Dissemination strategy on Electricity balancing
DESIRE
large Scale Integration of Renewable Energy

Reporting on dissemination activities carried out within the frame of the DESIRE project (WP8)

Name, Affiliation	David Toke, Katerina Fragaki, University of Birmingham
E-mail	d.toke@bham.ac.uk
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Brief abstract / description of dissemination activity	The economic performance of community (and some industrial) CHP will be considerably increased by the use of thermal stores. Our modelling suggests that the optimum economic size in MWe is increased by over 50 per cent for a given example. Moreover, if, in addition to this, CHP units are ‘aggregated’ together to sell power to the grid, the economic performance of the CHP units will be further enhanced, and the optimum size of CHP plant increased by even greater amounts. This activity depends on the use of the thermal store system to sell exported power directly to wholesale power markets through aggregated despatch. Moreover, recent changes in planning policy guidance and incentives inherent in new building regulations create great potential for development of community heating and CHP in new building developments.
Audience impact assessment	The information has resulted in enquiries received on the nature of CHP with thermal stores and the possibilities for aggregating exports from CHP units using this system
Dissemination	Included after this form

DESIRE UK – Summary of Interim Research Conclusions

By Dr David Toke[i] and Dr Katerina Fragaki[ii], University of Birmingham

Abstract

The economic performance of community (and some industrial) CHP will be considerably increased by the use of thermal stores. Our modelling suggests that the optimum economic size in MWe is increased by over 50 per cent for a given example. Moreover, if, in addition to this, CHP units are 'aggregated' together to sell power to the grid, the economic performance of the CHP units will be further enhanced, and the optimum size of CHP plant increased by even greater amounts. This activity depends on the use of the thermal store system to sell exported power directly to wholesale power markets through aggregated despatch. Regulatory changes to establish a right for CHP plant to receive the same levels of payment for exported electricity as large power stations could also reduce penalties that are effectively imposed on small generators by BETTA. However, we see no regulatory barriers in the way of use of 'aggregated despatch' by CHP with thermal stores. Work still needs to be done to investigate and disseminate information concerning this proposed practice of 'aggregation'.

Moreover, recent changes in planning policy guidance and incentives inherent in new building regulations create great potential for development of community heating and CHP in new building developments. Action at a local government level is necessary to realise this potential. In the long term the thermal store-gas engine-CHP system, which is extensively used in Denmark, offers a flexible option for the integration of high levels of fluctuating renewable electricity into the grid. We shall be conducting further modelling over the next few months in order to analyse and develop 'best practice' arrangements for CHP and thermal stores.

Use of thermal stores

The thermal store is used for short term energy storage. It is a tank with a zone of hot water at the top and a zone of cold water at the bottom. In the UK thermal stores can, in the short term, dramatically improve the economics of community CHP. Here we use the term 'community CHP' to mean CHP acting as primary heat source in a community heating network. In the long term community CHP using thermal stores can present a flexible means of absorbing the output of fluctuating renewable energy sources into the grid, so expanding the economic potential for supplying renewable energy.

In Denmark, decentralised CHP units consist of highly efficient gas engines and use of thermal stores. These CHP plant supply around a quarter of Danish electricity and together all CHP plant supply over half of Danish electricity (with wind power

[i] Dr David Toke, e mail d.toke@bham.ac.uk, tel 0121 415 8616
[ii] Dr Katerina Fragaki, e mail Fragakia@bham.ac.uk, tel 0121 414 7135

supplying around 20 per cent). A large plant is set up by stringing several gas engines together in modular form. This has advantages compared to gas turbine technology at sizes under around 100MWe because of relatively low capital costs, higher efficiencies, and greater ability to work in ‘flexible’ as opposed to continuous operating modes.

In the UK, as in Denmark, thermal stores can allow CHP plant to produce electricity when electricity market prices are high, and shut off production of electricity when prices are low. When electricity prices are high, the heat generated by the CHP unit can be stored in the thermal stores (sometimes called accumulators) when it is not needed on site. When electricity prices are low, the CHP unit can stop generating and still service its heat demand from the thermal stores.

We have modelled the economics of CHP with and without thermal stores using a typical heatload. If we assume that all electricity is exported outside the plant then, the optimum economic size of the plant for heating load of 20,000 MWh per year is a 3MWe engine and a 250m3 (7.8MWh) thermal store. If there is no thermal store then the optimum economic size of the plant will less than 2 MWe. This is shown in Figure 1 in the Appendix. We used typical contract prices for gas and electricity revenue and expenditure to derive this result. We should note that most of the existing community CHP plants in the UK do not typically have thermal stores, are very small, and are sized to meet the minimum heat load so that the engine can run without wasting heat. We plan to carry out further modelling of CHP and thermal stores. This will involve refining our general model, and, in addition, we shall use operating data from three existing CHP plant that employ thermal stores in order to examine the optimal theoretical sizes of engines and thermal stores in these cases.

