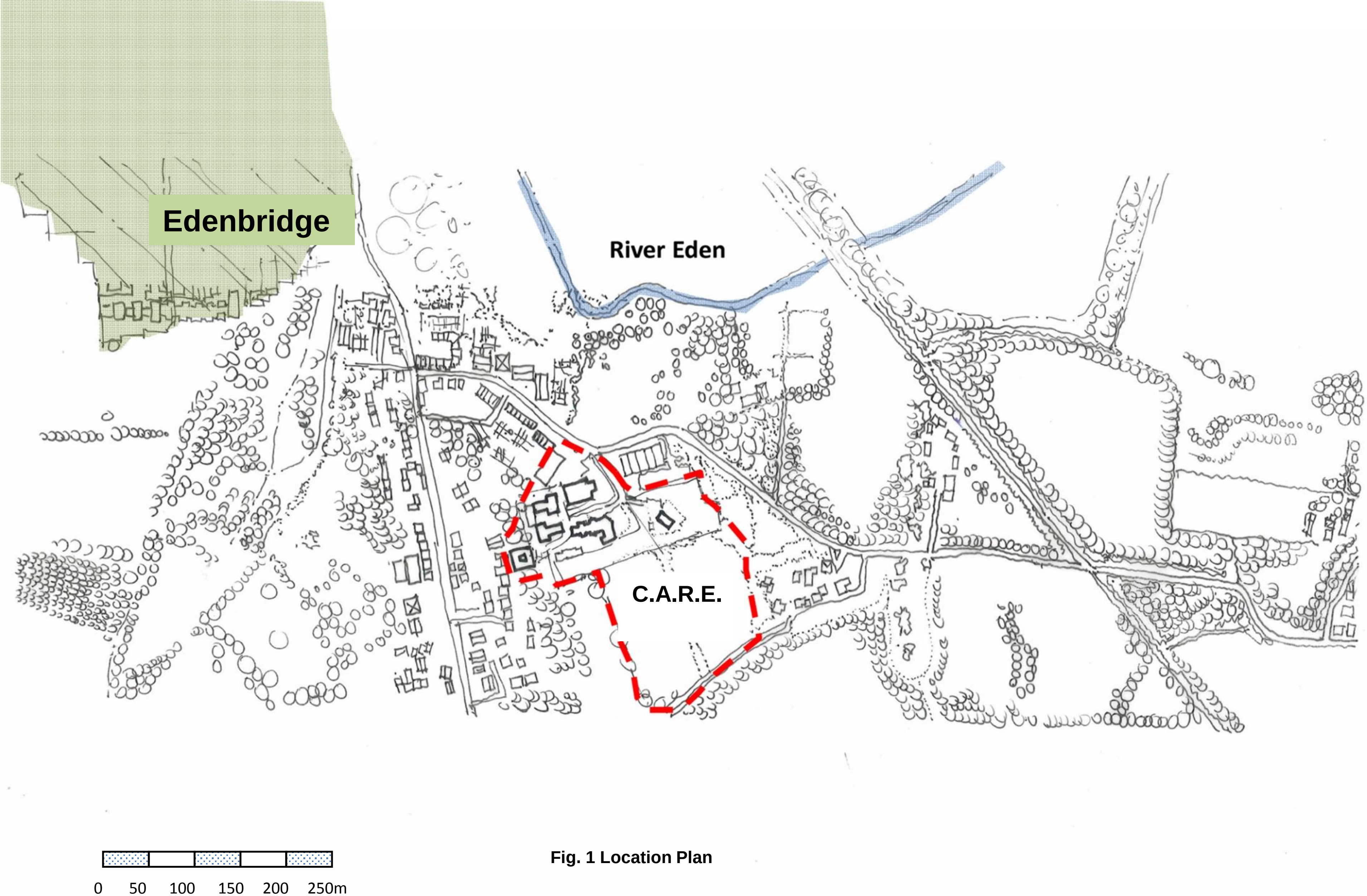

Fig. 1 Location Plan

Eco-Development, Edenbridge, Kent, UK

Eco City – Green City.

Author: Project Architect Michael F. Farragher RIBA . Lecturer in Architecture, Henan University, Kaifeng City, China.

C.A.R.E. Special Needs Community – Kent, UK

Site Area: 10 Hectares

Project Investment Cost. Equivalent to 100,000,000 Chinese RMB

Case introduction

1: United Kingdom introduction to ecological new town – Special Needs Education, Residential Development , Edenbridge, Kent, UK.

The development site is situated on the South East corner of Edenbridge in Kent , approximately 20 km from London in the South East of the United Kingdom.

The development provides independent living for young adults with Learning Difficulties and Mental and Physical Disabilities so that they can live a sustainable and self –sufficient life. The ecological and renewable energy technologies within the buildings provides a way that helps the residents achieve this goal: namely by the reduction of fuel poverty. The facilities provided within the development also encourage this sustainable life-style because here is an emphasis on workshop provision and community interaction by the inclusion of a café and retails area that is open to the public. The crafts and food that are made within the development can be sold to the Edenbridge public and thus forms a avenue for income for the residents.

