Renewable Energy Solution Using building foundations It's a no brainer!

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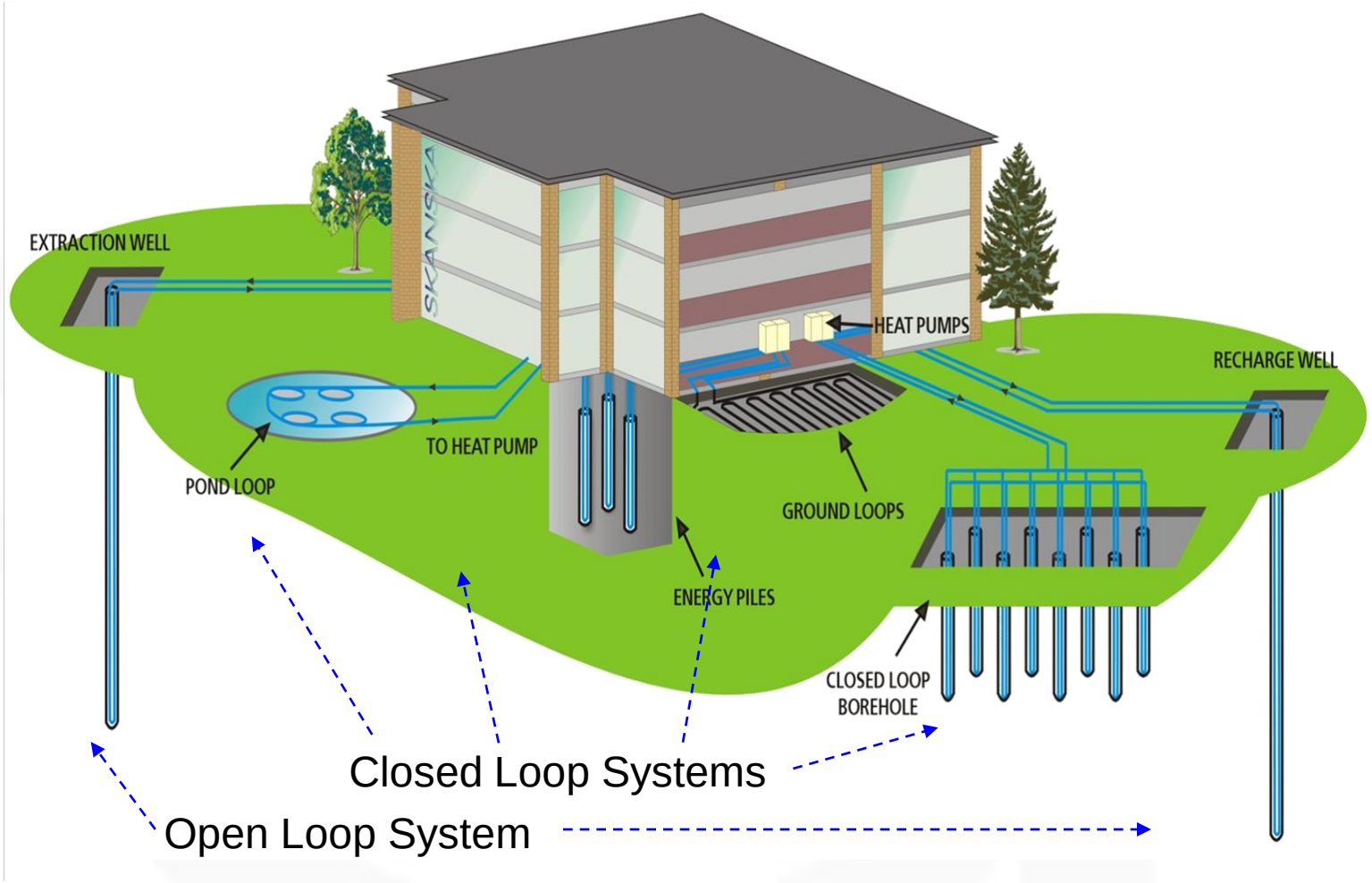
- What and Why
- Planning
- Ensuring Good Practice
- Examples
- Long term Monitoring
- Conclusions

Primary circuit options for GSHP systems

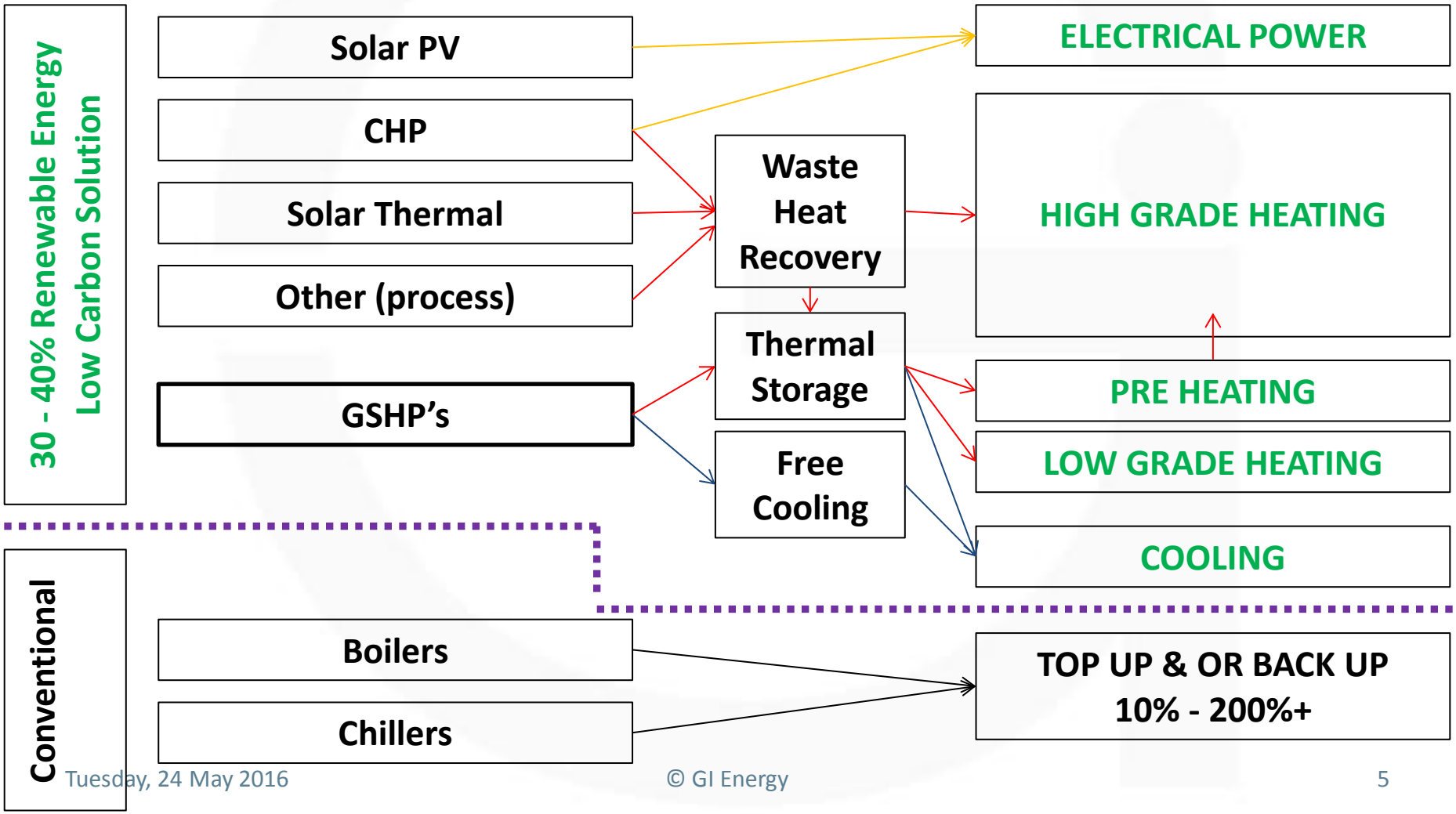


Systems can be combined to give optimal solution

- Lower operational costs
  - 4 times more efficient than gas fired boilers
- Reduced CO2 emissions
- Enhances benefits of other renewable solutions
- Reduced plant room requirements
  - units can provide heat and coolth
- Advantage for BREEAM / LEED buildings
- Attracts Renewable Heat Incentive
  - which can offset higher capital cost of installation
- **Provides a Stable & Sustainable renewable energy**