Incentives

Our overall conclusion here is that the current incentives available for CHP relative to conventional power stations are more than negated by the penalties imposed on small generators by the BETTA system.

The main incentive for CHP is the long term cost savings, but this is aided by the climate change levy (CCL) exemption. This involves CHP plant being exempt from paying CCL on gas consumed by the CHP facility and the and electricity that is exported. We modelled the impact of this in a typical UK CHP scheme assuming that it just covers its in-house electricity needs with the electricity produced. We found that for 2005 gas and electricity prices, it costs 34% less to run the CHP compared to a plant that has only boilers (operational and maintenance costs not taken into account). This percentage would be 27% if there was no CCL exemption. In addition to this the enhanced capital allowance and the business rates discount will give net benefits of the equivalent of around 5 per cent of CHP capital costs. However, we also have to bear in mind that a high proportion of CHP plant are currently in energy intensive sectors who in any case enjoy an 80 per cent reduction in liability for the CCL. This effectively reduces the value of the CCL exemption for CHP plant.

We must also take into account the most recent rounds of electricity market reforms, and these, in practice, work to considerably reduce the income of CHP plant and discourage them from exporting electricity. This occurs because all plant that trade on the electricity wholesale markets must comply with the terms of the balancing and settlement code (BSC). The administrative work required to do this, in addition to the fear of penalties that may follow defaulting on pre-announced output, dissuades CHP plant under 50 MWe from complying with BSC.

There is a common belief that 'consolidator' services, through which 'consolidator' companies buy power from several small plant and pool the output (treating them as negative demand), overcome the aforementioned problem. We do not doubt that consolidators generally increase income for CHP compared to the 'in house' electricity supplier, but our research suggests that the CHP plant still lose money compared to the prices large power stations receive for their electricity sales on the wholesale market. Analysis of typical examples used in our research suggests that **even using consolidator services, small (say 3 MWe), CHP plant will lose around a quarter of their income for exported electricity compared to the value of electricity sold by conventional power stations to power exchange markets**.

We have modelled the optimum economic size for a 'typical' community CHP plant using electricity export prices similar to that earned by large power stations. As can be seen in Figure 2 in the Appendix, if CHP plant export their electricity and use thermal stores and are paid the same for electricity as conventional power stations then the optimum economic size of the CHP plant increases considerably. This increase in size is from 3 MWe to between 4 and 6MWe in the case of CHP plant using thermal stores. Under current conditions of lower export prices and without a thermal store the optimum economic size is less than 2 MWe.

Hence the benefits derived from the CCL exemption and other incentives are likely to be outweighed by the fact that small CHP plant are unable to derive the same levels of income from exported electricity compared to conventional power stations. An additional problem, which has been highlighted by the Combined Heat and Power Association, and others, is that distribution network operators have a reputation of being uncooperative in connecting CHP units with nearby customers. This problem persists despite pilot schemes designed to alleviate this problem.

So how can we encourage CHP and community heating to be deployed in practice? One means is by taking advantage of recent changes in the planning environment. Further measures have been implied by our foregoing research conclusions; the development of CHP plant with thermal stores and also mechanisms to enable small CHP to earn the same levels of income for their exported electricity as earned by conventional power stations. We now turn to consider these various methods of bringing community CHP to market.

Bringing Community CHP to market

Two recent policy changes introduced by the Government have greatly enhanced the possibilities for community heating and CHP. First, Planning Policy Statement 1 (PPS 1) promotes CHP and community heating in new buildings. Second, the 2006 building regulations (Pat l) say that buildings must achieve 20 per cent greater carbon reduction compared to the 2002 building standards. Effective use of the PPS1 provision is patchy so far, but in parts of London spatial development planning is now at the stage where there is insistence that new housing developments must use community heating. CHP is incentivised through the new building regulations. Certainly, activity by NGOs and others to pressure local authorities and educate planning officers and engineers to adopt community heating and CHP will encourage more rapid proliferation of developments. If community CHP is in place in new building developments , and if PPS 1 and the new building regulations are properly enforced, then gas engine CHP using thermal stores can be introduced as a very cost-effective means of meeting the carbon reduction requirements in the revised building regulations..