The development consists of 50 living units, workshop facilities, a horticultural centre and a restaurant. This is achieved within an envelope of 5,650m2 gross internal floor area of residential, retail and workspace spread over 6 buildings. The buildings' are traditionally constructed of masonry, steel and timber and was traditional to the vernacular of Kent which throughout history has developed a unique building typology that has been influenced by Norman, Saxon, Flemish and Dutch architecture with the exception of the horticultural building which is almost entirely formed from ecologically responsive building materials.

Fig 2 . View of Sedum Roof

The choice of building materials is vital in the provision of a fully ecological development. In some projects this goes also extends to the cement specification within the concrete elements. This is worth noting on large developments such as the Chinese Eco-city as the ppfs cements that are used world-wide within concrete are very destructive to the ozone layer and it has been reported in the global press that China have been criticized for the quantity of these reinforced concrete products that it uses. There is an alternative which is a cement that is formed from the waste material from the coal industry. Currently this is expensive to use as it is not adopted extensively throughout the industry although if this cementitious material was used on a large scale the financial efficiency of this cementitious slack coal would be make the product more viable. The use of coal extract cements could be a perfect opportunity for China to silence its critics together by providing a better image for the coal industry by using recyclable materials to reduce carbon emissions elsewhere.

The cement that coal slack produces is certainly less harmful to the ozone layer when used within curing concrete in large quantities although in the case of the Edenbridge development there was not an opportunity to use this type of cement on this size of development and a locally produced concrete block products which had good embodied energy properties.

Initially the site posed some difficulties due to the location of a river nearby ; the Eden. This was prone to flooding and after consultation with a flood engineer it was decided that a flood mitigation barrier was needed in the form of a holding pond so that waters from the development site could be controlled before being released into the river.
At an early stage the client, which was a national Special Education Needs Development Charity called C.A.R.E. decided that they wanted a fully ecologically responsive solution to the project. The final result was a development that would have attained Level 5 in the Code for Sustainable Codes model (this is a residential code that is similar to L.E.E.D. ratings).

The main workshops were heated by a 24kW Ground Source Heat Pump which takes heat out of the Kentish clay and distributes a mixture of Glycol solution through slinky connection pipes to a heat exchanger pump within the building. This provided a low level temperature underfloor heating during the daytime by the means of an underfloor heating system.

Electrical power was provided by the use of two wind turbines, that were both 6kWp power. The development was arranged so that the wind turbines would obtain maximum efficiency from the open countryside in the direction of the prevailing winds to the south west. These provided a D.C. current that is then inverted at the meter position to an A.C. current to provide electricity for lighting and power.
At the time of construction the UK had a Renewable Obligation Certificate system (ROCs) which was controlled by government regulated renewable power generation meters. These meters could check the amount of electrical power that the development is producing and then the owner could claim back the cost of the power by the use of R.O.C.s which ,for wind power at the time in the UK , was in the region of 17-18 pence per kW.

The other renewable energy systems in the development included Solar Thermal panels which provide hot water for the bathrooms. This was achieved by flat plate collectors on the vertical side of the buildings walls orientated to the south. Although the development is small in terms of comparison with the Chinese Eco –City program, the principle of the combination of technologies is the same.
The Ground Source Energy station in the United Kingdom runs by the use of Heat Pumps in order to pump the glycol liquid through the ground pipes. This takes heat from the ground and can also put heat into the ground in order to cool. The pump itself runs on different size motors. The one that was used at Edenbridge is a 24kw system which is relatively small but whether 24Kw, 100Kw or 500Kw there is an amount of electricity needed to run these units.

The success at Edenbridge was in combining the Wind Turbines which powered the Heat Pump for the GSHP. On a larger scale the efficiencies of these combinations would become even better. Within the Eco-City program in China, combined renewable technologies, both in the form of Ground Source Energy (GSE) and Combined Heat and Power (CHP) stations on the microgeneration level would produce better efficiencies.

It is worth referring to the importance of genus locii in the choice of GSES technologies within large scale urban planning projects The use of natural geological features within the sites for Eco-City is vital. The locality of rivers, mountains, ground conditions, sewerage systems, pollution, air quality and annual temperatures will all have a part to play in the design of the energy station. Multiple sources can be used to obtain heat. Ground drilling can be combined with heat the from lakes, rivers or sewerage or waste heat from air-conditioning systems. The evidence of useful amounts of heat within the earth's surface and the capacity of the earth to store heat are well documented. Even on a cool winter's day, miners who chisel away at gold veins exposed in tunnels 3.5km below the surface swelter in temperatures of about 53° C. At the upper part of the crust of the earth, the Geothermal gradient averages between 15° C and 50° C per Km. Quite possibly, other than the Sun itself, the Earth is the biggest battery of them all.

At Edenbridge, Kent the planning policies by the UK government requested that several environmental reports be completed. These included, acoustic and aeronautical reports for the Wind Turbines, a Geothermal Capacity test report, and a rainfall Hydrocarbons test (this was due to the fact that a rainwater –harvesting system was installed so that pressure on the national drainage system could be alleviated. The rainwater –harvesting system provided a constant supply of Level 2 (UK Coding for water quality). This water was used to flush toilets and water plants. The water that was collected from car- parks and roofs had to be double filtered by vortex units that took harmful hydro-carbons and toxins out of the water.