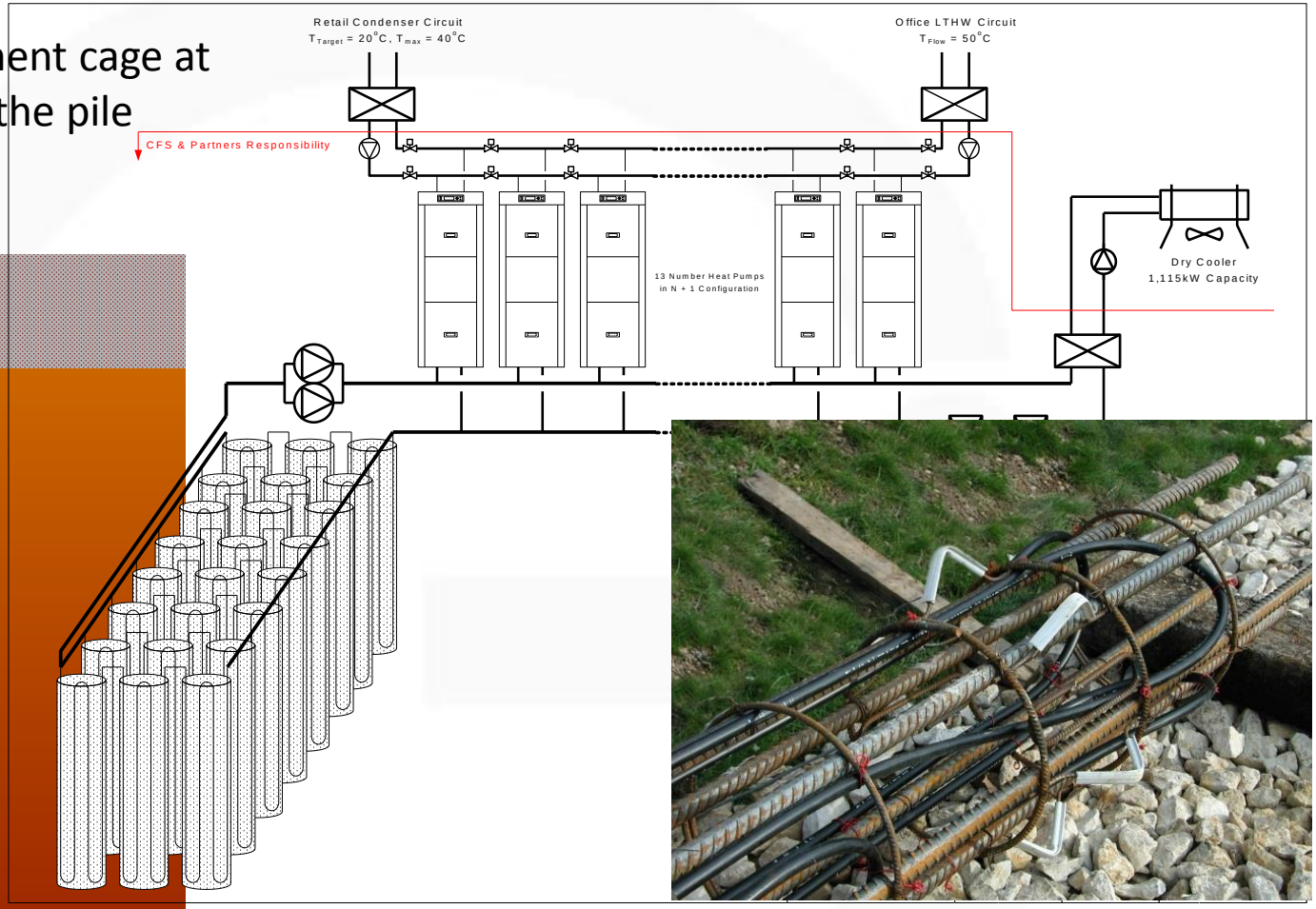
GI ENERGY
Supply & Management

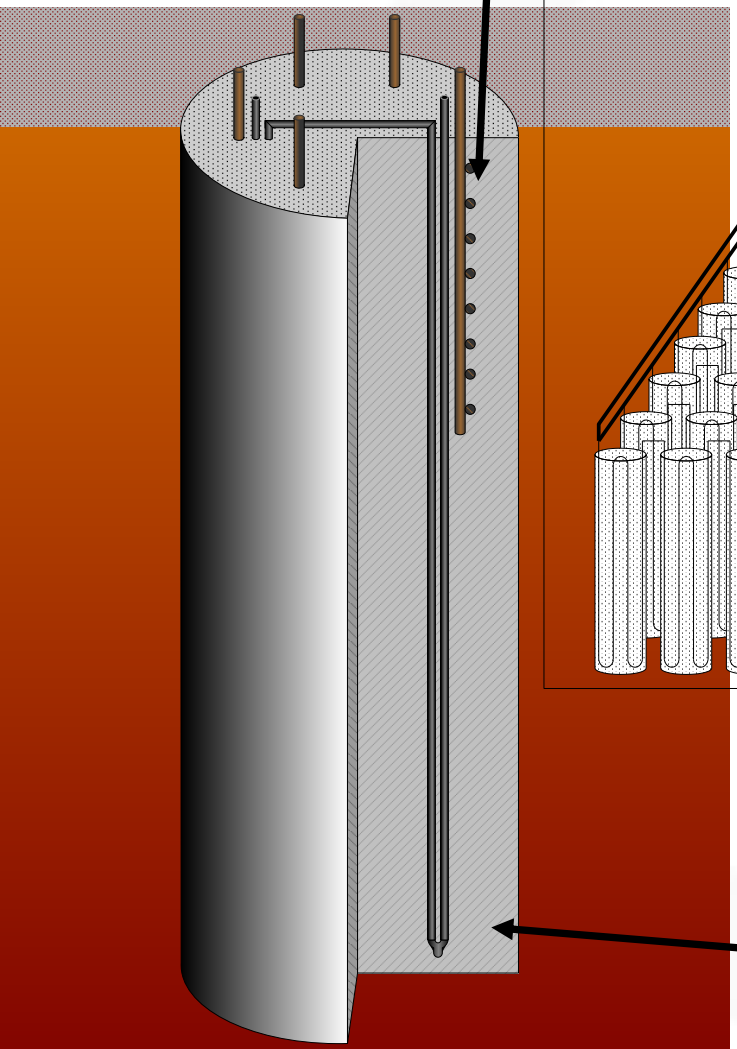
Aim
Long Term System Optimisation
Maximising CO2 & Run Cost Savings



What is an Energy Pile

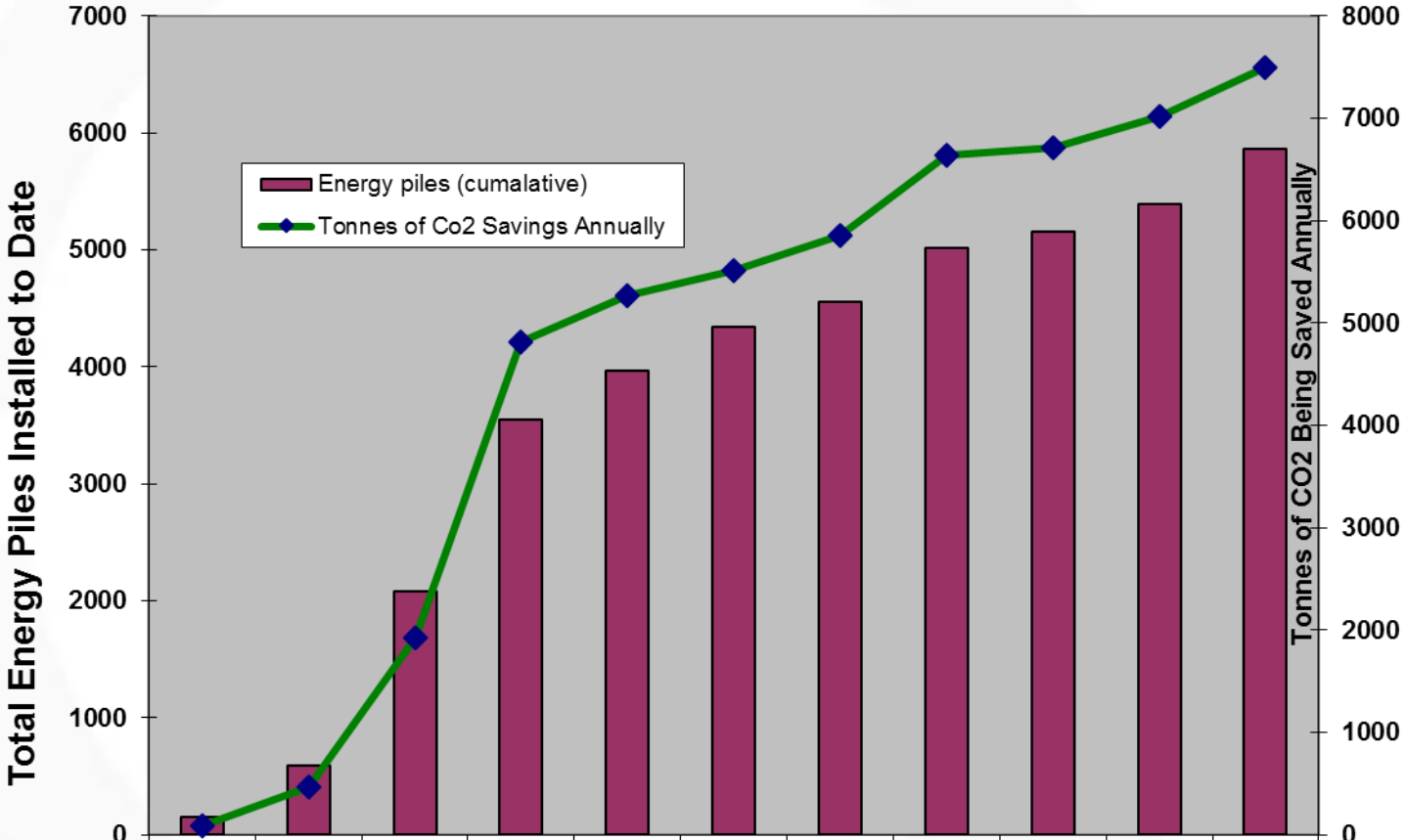
Reinforcement cage at top of the pile





Geothermal loops generally installed full depth of pile to maximise geothermal energy