Currently a very small number (around 5) examples of community CHP using thermal stores exist in the UK. Nevertheless a small number of companies with the expertise do exist to implement this technology, and a number of projects are in the pipeline. **It would be beneficial if case studies of existing schemes and those which are in the planning stages could be prepared and publicised among engineers and planners in local government, commerce and industry.**

Aggregated despatch

Aggregated despatch may allow CHP schemes to gain access to higher electricity prices than is practically possible at the moment. Note: this needs to be sharply distinguished from 'consolidation' where CHP power is aggregated as negative demand. By contrast aggregated despatch involves CHP plant acting together to sell electricity directly to one or other of the wholesale power markets. This would involve CHP plant with thermal stores being co-ordinated (as they are in Denmark) to act as 'big' power stations so as to generate electricity when there are peak power prices available.

When there is a critical initial mass of community CHP with heat stores (say 50 MWe) then full scale 'aggregated despatch' can be achieved. We see no reasons, in principle, why this should not be possible within the context of the present Balancing and Settlement Code. However, demonstrations will need to be conducted to investigate the adequacy of current regulatory arrangements.

Regulatory reform

A regulatory reform agenda could include a measure ensuring that all decentralised power generation (including, perhaps, microgeneration as well as CHP) receives the same sort of payments for electricity exports as conventional power stations receive on the power exchange markets. Such a regulatory reform would bring the UK in line with the EU Electricity Directive 2003/54/EC which proscribes electricity market balancing arrangements which discriminate against particular generators. For example, it is stated:

7. Rules adopted by transmission system operators for balancing the electricity system shall be objective, transparent and non-discriminatory, including rules for the charging of system users of their networks for energy imbalance. Terms and conditions, including rules and tariffs, for the provision of such services by transmission system operators shall be established pursuant to a methodology *compatible with Article 23(2) in a non-discriminatory and cost-reflective way and shall be published.*

In addition to this, regulatory reform is also required to establish transparent, effective rights for small generators to be connected to the distribution network. In general we believe that a ‘rights based’ approach to affording equal payments for electricity exports compared to conventional power stations and also easy grid and distribution connection is a necessary step.

The long term picture – absorbing more renewables

A key long term advantage of having a significant proportion of electricity generated from CHP with thermal stores is that this will reduce the costs of integrating high levels of fluctuating renewable energy sources into the grid. Community CHP is designed to be a flexible mode of generation, responding to changes in demand. Gas engine CHP organised in collaboration with thermal stores allow generation to be started and stopped with minimal losses in efficiency and maintenance problems compared to large conventional power stations.

The existence of large amounts of CHP with thermal stores will allow very large amounts of renewable energy to be absorbed into the grid without increasing economic penalties. This is because CHP with thermal stores are designed, as a system, to come on- and off-line in response to price changes. This flexible system is already being used in Denmark to integrate their large amounts of wind power into the grid, and it is likely to be used more in the future as the proportion of electricity generated from renewable sources increases beyond the present 20 per cent.

This lack of power stations flexibility will not be a problem at relatively low loads of renewables penetration (up to around 20 per cent). However, if, in the long term, the UK wishes to increase the proportion of renewables beyond 20 per cent and at the same time reduce the increasing costs of integrating such amounts, then it will be helpful to have a significant volume of production generated from gas-engine CHP with thermal stores.

The DESIRE Project is funded by the EU’s FP6 Programme. It is a consortium consisting of research and commercial institutions drawn from Denmark, Germany, UK, Spain, Poland and Estonia. DESIRE stands for Dissemination strategy for balancing for large scale integration of renewable energy. We acknowledge the information and advice from our sub-contractors, PB Power. This input has been invaluable to the project.