Fig. 3 View looking east from Day Centre to Horticultural Building

The rainwater harvesting system also worked well with the use of a Sedum roof to one of the buildings which combined with other ecologically sourced materials. The green (Sedum roof material) was originally a green seedling plant that was laid in mats onto an impervious substrate. The sedum roof also works well in water preservation as the roof can hold a large quantity of water . Prior to the current economic crisis the UK government offered tax concessions for developments that contained S.U.D.S. drainage systems such as the one at Edenbridge. This refers to Sustainable Urban Drainage System and encourages the holding or self drainage of waters within the development site itself either through the use of Reed beds, Sedum Roofs , holding or septic tanks in order to reduce pressure on the national drainage system.

The detail design of the roof membrane at Edenbridge allows the rainfall that soaks into the Sedum a chance to evaporate so that the stress on the surrounding drainage system reduces. It also gives the additional benefit of being excellent in ecological camouflage. The horticulture building in question blended in superbly with the rural surroundings.

The structure of the buildings was based on a standard masonry system with FSC (Forestry Stewardship Council) rated timber external frame with a Glulam and Plywood Kerto S joisted roof. The insulation within the walls was provided by a recycled wood pulp board. The reduction of condensation within the roofs was achieved by the use of a Warmcel pumped Cellulose fibre insulation. This is produced by the recycling of newspapers.

The success of the renewable energy science within the building also achieved some positive social advantages in that young adults who usually remain with in institutions within the UK could now become self-sufficient both financially in terms of fuel bills and also and by producing simple goods and food for sale within the workshops and restaurant in order to supplement their income. This also led to a better way of life for them to have contact and inclusivity with the local community of Edenbridge.

Analysis.

Although the development was small in terms of comparison with the Chinese Eco –City program, the principle of the combination of technologies is the same.

The Ground Source Energy station in the United Kingdom runs by the use of Heat Pumps in order to pump the glycol liquid through the ground pipes. This takes heat from the ground and can also put heat into the ground in order to cool. The pump itself runs on different size motors. The one that was used at Edenbridge is a 24kw system which is relatively small but whether 24Kw, 100Kw or 500Kw there is an amount of electricity needed to run these units.

The success at Edenbridge was in combining the Wind Turbines which powered the Heat Pump for the GSHP. On a larger scale the efficiencies of these combinations would be even better. On large scale projects such as the Chinese Eco-City program , combined renewable technologies, both in Ground Source Energy Stations and Combined Heat and Power (CHP) stations on the microgeneration level would produce better efficiencies.

The use of natural geological features within the sites for Eco-City is vital. The locality of rivers, mountains, ground conditions, sewerage systems, pollution, air quality and annual temperatures will all have a part to play in the design of the energy station. Multiple sources can be used to obtain heat as mentioned above. Ground drilling can be combined with heat the rom lakes, rivers or sewerage or waste heat from air-conditioning systems. The evidence of useful amounts of heat within the earth's surface and the capacity of the earth to store heat are well documented.