Energy Piles Installed In The UK & Resultant Annual CO2 Savings To Date At Dec 2015



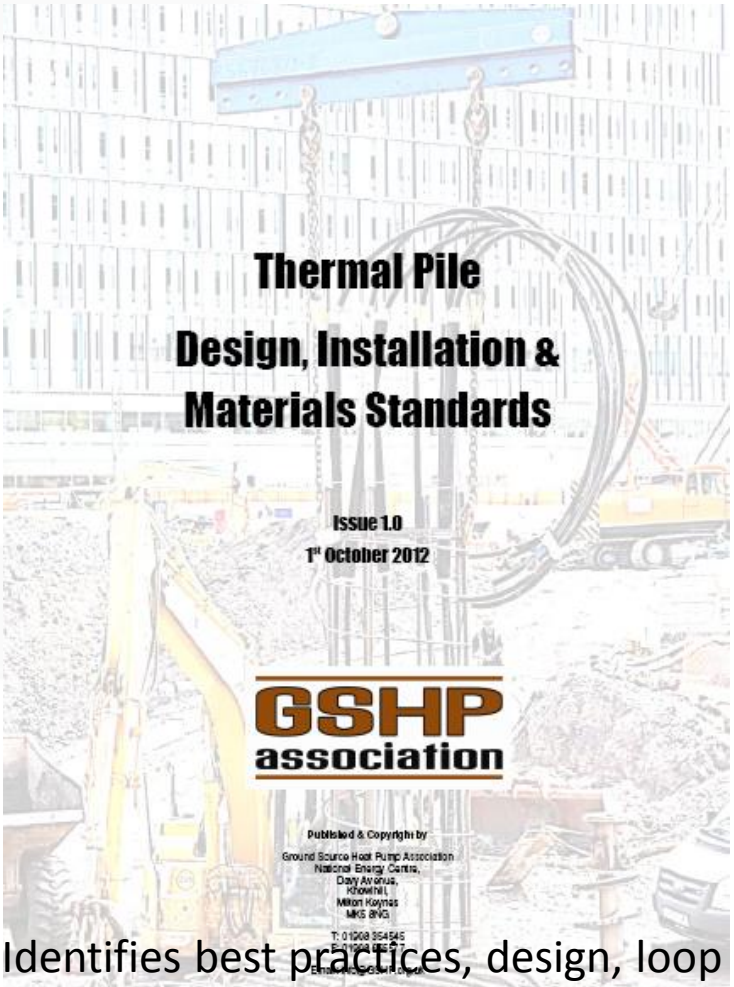
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Energy piles (cumalative)	150	590	2085	3552	3967	4339	4554	5012	5157	5397	5863
Tonnes of Co2 Savings Annually	92.8	467.2	1930.24	4809.0	5267.8	5513.3	5857.92	6640.64	6717.64	7018.44	7499.08

Year

1. Utilises the proposed new building foundations
2. No additional activity to add on to the critical path
3. No programme implications
4. Better solution than conventional ground loop solutions
   - Economically
   - Provides a better thermal storage device than conventional ground loop enabling greater system out performance in the long term
5. Building protects loops from being damaged by future external works
6. Enables future expansion of property

Publications Substantiating Use of Energy Piles:

1. The Effects of Heating and Cooling energy piles under working load at Lambeth College UK 2007
2. Energy Pile Test at Lambeth College London: geotechnical and thermodynamic aspects of pile response to heat cycles – Geotechnique 2009 Peter Bourne Webb et al
3. Integrating Thermal Loops into Diaphragm walls of Knightsbridge Palace Hotel 2009
4. Thermal Conductivity Evaluation of a pile group using thermal conductivity Tracy Brettman 2011
5. Thermo- Mechanical Behaviour of Energy Piles - Geotechnique 2012 Binod Almatya et al
6. Energy Pile Performance and Preventing Ground Freezing – Fleur Loveridge et al 2012



Identifies best practices, design, loop installation, laboratory testing, & field testing

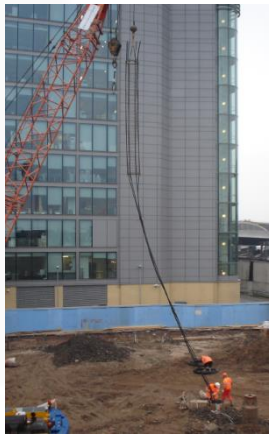
UK Thermal Pile Standard

Can be purchased from www.gshp.org.uk/shop.html

Geothermal Loops Have Now Been Installed Successfully In All Foundation Types

- Small / large diameter bored piles –

  Westminster Academy / One New Change
- Piles under bentonite or dry bore – Bankside London
- CFA piles - Canterbury University/ Belfast Police station/ Crossrail Depot
- Driven Cast In-situ piles. North Kent Police Station
- Driven Precast Piles – Balmore Glasgow
- Diaphragm walls - Bulgari Hotel Knightsbridge / Crossrail Stations



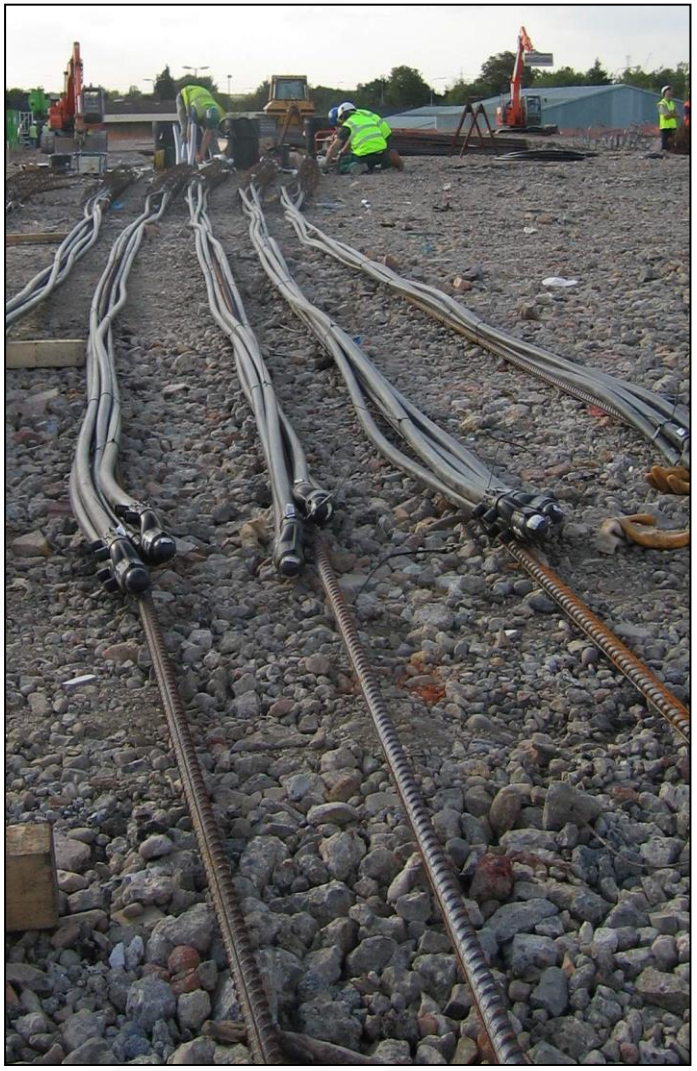
1. Understanding responsibilities
2. Introduction of loops into the pile cage
3. Effect of the piling technique
    a. Rotary piles
    b. Driven cast in situ piles (DCIS)
    c. Continuous flight auger pile (CFA)
4. Protection to loops
5. Ensure loop Integrity

Understanding responsibilities

- Contractual relationships : potential limitations
- Agreement of scope and responsibility
- Importance of coordination
- Evaluating critical points (installation and connection levels)
- Consider any system redundancy (who is assigned the redundancy) and any fall back plan.
- Consider your risk assessment throughout the process

