs is respectively 0, 2 and 4 hrs (in round terms) after Cardiff's.

BELOW: regrettably, persistent gross underestimates of the UK's tidal energy potential, alongside well-meaning targets (e.g. '20% by 2020') based just on wind power, have reinforced the marginalisation of TESAR – a tendency reinforced by proponents themselves when the potential from a single big scheme like the Severn Barrage is shown in isolation, as here (STPG drawing).





Even during 'average' tides..

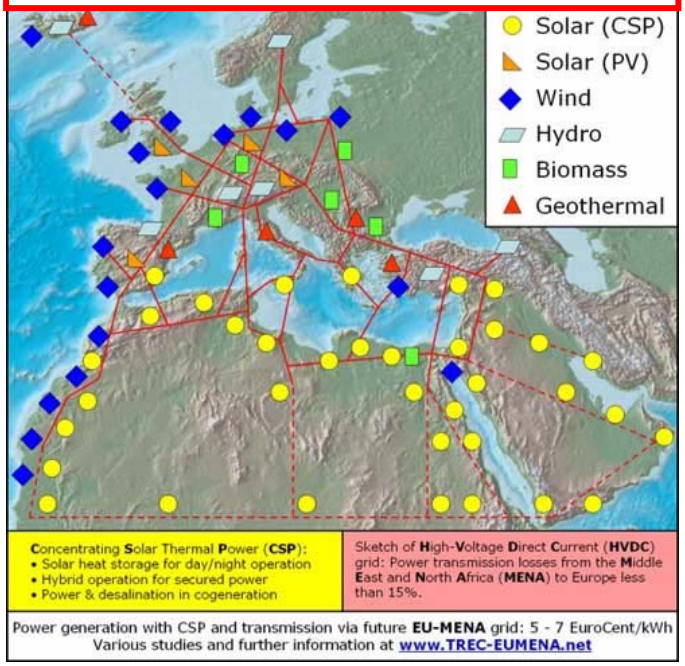
Continuous net base-load grid supply (+) from TESAR

This potential is VASTLY greater than previously understood!! The total order of cost, extrapolating from Severn Barrage work (p.10) may be of order £300bn – ie equal to est. value of residual UK North Sea oil before recent price rises.

Factual note: tidal energy is based on the 'freedom' of water particles to oscillate between the effects of the various gravitational and rotational effects acting at the earth's surface. Development of 3000MW of mean capacity would be needed to double the earth's present rotational slow-down rate of 1 second every 288 yrs

'GOING ELECTRIFYINGLY DUTCH' in the WORLD CONTEXT

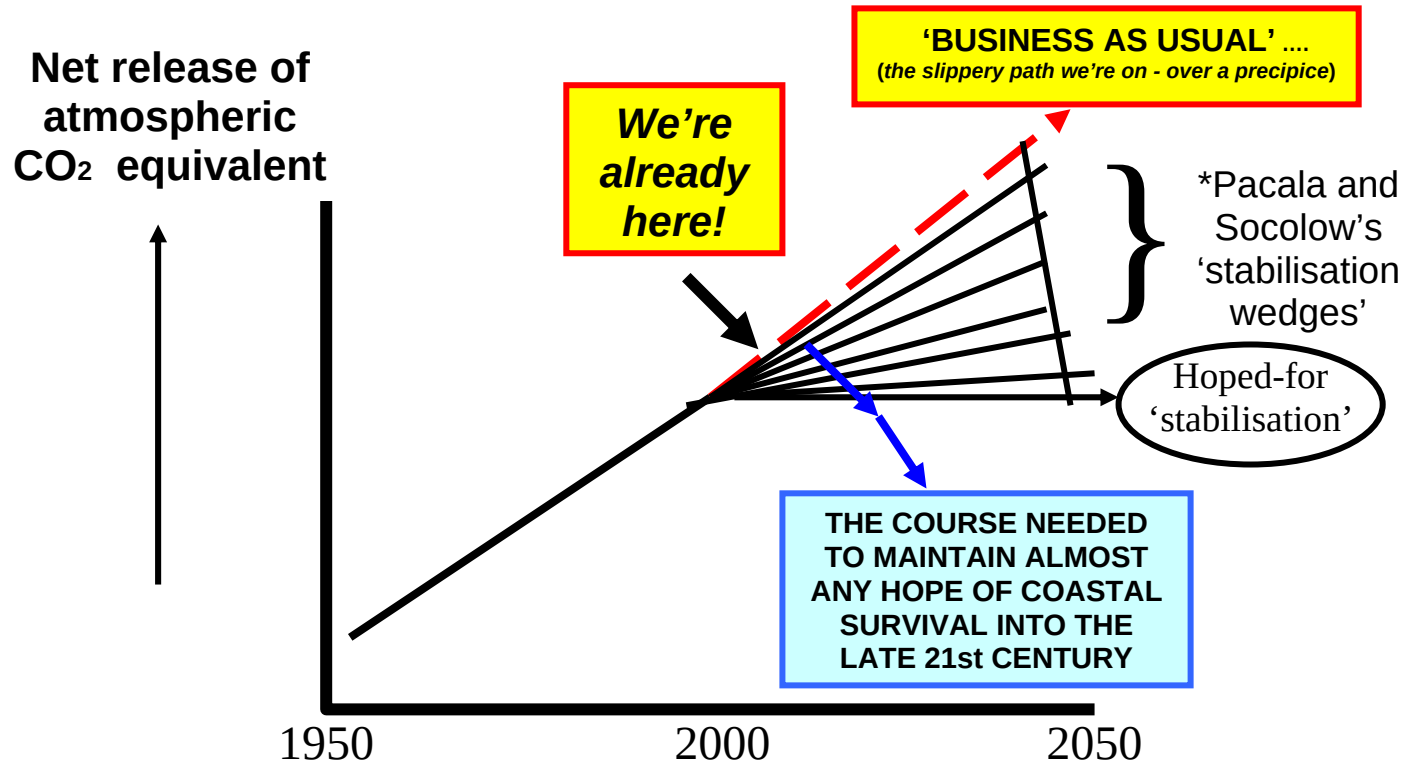
BELOW L: using DC line technology, a 3x increase in grid capacity is required worldwide to allow 'clean' electricity to take over from fossil fuels. Despite its accessibility and vast worldwide potential (N France alone has 3x, and European Russia 5x, the UK potential) TESAR still fails completely to appear in the 'TREC' (Trans-Mediterranean Renewable Energy Co-operation) maps:-



BELOW R: torrents pouring down and out through Greenland's glaciers. The race is on to slow the rate of Greenland & Antarctic ice melt-down/break-up enough to stop the threat of catastrophic, runaway sea level rise engulfing huge coastally populated areas by late 21st C.

'There is enough information now to make it a near certainty that business-as-usual scenarios will lead to disastrous multi-metre sea level rises on the century time-scale'

James Hansen, Director of NASA's Goddard Institute for Space Studies, New York, June 2007 – as quoted in 'New Scientist' of 28.7.07



*Pacala S & Socolow R. Stabilisation wedges: solving the climate problem for the next fifty years with current technologies. Science 2004; 305: 968-972