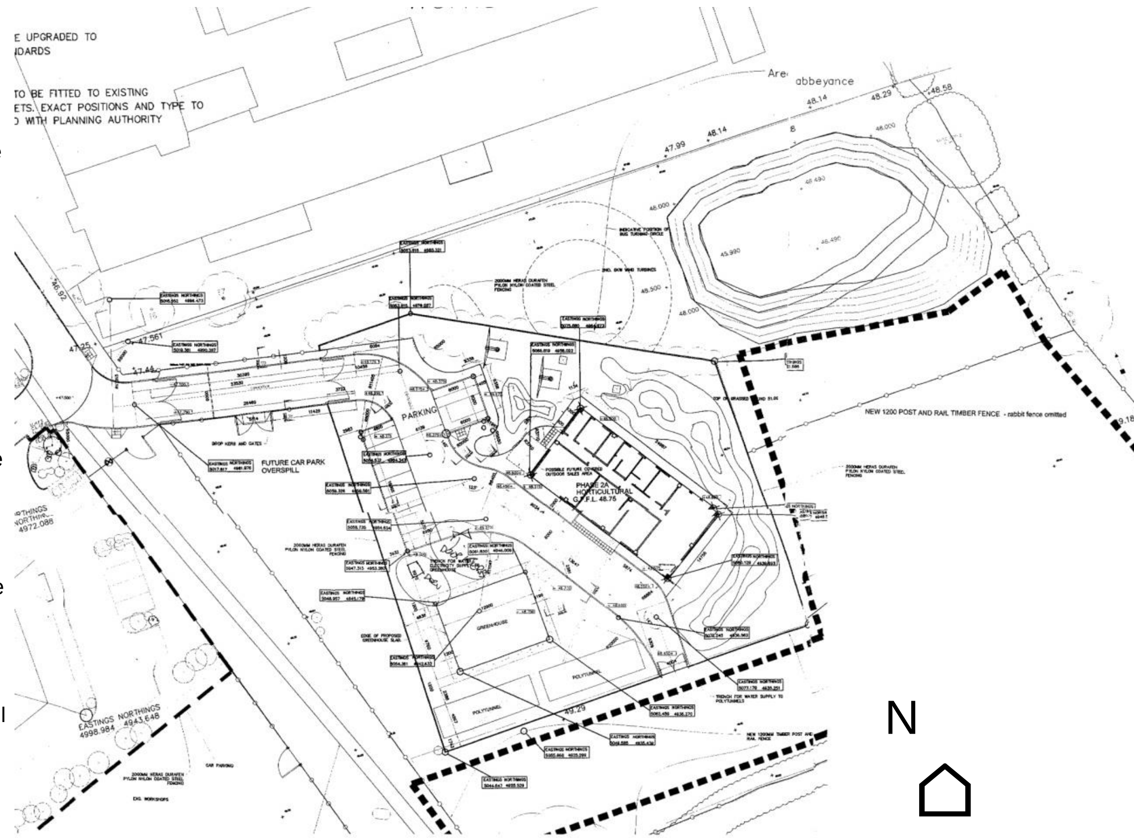

Fig. 4 Horticultural Building Site Plan

A major factor in the design of the system was that the site was originally 10 Hectares of farmland that was owned by the C.A.R.E. Trust and they had the luxury of having more land that they needed in reference to the number of inhabitants in the development. Also the ground itself in Kent is a soft clay which was perfect for shallow trench technology in which a plastic tubular coil is layed horizontally for 50-100m lengths and then – these are called ‘Slinkies’. It was determined from the Thermal Capacity test which was part of the original site borehole test, that a 24kW heatpump system was sufficient. The cost of this system including Heatpump, Controls, Underfloor heating coils and Slinky trench coils was, the equivalent of 1,000,000 Chinese Yuan based on installation in the UK construction market. (like popular science knowledge).

After the installation of the Slinky pipes within the ground and their connection to the Ground Source Energy Pumps in the building the system is charged with a Glycol solution. The solution has a lower boiling point than water and is more sensitive to the absorption of energy from the ground. The energy of the Kentish clay allowed a better efficiency than the rock strata at a lower depth. The fact that the Client had a surplus of farmland in the area, led to the conclusion that the Slinky system would be the most efficient system. It was determined that the added cost of the system compared to the installation of a standard Low Pressure Gas Heating or Electrical AC system would be regained in reduced energy bills within 7 years. There was a conscious decision made to combine multiple renewable technologies. The UK government renewable investment policy at the time encouraged the Client to choose multiple renewable technologies. One technology offsets and helps the other. The use of a 24Kw wind turbine system in this location both powered the pump within the Ground Source Energy system.

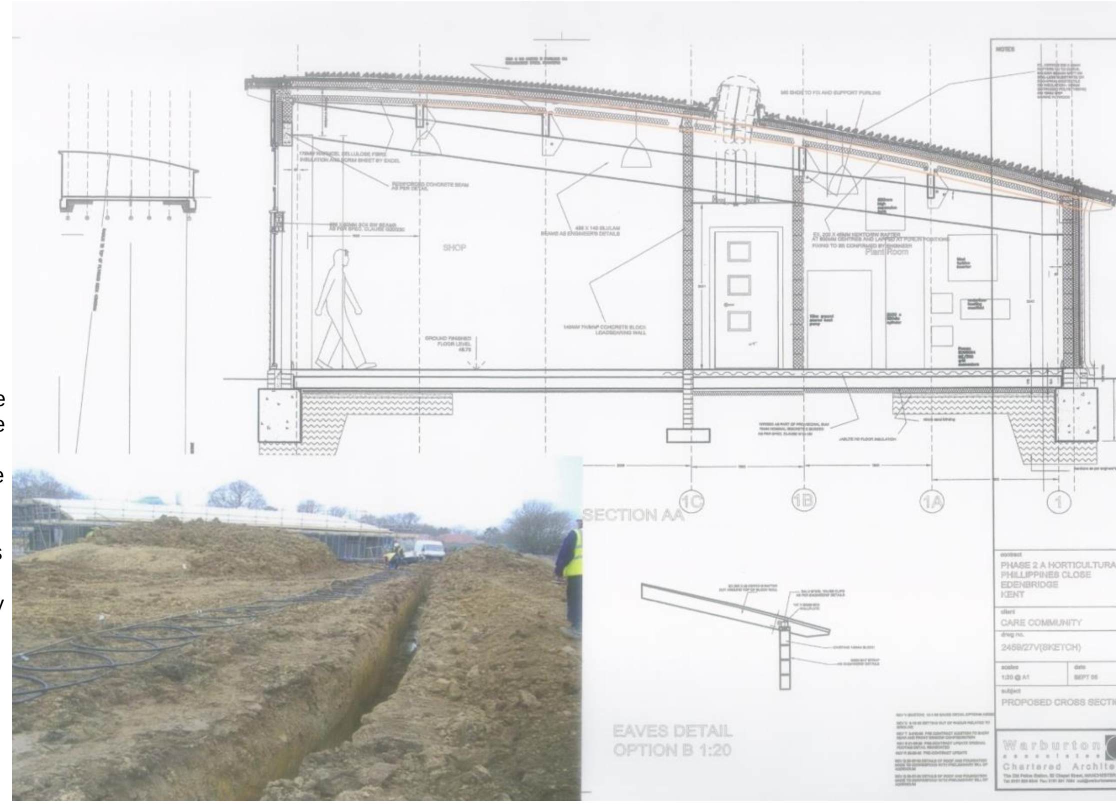

Fig 5. Cross-section of Horticultural centre

The selection of this technology was also based on the exposed nature of the site on a high level above a wind-swept country plain. In surplus wind the wind turbines produced enough energy i.e. 24kW peak per hour, which powered the heat pumps, lit the building and also light either the day centre in the day or switched over light and some of power some of the residential blocks in the night-time. This was achieved