- Cage placed in an empty bore before concreting
- Loops can be suspended below the cage
- Steel at base is required
- Care to be exercised if using a tremmie

- Cage placed in an empty bore
- Loops attached through cage onto full length heave steel bar



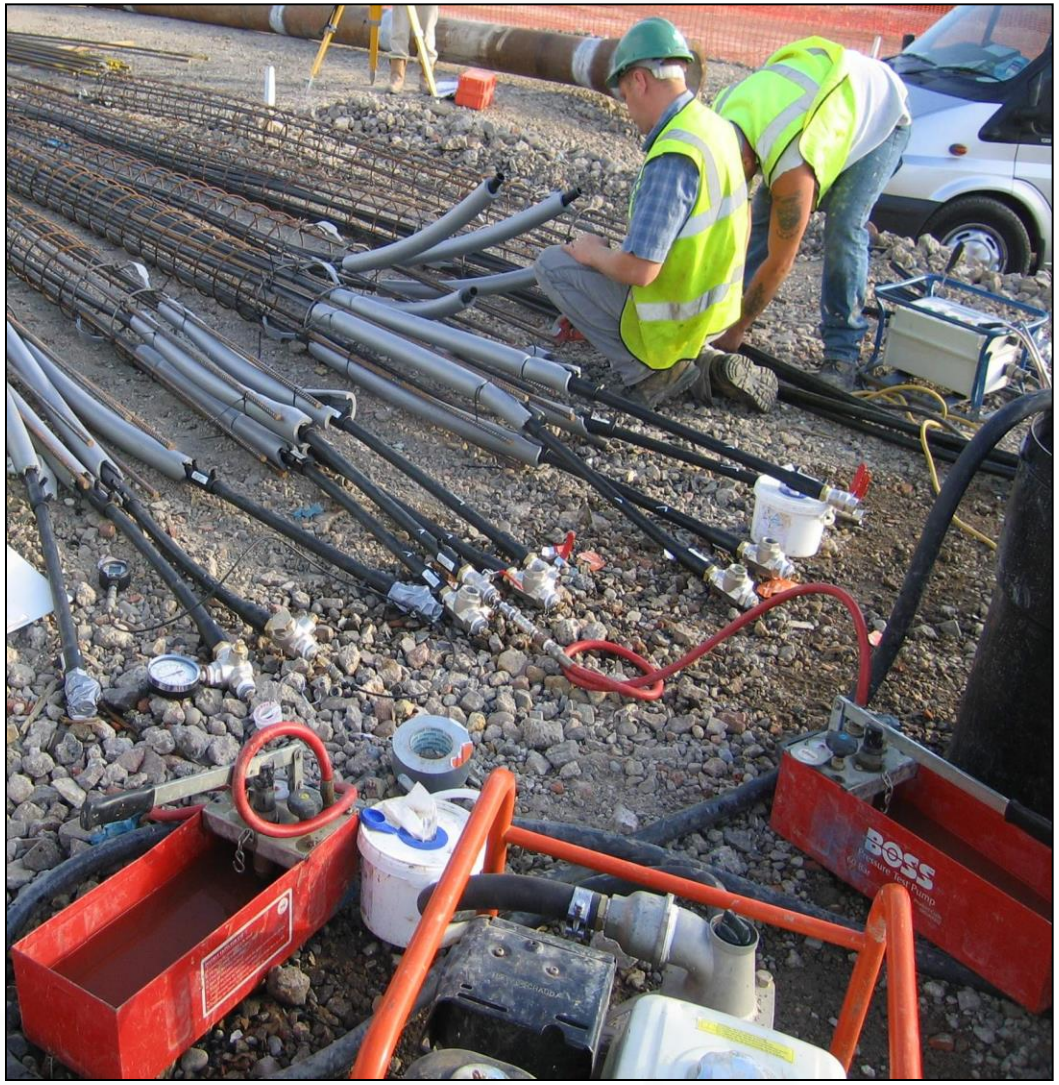
- Fluid Concrete
- A Single bar, rigid enough for the depth
- Spacers
- Use a vibrator if required – no mechanical surging

Protection to loops

- Foreign objects internally – block all ends
- Protect with foam or steel to prevent mechanical damage from pile trimming
- Dialogue with groundworker
- Protection from other trades

Ensure Integrity

- Install full of water
- Preferably under pressure
- Testing involved for acceptance at every stage and handover

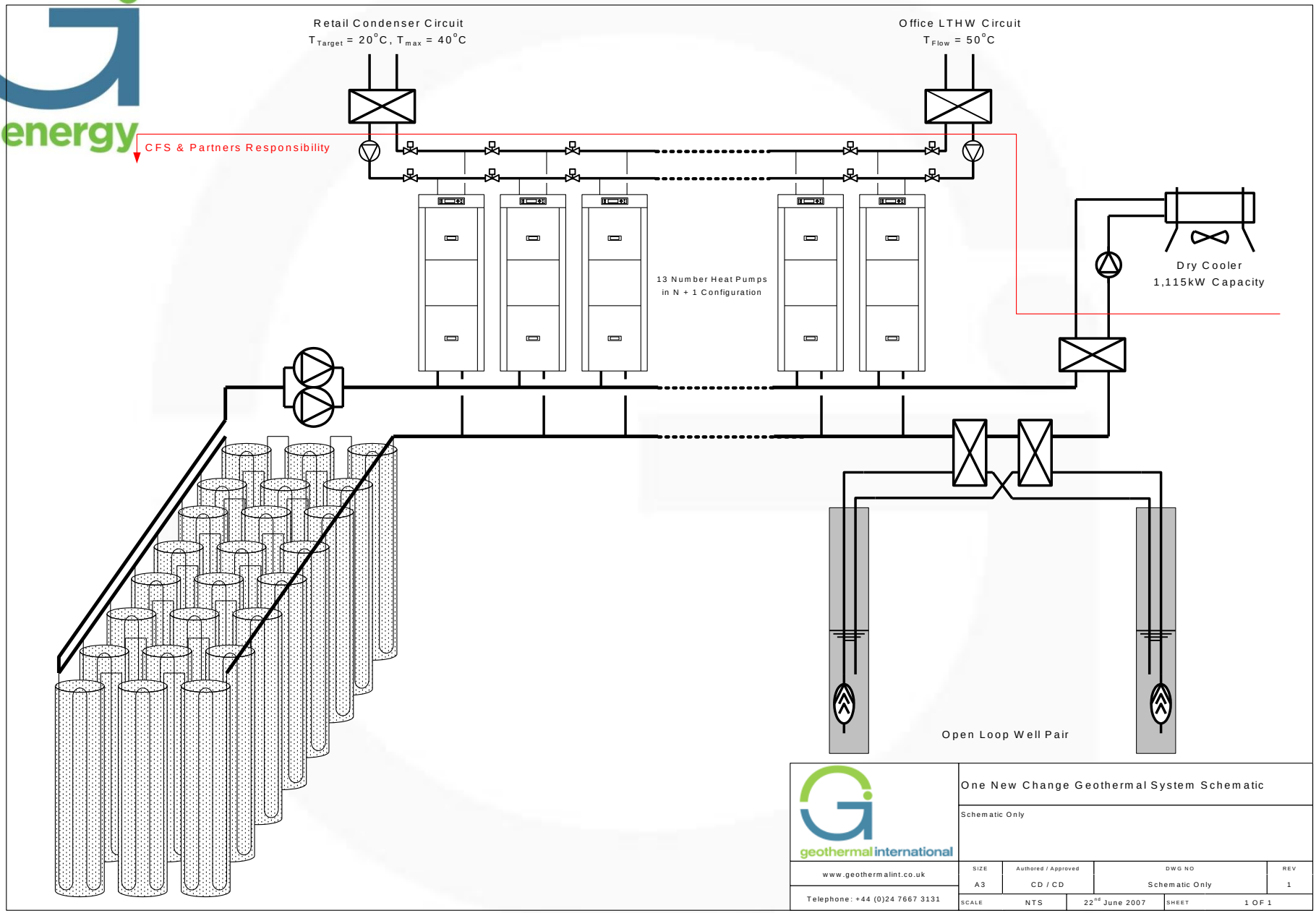


Land Securities & Skanska

trusted partners

- This 3.3MW, £3.4mn system in the City shows GSHPs are becoming mainstream solutions
- The system provides upward of 40% of the building's energy needs, but meets all the stringent new planning requirements for CO_2 reduction
- Completed in 2009

