of the nuclear establishment and its critics that has provided Carter with room for political maneouvring. And to give in at this point on the Clinch River issue would do little to help a presidential image already tarnished by an apparently equivocal stand on issues such as the neutron bomb.

The compromise solution has, admittedly, not pleased the environmentalist lobby, who point out that it merely reinforces a commitment to a nuclear future, and that it is, in the words of James M. Cunie of New Directions, "a *de facto* re-establishment of a commitment to move forward with commercial demonstration of the breeder reactor."

The environmentalists, having previously supported Carter's efforts to terminate Clinch River, have urged that the compromise be rejected by Congress—which, if nothing else, will make it easier for the nuclear supporters who oppose the environmentalists to accept it. But even the science committee vote, plus the likelihood that the appropriations committees in both the House and the Senate will continue to support the project, does not make a presidential veto inevitable.

Two alternatives remain. One is that Democrats in Congress, aware that there is little chance of raising the two-thirds majority needed to over-ride a presidential veto, and unwilling to embarrass Carter—particularly in an election year—by further confrontation, will introduce an amendment along the lines of that proposed by Mr Flowers in debate on the DoE bill.

The other possibility is that the Senate Committee on Energy and Natural Resources, which meets soon to decide its position on the president's budgetary request, will accept the Schelsinger compromise, thus opening the way for it to be debated between Senate and House in conference.

If all else fails, and both houses reject the compromise formula, another presidential veto seems inevitable.

David Dickson

Little renewable energy until next century

RENEWABLE sources of energy—wind, wave, sun, geothermal heat and the like—are, you may be surprised to learn, taken seriously at the United Kingdom Atomic Energy Authority, Harwell. Dr Freddie Clarke, Research Director (Energy), who is responsible for the non-nuclear energy programmes of the UKAEA, delivered his assessment of alternative energy futures—broadly a thumbs down until next century—to a one-day meeting on energy in London last week. The meeting was organised by the National Federation of Women's Institutes, and was opened by the Prime Minister.

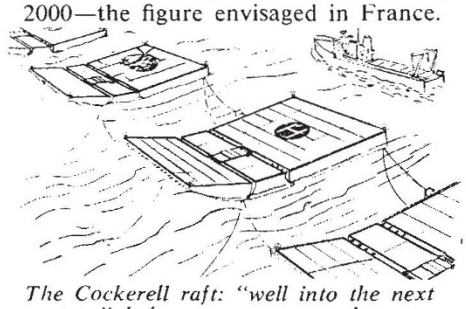
What could we consider to be a "substantial" contribution to UK energy supply by the year 2000? We now used 330 million tonnes of coal equivalent, Dr Clarke said, of which some 200 mtce were in oil and gas—forms which might be scarce and more expensive "sometime after 2000".

Official forecasts put demand at 500 mtce by 2000. The possibilities for meeting this increase, Dr Clarke said, are conservation, coal, nuclear, and renewable sources. But no contribution of less than 50 mtce per year could be considered substantial, he thought, and he set out to measure the renewable potential against this yardstick.

The conclusion he reached was that by 2000 there would only be a "minor" contribution from renewable sources of energy. But "somewhere in the world" they are economical here and now. Only if there were no technical setbacks in the development of renewable sources (an unlikely event), might we reach take-off—application in the UK on a substantial scale.

Some 30% of the UK's energy is for low temperature space heating, which makes geothermal heat look a good bet. The temperature of rocks increases at about 30 °C per km, and some deep sedimentary rocks are penetrated by water, which can be drawn up to provide heating. A block of flats in Paris already receives 70% of its heat from such a source. In the UK, the midland valley of Scotland, the East Yorkshire-Lincolnshire basin, and the Hampshire basin are the best sources.

But this form of energy is not easily transported, and we have to see if demand is where the water is. The match in the UK is not very good, and Clarke could see little more than 2 to 3 mtce from this source by 2000—the figure envisaged in France.



The Cockerell raft: "well into the next century" before wavepower makes a substantial contribution

The "hot rock" technique, on the other hand, in which dry rocks are fragmented at 2 to 3 km depth and cold water pumped down to heat up, could yield several times the 2 to 3 mtce figure. Early results from a test site at Los Alamos "look encouraging" said Clarke.

Household solar energy, used for water heating, cost £600 to £700 to fit. At a current return of £20 to £40 per year, it was not yet economical—though the Government was researching ways to reduce the capital cost. It might pay by the 1980s. But here was a problem for all energy accounting: we don't know how easily the new technologies can be developed. Also, solar energy came mainly in the summer, and we need our heat mostly in the winter. Yet it was possible, said Clark, if everything went well, that solar energy could contribute 50 to 100 mtce by 2000.

The remaining renewable sources would be most likely to generate electricity rather than direct heat. A 50-metre windmill (about as high as an electricity pylon) could be economical now. But the interaction of an erratically turning mill and the national supply grid—into which it would feed—might cause problems. And the most efficient land-based sites for the mills would be on coastal hills in some of the most unspoilt parts of the country. The mills could be based off-shore, but would be more difficult to engineer there. On-shore, using the best sites, they could provide 6 mtce per year, Dr Clarke estimated. At sea this might rise to 20 mtce per year.

Wave power is the "most promising" renewable source in government eyes, with 100 mtce per year by 2000 "not inconceivable". But this system faces the greatest engineering difficulties.

The Department of Energy began a study of wave power. "Something struck me greatly when I saw artists' impressions of the full-scale machines" said Clarke. "It's the scale of the things". Clarke showed pictures of projects such as the "Salter ducks" and the "Cockerell rafts". "One element of these devices could contain this hall (the Central Hall, Westminster)" said Clarke. And they must run reliably even in the roughest part of the year. They represented "a new dimension in engineering" which was going to take time. It would be well into the next century before they make a big contribution, said Clarke.

Finally, tidal power, even using the best sites in the UK, can provide no more than 10 mtce per year and so cannot be a substantial contributor. It is also at present uneconomic.

Robert Walgate

0028-0836/78/0272—0661$01.00