by the inverters within the horticultural building which were linked to all 6 blocks. The cost of electricity and gas within Kent was used as a comparative. Electricity in Kent at the time cost the equivalent of 3 Chinese RMB per kW and Gas cost the equivalent of 2 Chinese RMB per kW. Therefore the running cost of a Ground Source Energy system in this location compared to a LP Gas Heating system was financially better for the inhabitants. Similarly if a Ground Source Energy system was used on a larger scale within the Chinese Eco-City this would work even better. An Eco-City development based on units of 30,000 sq. m of development within each city, could generate electrical power as well as cooling from Ground Source Energy Stations . It is worth noting that Ground Source Energy Stations (GSES) work slightly differently to Ground and Air Source Heat/ Cooling Pumps in that these can power electricity turbines as well as directly cool on a district cooling system basis. This technology has already been widely used in the US, Canada (Vancouver Olympics), China and Korea on large developments. In these countries the financial benefits are even better as most of the cooling systems are currently run on direct electricity rather than micro generation technologies.

- On a smaller scale than Eco-City, the Edenbridge development proved that the usage of the buildings was a vital factor in the correct renewable choice of technology. A single family house or a series of apartments are not necessarily going to benefit from on its own from an investment for renewable systems. The combination of other building typologies such as leisure, healthcare, and education with residential can be the catalyst in terms of usage efficiency. An example of this is the amount of electrical energy that it takes to switch on and off the Ground Source Energy Station. This is inefficient if there is thermostatic cut-off control. As residential properties are not usually used in the daytime as much as public buildings, it is better to divert usage during the day to other buildings within Eco-City. At peak-usage during the year cooling will be required in the daytime within public buildings as direct cooling although power can still be stored from the system for the evening power for the residential properties. In this way the use of Ground Source Energy Stations for Eco-City is even more efficient than the stand alone Ground Source Heating or Cooling for smaller developments, as there will be a 24-7 need for energy from the collection of buildings in one development. One residential block could contain a Gymnasium and Swimming Pool which is ideal for heat recycling. One residential block could contain a school which is in peak use in the day and sometimes has an evening community facility. Certainly in the UK currently schools are trying to market their facilities in the daytime more often so that a private revenue by each school can be achieved.
- Although there is an exciting global potential in the use of these technologies, each site must undergo a thorough investigation in order to determine the thermal capacity of the ground in the choice of micro generating technologies. The efficiency of the system is also a vital factor in obtaining investment for the project as the calculated average energy generation during an annual period has to be proven to be meet efficiency markers so that government funding could be secured. The funding of this part of the development also effected the detailed design of the building and indirectly the costing for the whole project.
- With respect to the procurement of the ground source energy system, the regulations for the application for government investment gave markers for what technical design information was required and this initially took the form of a ground capacity test and the requirement that a specification and a tender cost should be given by three specialist contractors that were registered installers under the Low Carbon Buildings Programme. This was the UK government body that controlled investment for renewable energy installations.
- The contractual arrangements for these specialist contractors was the responsibility of the project architect . There was a necessity to make clear to this select list of contractors that the choice of contractor was to be determined by the government investment body in their acceptance of the proposal application.
- Currently there are large applications being researched in China as a business model. There are foreign countries that are vying for a type of Private Finance Initiative for the installation of Ground Source energy station for combined heat and power. The main difficulties that will arise are how to monitor the energy use of each individual tennant so that accurate payback can be made. This can be carried ou with simple metering but the meters installed shold take account of future political policy change which may allow credits for reduction in carbon. Meters that can determin how much Co2 saved by each tennant.
- tennant wil be vital. The fixing or likewise opposing fluctuations in tennants energy costs per kW shold be clarified in contracts prior to letting as changes in payback rates for the initial PFI investment from overseas consortiums can be diificult to manage.