One New Change - Schematic



geothermal international

www.geothermalint.co.uk

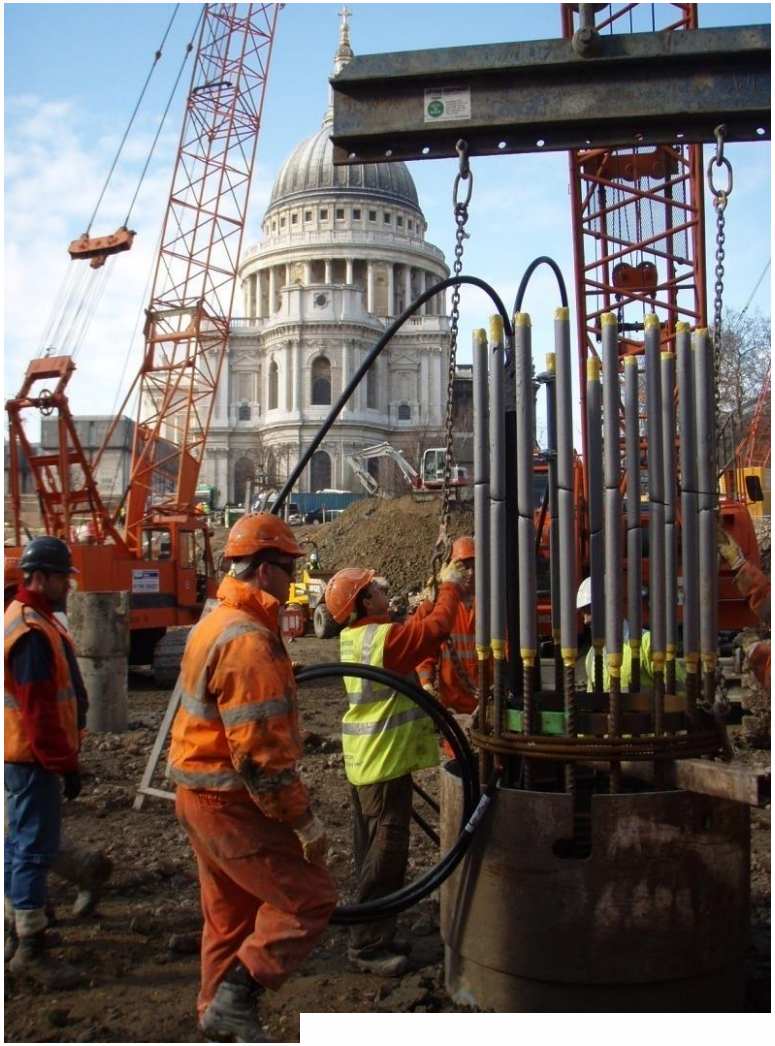
Telephone: +44 (0)24 7667 3131

One New Change Geothermal System Schematic

Schematic Only

SIZE	Authored / Approved	DWG NO	REV
A3	CD / CD	Schematic Only	1
SCALE NTS	22nd June 2007	SHEET 1 OF 1	

One New Change, London



gi energy

LandSecurities DEVELOPMENT

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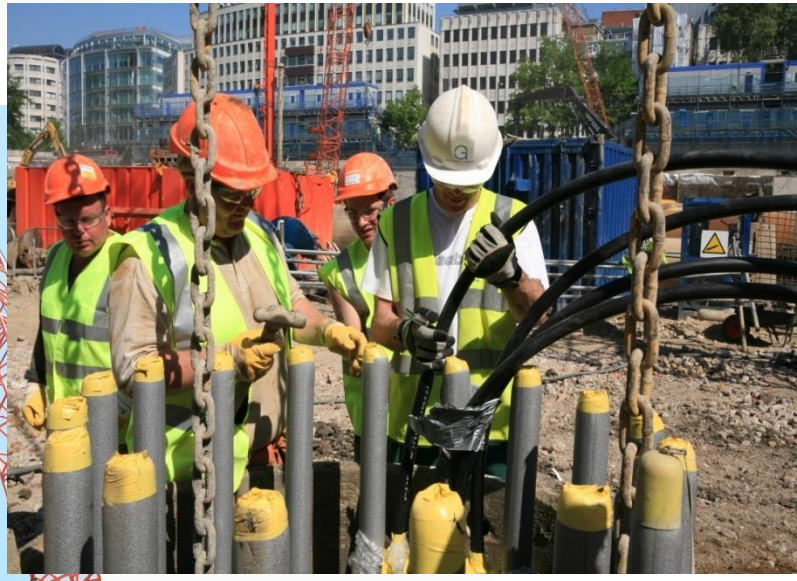
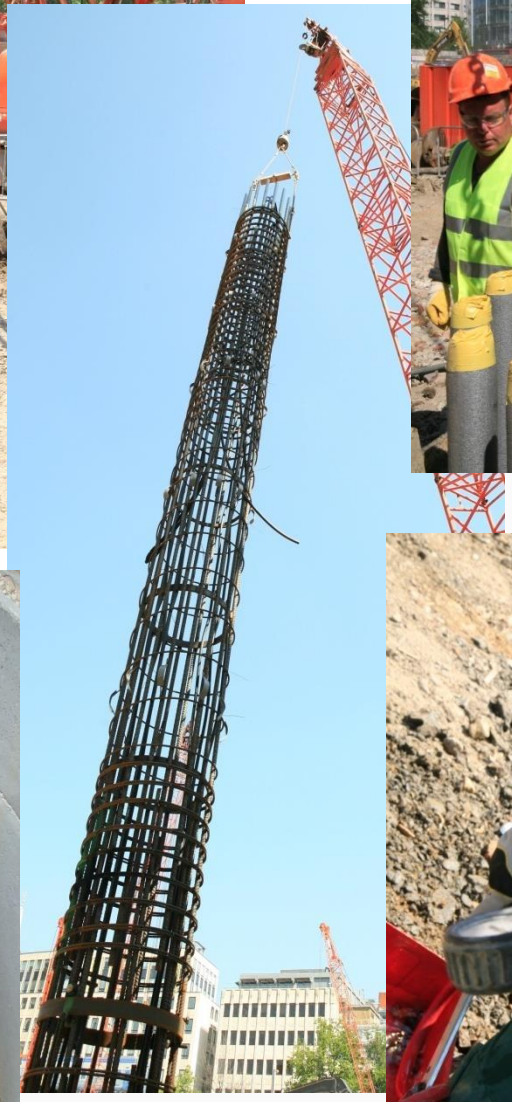
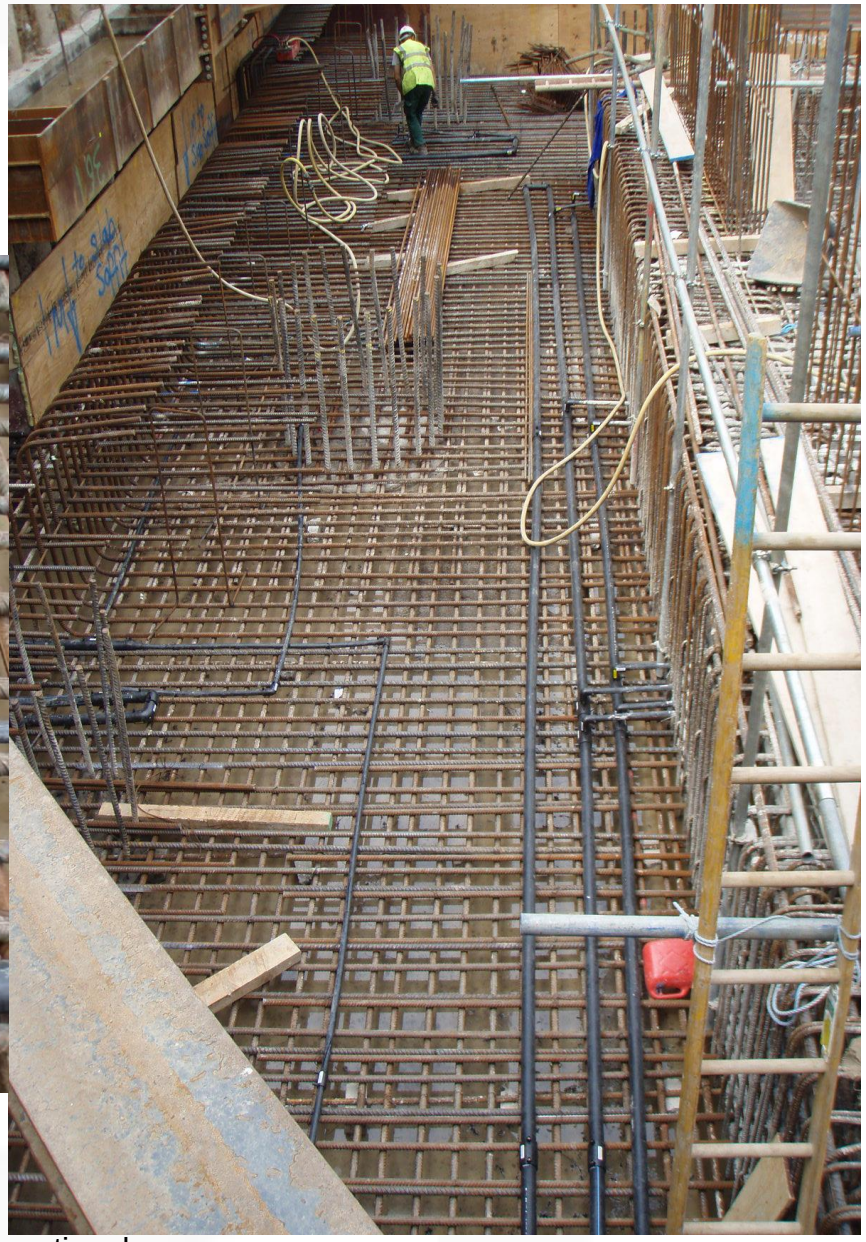
ONC Energy Pile – Loop Installation