APPENDIX

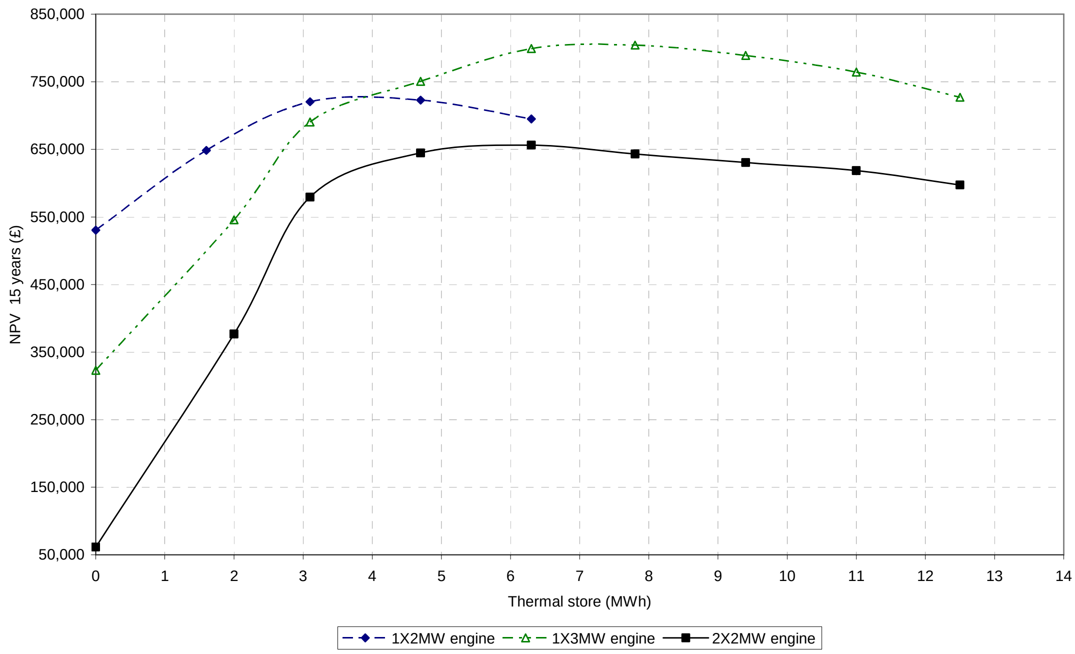

Figure 1: Thermal store optimization study for the UK, using typical **export electricity prices (September 2005-August 2006).**

The optimum plant for a district or community heating load of 20000 MWh per year seems to be a 3MW plant with (7.8MWh or 250m^3) thermal store. The Net Present Value of a 15 years investment assuming 5% discount rate is £ 804,231. **The pay back time is 6.9 years**.

NOTE: **without thermal store, the pay back time for this engine size is 8.4 years,** and the Net Present Value is £323,042.

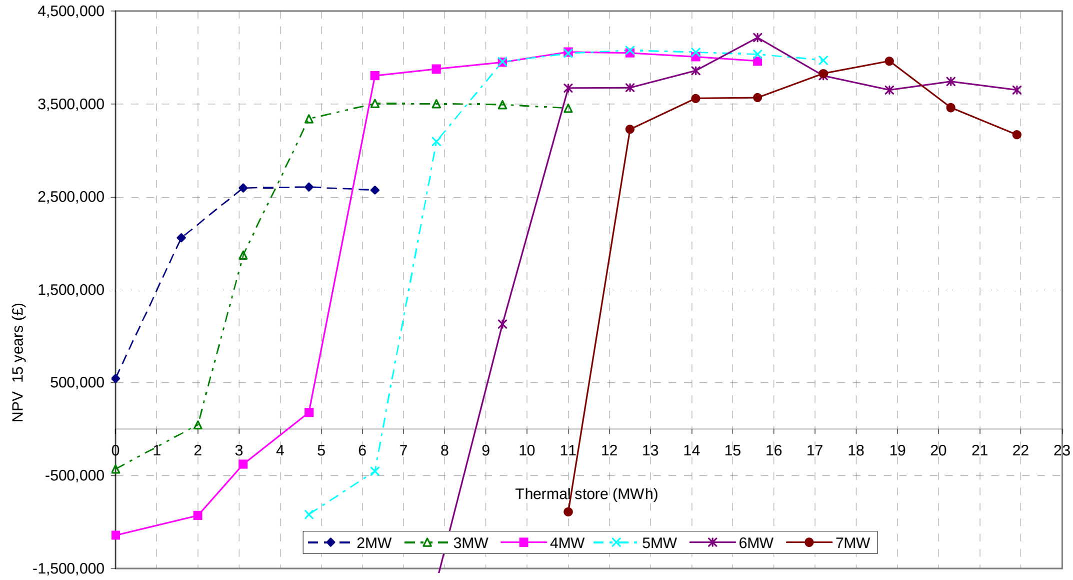

Figure 2: Thermal store optimization study for the UK, using **SBPs (July 2005-June 2006),** as a proxy for the system power exchange prices

The optimum plant for a district or community heating load of 20000 MWh per year seems to be a 6MW plant with 15.6 MWh (or 500m^3) thermal store. The Net Present Value of a 15 years investment assuming 5% discount rate is £ 4,216,324. **The pay back time is 4 years**.

END