Fig 6. View of Wind Turbines

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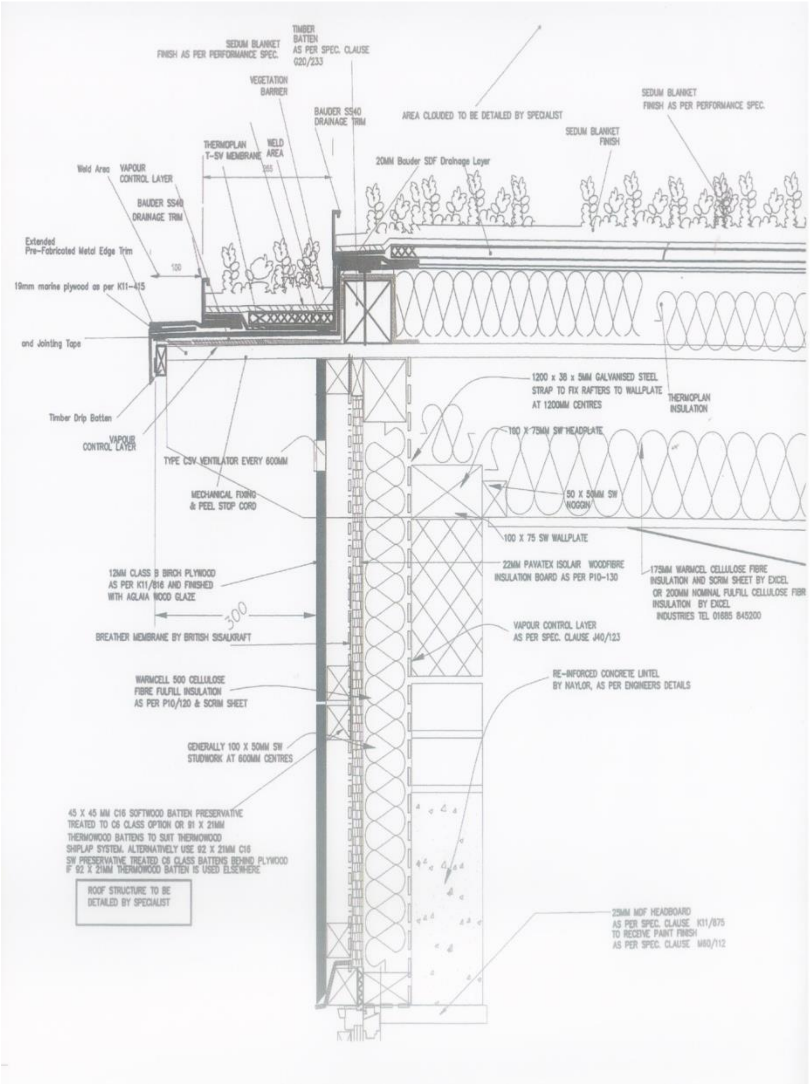


Fig 7. Section through Sedum Roof

Fig. 8 Performance Summary

Type	kWh /m2 /annum	Electric Cost (£)/per quarter	Gas cost (£)/per quarter	Total Cost (£)per/ quarter	CO_2 emissions (kg/m^2/ annum	Construction cost (£)
Edenbridge Development	80	180	180	360	1325	1700/m^2
Typical Similar Development	270	540	632	1172	9000	1500/m^2
Savings	190	480	552	1032	8675	-200/m^2

Fig. 9 Embodied Materials Energy Summary

Building Element	Description	Embodied Energy	U Value
Walls	Concrete block structure with FSC rated with timber framed outer leaf or cavity was filled with Pavatex wood pulp insulation. External cladding of Finnforest heat treated wood paneling.	Offset with travelling distance of other materials. Blocks and flooring made locally.	0.21 Wm^{-2}
Floor	Insulated floating concrete screed on concrete beam and block with under floor heating.	Offset with travelling distance of other materials	0.18Wm^{-2}
Roof	Bauder Sedum Extensive Roof on Plywood deck on Plywood and Steel Structure. Finnforest Kerto S plywood beams and FSC rated timber rafters.	Negligible	0.13Wm^{-2}
Window	FSC rated Meranti hardwood low –e (emissivity) glazing with 28mm argon filled hermetically sealed gap.	Negligible	1.5W^{-2}