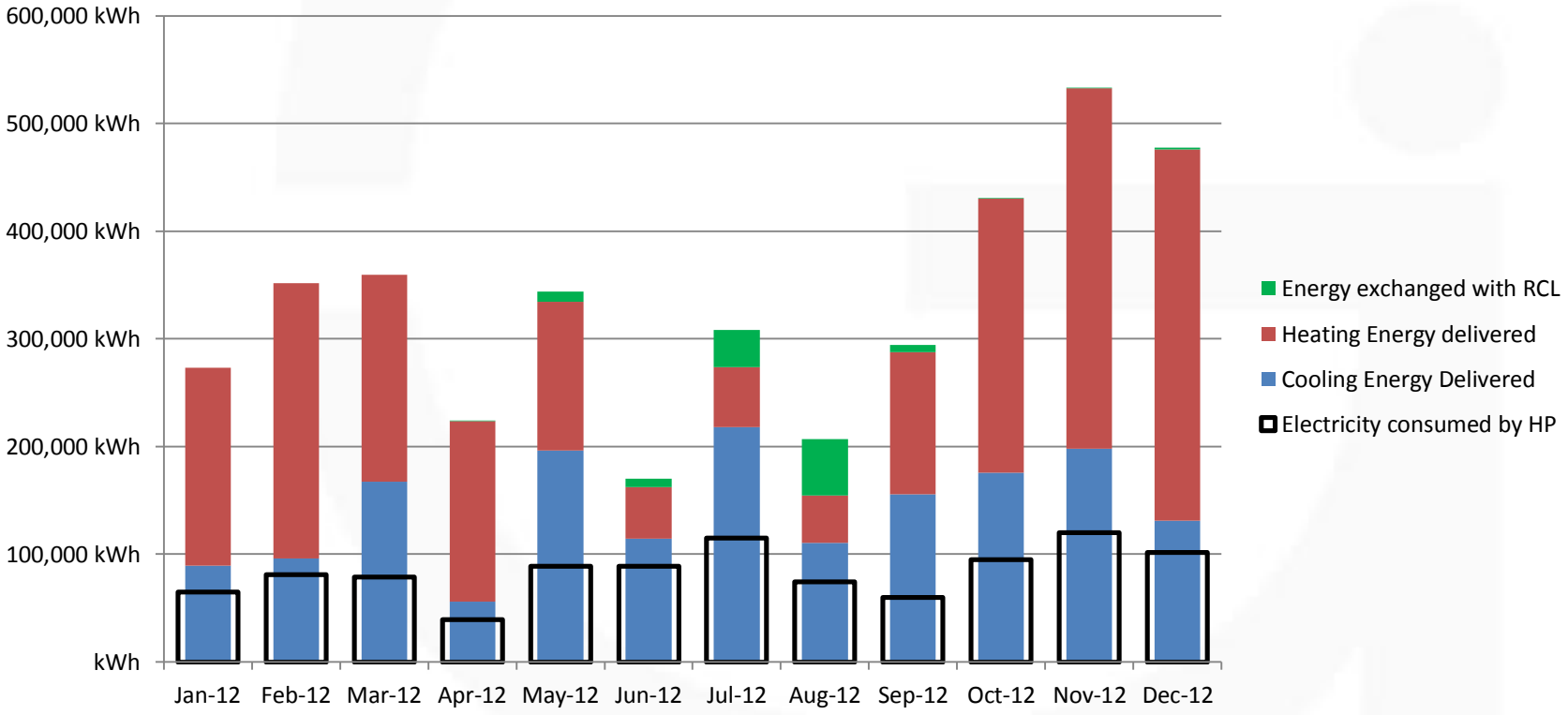
One New Change- Headering Work



Completed Plant Room

Computer driven according to various scenarios

Global annual efficiency of the GSHP system (*)	**4.1**
Annual CO2 savings (tons)	**294**
Annual financial savings (£)	**£62,374**



Note: (*) Consumption of Heat pumps only; excludes all the pumps and auxiliary ancillaries. pumps only; excludes all the pumps and auxiliary ancillaries.

Bulgari Hotel - First Energy Diaphragm Wall Project in UK

- System:
  - Diaphragm Wall & Energy Piles®
- Size:
  - 150kW Heating
  - 150kW Cooling
- Collector type:
  - 50 Energy Piles
  - 150m Energy D. Wall
- On Site:
  - Commissioned 2012

Crossrail Stations London

- System:
  - Diaphragm Wall & Energy Piles®
- Size:
  - 150kW-300kW Heating
  - 150kW-300kW Cooling
- Collector type:
  - Energy Piles
  - Energy D. Wall
- On Site:
  - Farringdon Street
  - Tottenham Court Road
  - Bond street
  - Fisher Street
  - Paddington

H&V news AWARDS 2016 — AWARDS HEADLINE SPONSOR PIPE CENTER

WINNER

Renewable Project of the Year

The contract between Transport For London and Bombardier covers the supply & delivery of 65 new 200m long trains in 2017 & maintained for 32 years at Old Oak Common.

CROSSRAIL – OLD OAK COMMON DEPOT

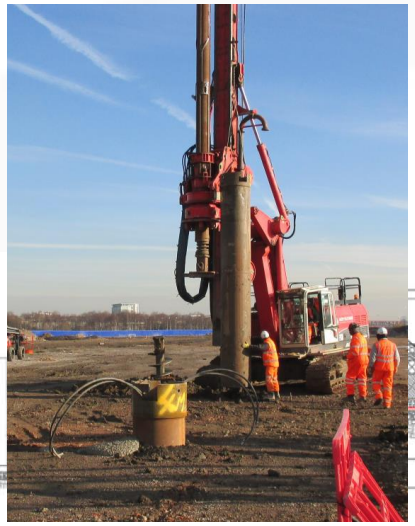
VINCI CONSTRUCTION UK

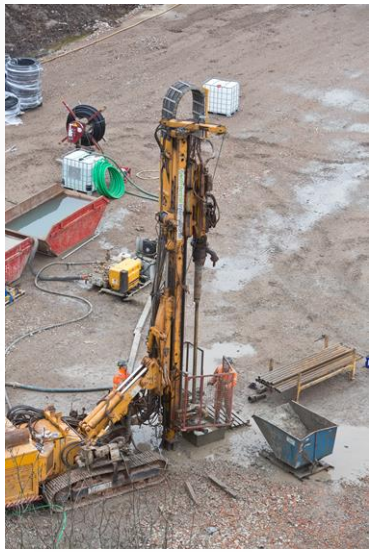
HS2 – Old Oak Common Interchange

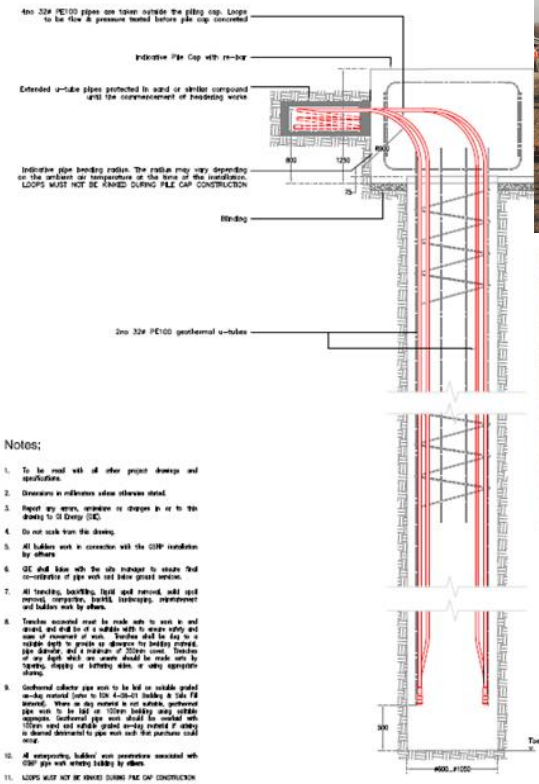
GI Renewable Energy Solution - Crossrail Old Oak Common Depot

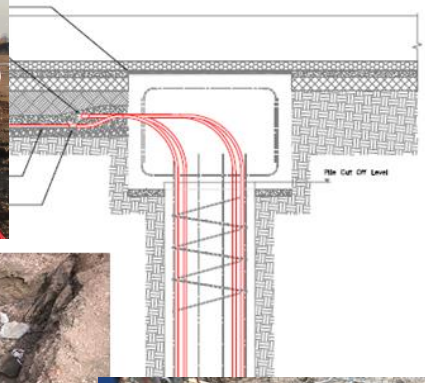
- GSHP System will provide 1000kWth heating and 600kWth cooling using
  - 52no 150m deep boreholes
  - 466no 15m deep energy piles under the building
- CHP System will provide 420kWth heating and 290kWe of electrical load
- 200m² Solar Thermal will add a further 140kWth of hot water load
- 1500m² Solar PV will provide a further 220kWe

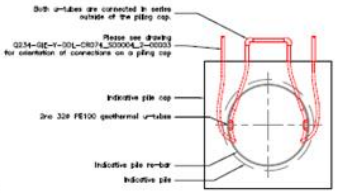
Case Study – Old Oak Common Crossrail Depot - Energy Pile Construction

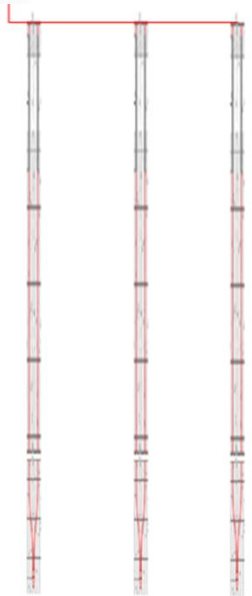












Through our controls & long term management we will be looking to outperform on current assessed performance..

Based Upon Electrical, Heating and cooling profiles provided by Atkins

- 54% Heating and cooling will be provided from renewable technology
- 20% of electrical load generated on site from CHP / Solar PV
- 33% Renewable energy solution

Providing Demonstrated Savings Of.....

- Run cost savings £97,000 per annum when compared against conventional equipment
- Renewable Heat Incentive £193,628/ annum
- 530Tonnes of CO2 per annum
- Potential payback on investment < 10 Years

- 81 CFA energy piles of 450mm diameter
- 68 CFA energy piles of 600mm diameter
- Pile lengths between 20 m and 25 m
- Gault clay formation with high groundwater table
- Delivering
  - 280kW Heating
  - 330kW cooling
- System Operational spring 2015

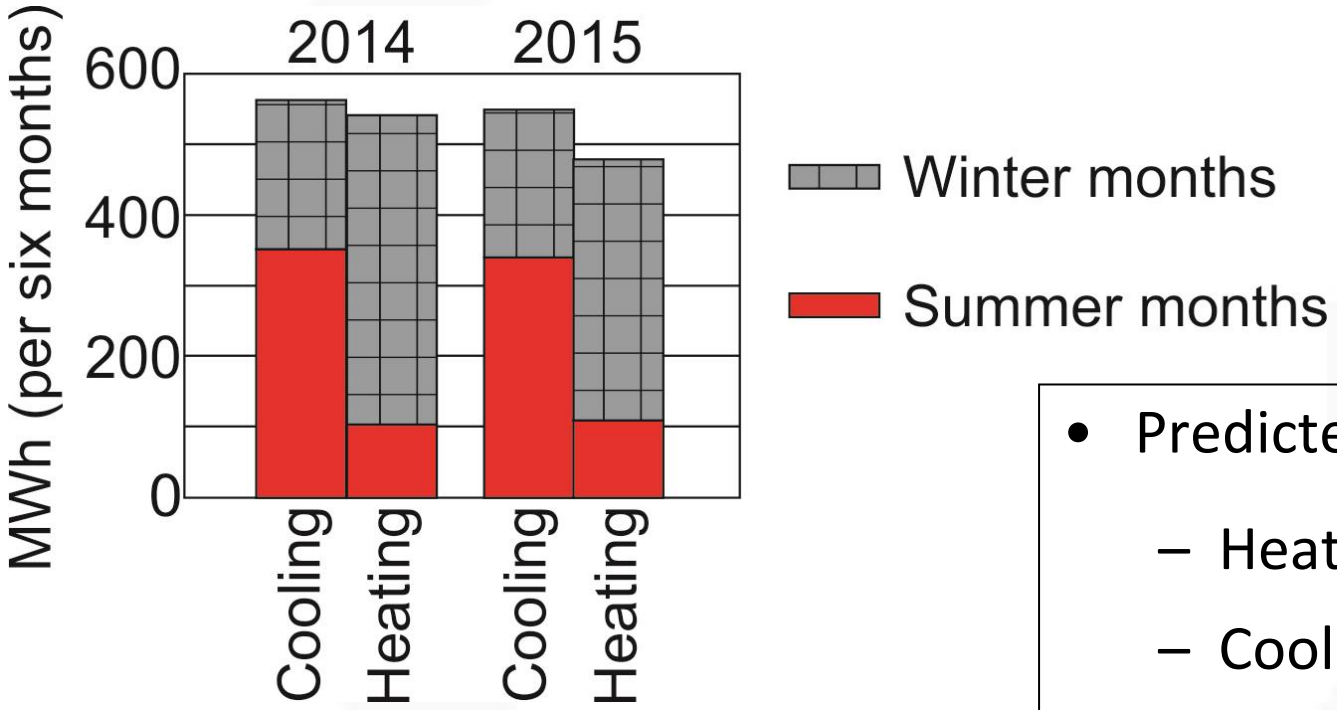
Long Term Energy Pile Monitoring Sites

Dr Fleur Loveridge

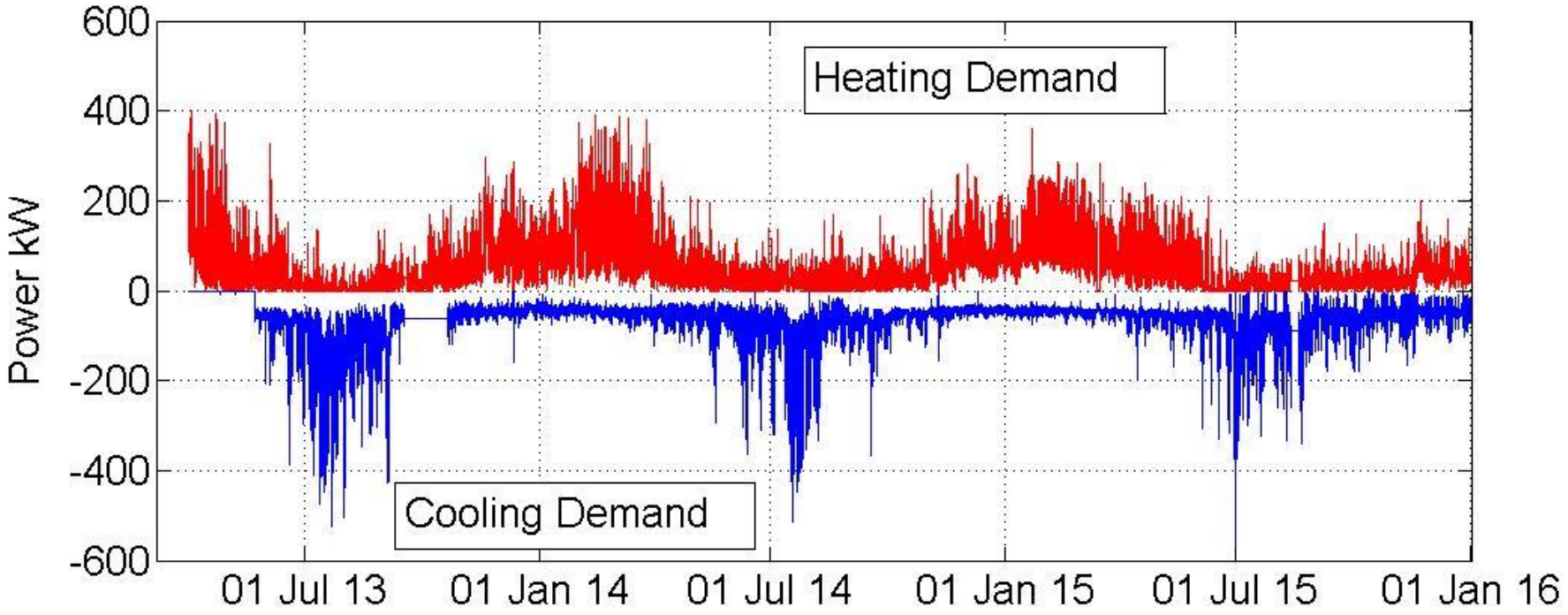
Royal Academy of Engineering Research Fellow

- Energy piles are the most common energy geo-structure
- Analysis & design method adapted from traditional ground heat exchangers
- Few well documented operational case studies
  - Build confidence in energy performance
  - Allow validation of analysis methods
- Two UK case studies in partnership with GI Energy

- Siemens landmark new all electric building in East London
- 160 energy piles (600mm to 1200mm diameter; 21m deep)
- 36 closed loop boreholes (137.5 mm diameter; 150m deep)
- Monitoring single pile temperature and energy performance