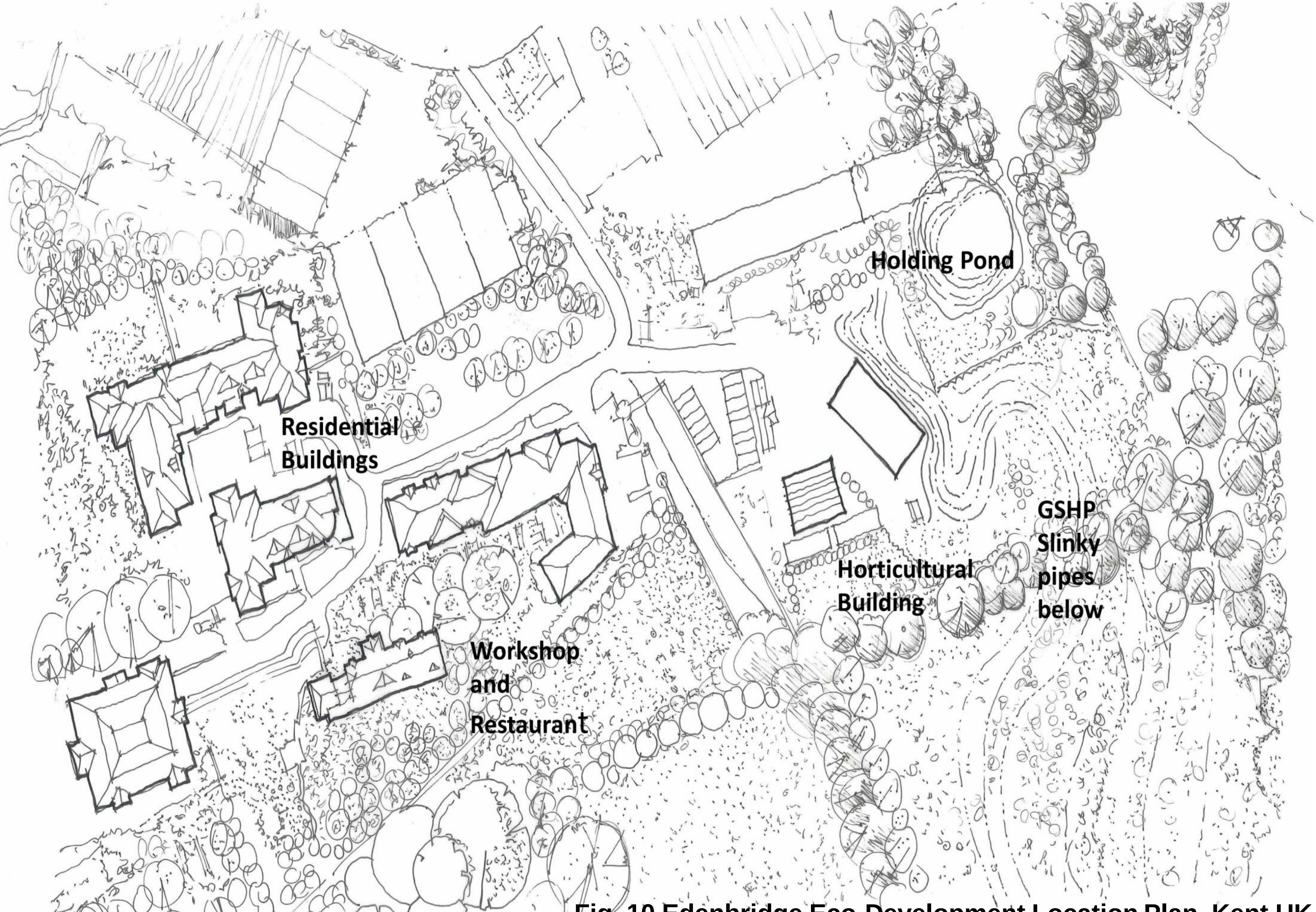
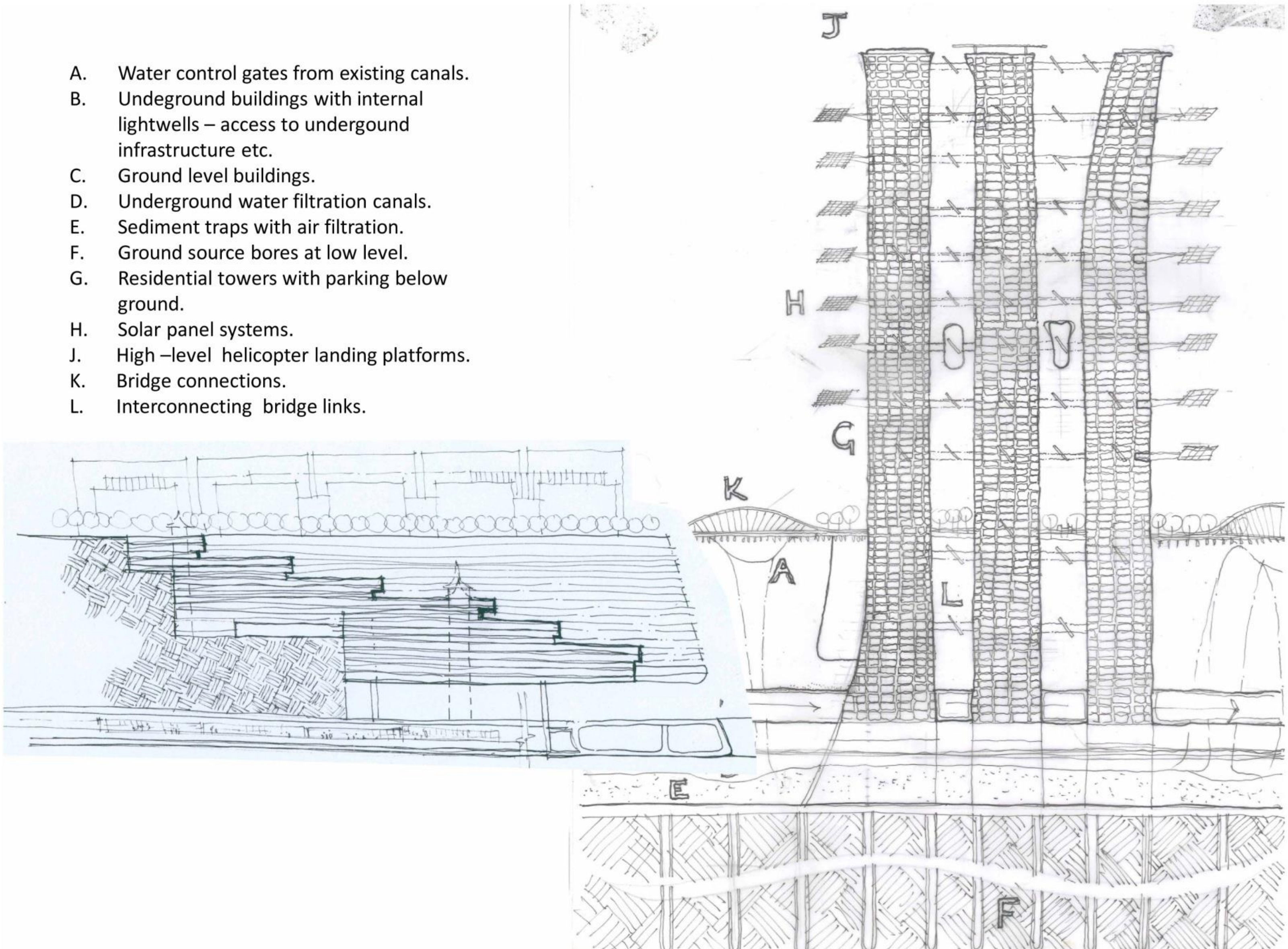