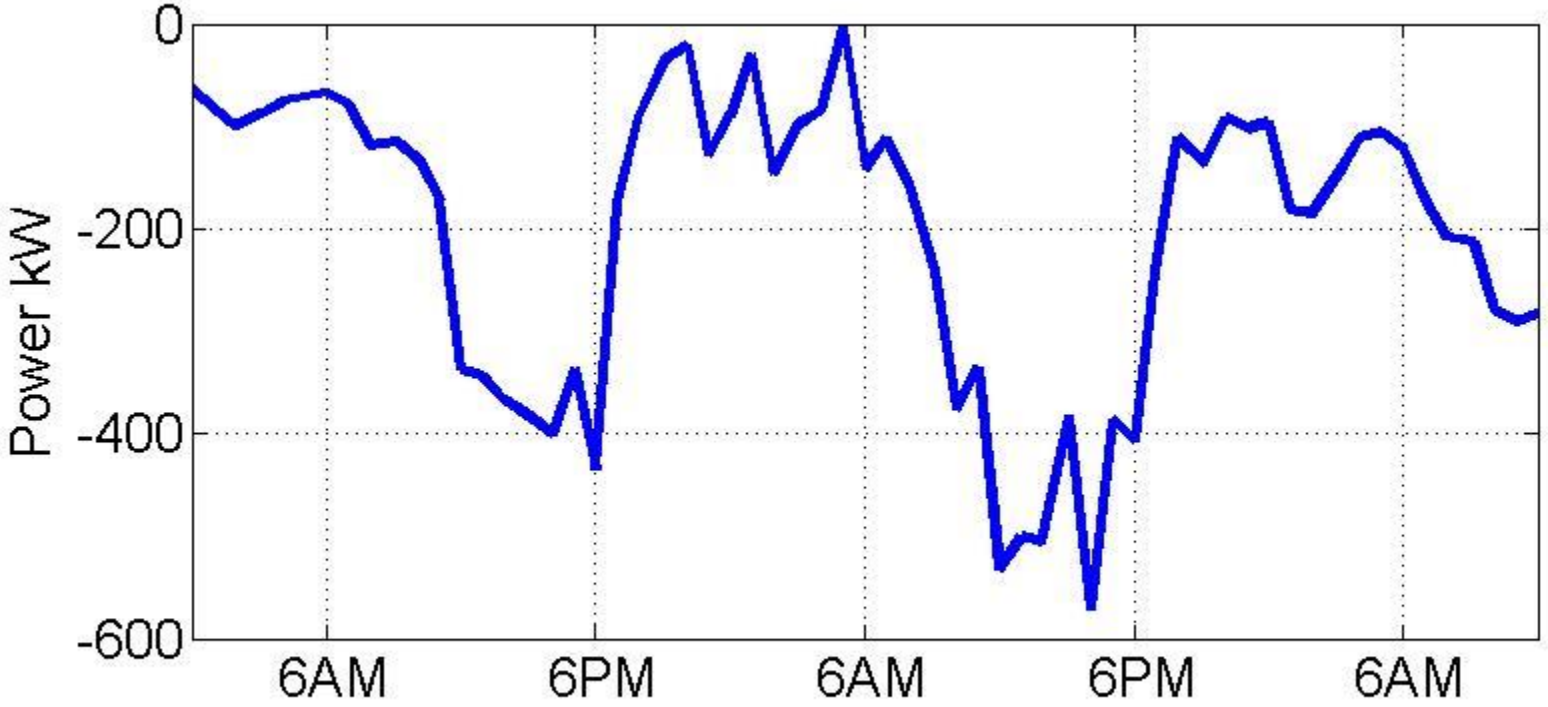


- Predicted demand:
  - Heating 307MWh/yr
  - Cooling 173 MWh/yr
- Actual usage:
  - Heating ~ 550 MWh/yr
  - Cooling ~ 550 MWh/yr



- Predicted demand:
  - Nominal 600 kW

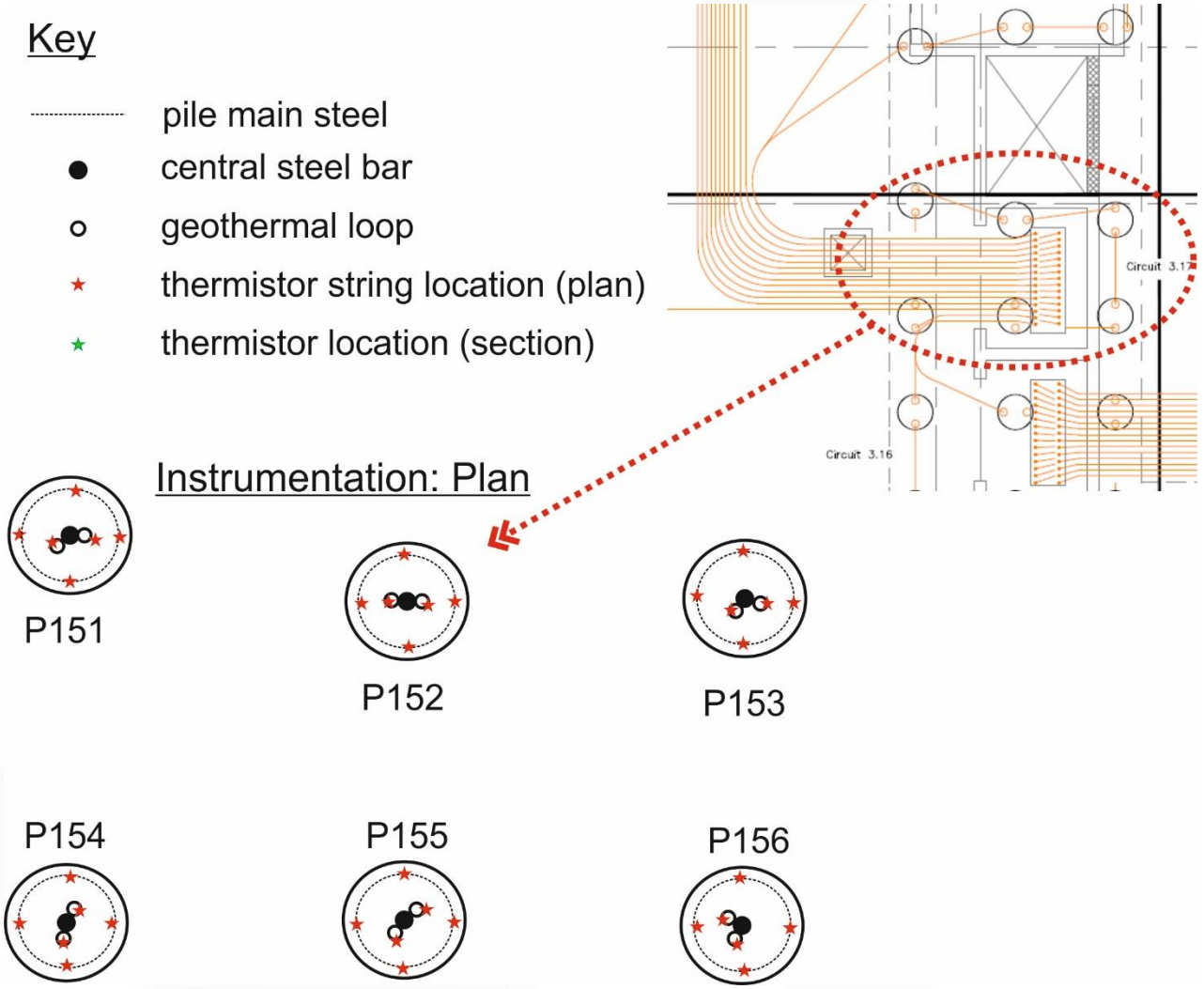
- Actual peak usage:
  - Heating ~ 399 kW
  - Cooling ~ 572 kW



- Up to 100 W/m peak transfer to piled foundations
- Peak pile capacity > 300 kW

- New office development
- 81 energy piles of 450 mm diameter
- 68 energy piles of 600 mm diameter
- Pile lengths between 20 m and 25 m

- Series of 6 no. 600mm dia piles
- Temperature sensors
- Heat meter
- Building energy monitoring



- Energy Foundations are a great solution
- Importance to capture operational data from energy pile schemes
- Heat pump systems are more complex than traditional HVAC equipment >> require several years to optimise performance
- Complex thermal demands >> use hourly demand in analysis
- Recognition of demand uncertainty >> partnership between designer, constructer & users

- Funding:
  - Engineering and Physical Sciences Research Council (research grant number EP/H049010/1)
  - Royal Academy of Engineering
- The Crystal
  - Siemens, GI Energy, Balfour Beatty Ground Engineering, Arup, Foundation Developments Limited and IGS
- 22 Station Road
  - GI Energy, Mott MacDonald, Central Piling and Wates

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