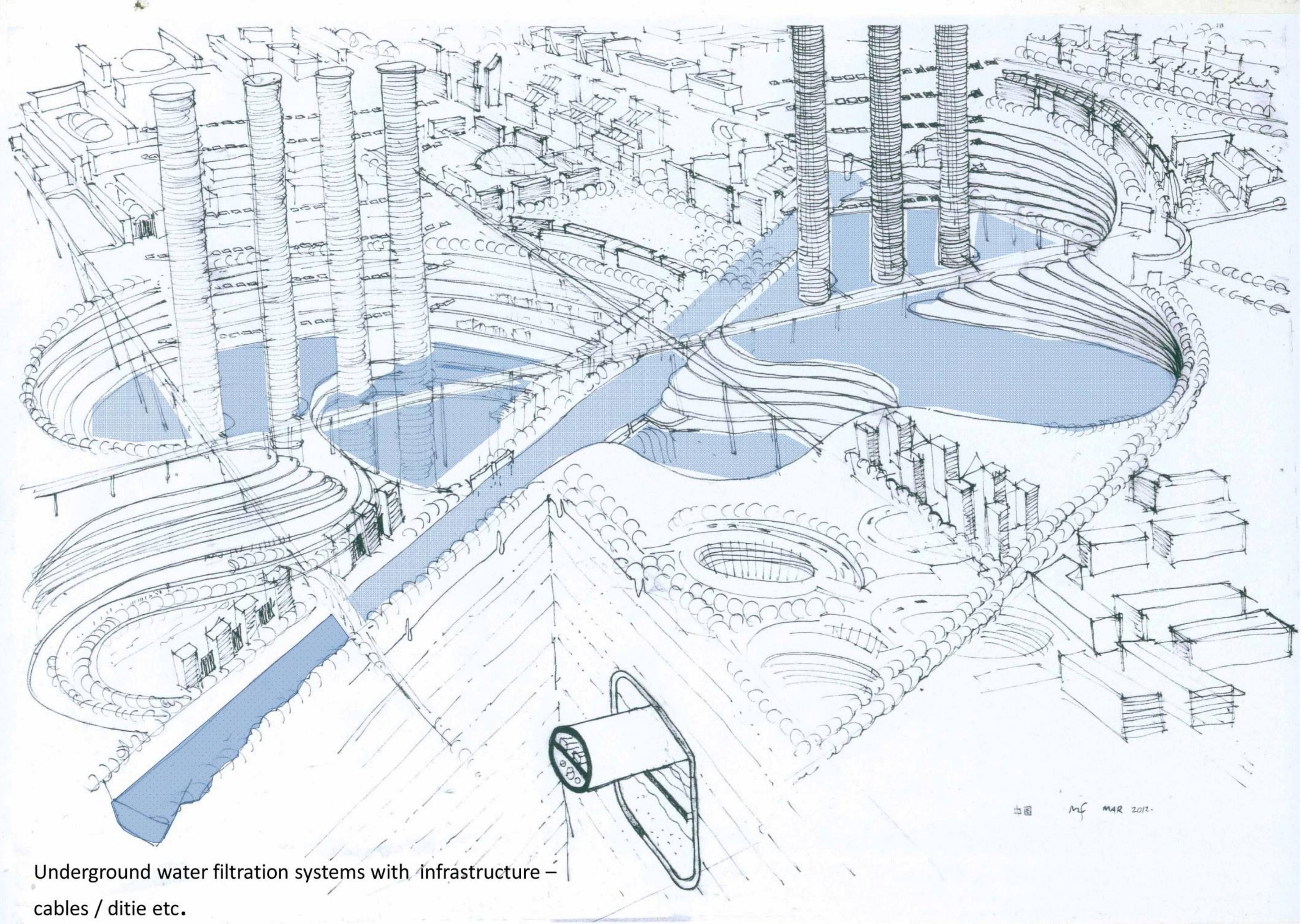
Fig. 10 Edenbridge Eco-Development Location Plan, Kent UK

A. Water control gates from existing canals.
B. Undeground buildings with internal lightwells – access to undergound infrastructure etc.
C. Ground level buildings.
D. Underground water filtration canals.
E. Sediment traps with air filtration.
F. Ground source bores at low level.
G. Residential towers with parking below ground.
H. Solar panel systems.
J. High –level helicopter landing platforms.
K. Bridge connections.
L. Interconnecting bridge links.



Example of Ground Source Energy Station integration in large -scale Eco-City such as Zhenzhou,

Henan Province



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