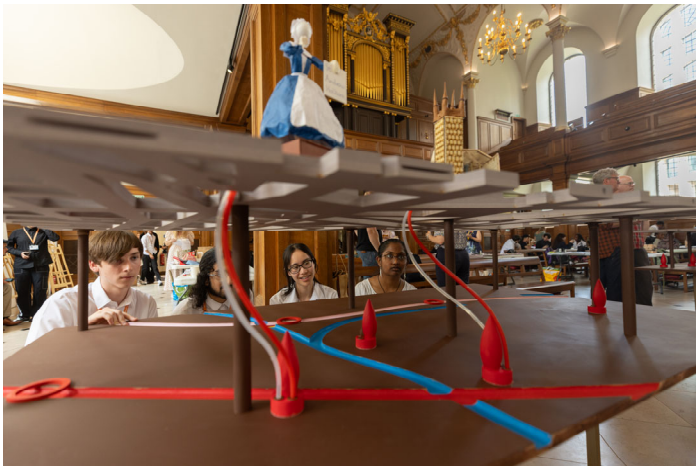

MAPPING ENERGY: EVALUATION REPORT

Dr Melita Armitage
August 2025

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INTRODUCTION

The Mapping Energy Project created a learning opportunity for Year 12 students from eight secondary schools across the capital to think about alternative energy sources for historic churches in the Square Mile. It is part of a larger project that is taking place during 2025 to develop ways to progress the Square Miles Churches movement towards Net Zero Carbon in 2040. Working with engineers at the start of their careers, the students were introduced to the subject by energy engineers from the City of London, Transport for London, Greater London Authority, Nottingham Trent University and officers from the Diocese of London. The project took place over an academic year and included webinars, site visits (Bunhill Energy, City Gen and St Andrew by the Wardrobe) to explore existing heat sources as well as visits to churches. Students were also given advice by a practicing artist and educationalist, to support the presentation and final display of their work.

The project was called Mapping Energy because it took at map as a literal way of organising the project. A map of the Square Mile Churches was divided into 12 sections and each team (students & engineers) were allocated that section. The churches within each section were the locus for applying learning from the webinars. Students met with incumbents or PCC administrators to understand the heritage and conservation needs of the , measured and compared heat levels in their church, on the pavement outside at in the nearest underground station. They considered options for sustainable heat sources that took into consideration energy from underground rivers (Fleet and Walbrook), excess heat from the London underground system, as well as where there were opportunities to connect into the city's heat networks.

The final celebration day of the project (June 2025) brought all participants together to present a model of their church and connect it to a model map of the city, linking to their recommended heat sources. Student teams also created posters and gave presentations of their findings from the project to an invited audiences of parents, school representatives and the Bishop of London.

A citizen science guidebook was created by two of the participating engineers and this will be shared on the Square Mile Churches website as well as to students studying at Nottingham Trent University. The map is currently on display at The Green Skills Hub, Fleet Street and will continue its tour during 2025 and be on display at St Michael's Paternoster Royal.

The project was led by a team of professional educators from the fields of heritage, engineering and architecture. The team comprised:

- Carole Patey, Project Leader
- Jonathan Bartlett, Project Director
- Dr Yan Xing, Science lead (NTU)
- Simon Turner, Education Consultant

- Cathy Wren, 3D Artist & Designer
- Helen Vigors, SMC Sustainability Project Lead

The project was made possible through the support of the Diocese of London and London Diocesan Board for Schools (LDBS), project partners (Nottingham Trent University (NTU), Chartered Institution of Chartered Building Service Engineers (CIBSE)) and grants from the Royal Academy of Engineering (Ingenious Fund) and the National Lottery Heritage Fund.

PROJECT PURPOSE

The application to the Royal Academy of Engineering lists eight objectives for the project which include:

1. Organising citizen scientist groups with school pupils, engineers and teachers (science, physics, geography, engineering, art, etc., to create an "Energy Map" for the adopted churches and schools.
2. Develop Novel zero-carbon transition pathways.
3. Developing zero carbon churches and schools transition pathways and discussing key technical components, issues, calculation and decision processes towards developing novel ideas for transforming cities.
4. Exploring the history of the City of London through its streets, underground rivers and historic churches. Understanding dramatic changes over time, causes of pollution, different sources of energy and the context for transition to NZC heating systems.
5. Creating an artistic representation of the energy map for a zero carbon future and encouraging engineering design skills for a pipe-work system underground. This will be a collaborative exercise and the map produced will be on public display in a City of London church.
6. Public Engagement: Giving the young engineers and EPQ students the experience of working with younger age groups and explaining complex issues in a simple way. Presenting the results of their research to a wider public in a discussion forum and online.
7. Making links with TfL, Thames Water, CAT and other professional bodies as necessary.
8. Producing a Citizen Science handbook and making it available on-line and accessible to other schools, the wider public and future generations.

ENGINEERS

Through to realisation of these project objectives, participating engineers were expected to develop skills in public engagement, learn how to apply their knowledge in historic places of worship, grow their professional networks and consolidate their knowledge of sustainable heat sources.

YEAR 12 PUPILS

Their involvement was designed to give them insights into careers in engineering, the diversity of engineering roles in society and experience problem-solving using engineering in a current and real-world situation. Their onsite activities were designed to be useful to the participating churches and to the Square Mile Churches as a whole as well as giving students an opportunity to carry out complex calculations and consider options for energy efficiency in the future. In addition to having direct contact with energy experts, pupils were also introduced to ideas about sustainability in a historic context.

METHODOLOGY

The evaluation methodology comprised observation on the day and informal interviews with participants and professionals on the day, a post project legacy interview with the project team, a survey completed by students on the day, a survey completed by school staff after the Summer break, a survey completed by engineers together with project documentation created and developed during the lifecycle of the project.

A challenge for the evaluation was allowing enough time to elapse between the final event and the report to represent the impact for participants. Similarly, although the engineers agreed to respond after they had time to absorb the project and after the halo effect of the final event, once they returned to the workplace some required a lot of chasing to respond to our survey. While formal responses were difficult to respond, verbal and email updates continued after the project completed. This project isn't unusual in this respect.

QUALITY OF THE LEARNING EXPERIENCE

We were particularly interested to learn how the Mapping Energy project was experienced compared to the Dome Building Day we delivered as part of the Wren300 celebrations that the RAE also funded. While the Dome Building Day was a single day's activity, the Mapping Energy project took place over six academic terms, with planning and recruitment commencing in the autumn terms (Sep-Dec 2025) and direct delivery to students in the last four terms (Jan – Jun 2025). Like the Dome Building Day, this project culminated in a full day, high impact celebratory event. The Mapping Energy project required ongoing commitment from engineers including a commitment to attend online seminars, meet with schools and take on a stronger leadership role.

We asked students, teachers and engineers to give the overall experience of the day a star rating which ranged from OK (with a numeric value of 1) to Excellent (with a numeric value of 5). Taking an average of their responses, everyone rated the day above 4.3 and students above 4.5.

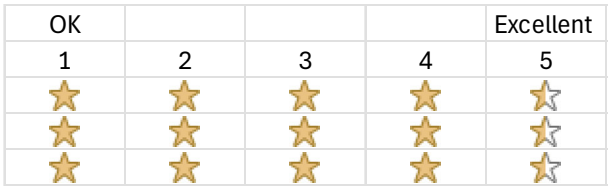

Figure 1: Participant star ratings for the Mapping Energy Project

This high rating was echoed in a later question where students were given two statements against which to indicate their agreement. Here their responses showed 100% enjoyment of the project and 100% agreement that they would recommend the project to other people. As part of our consideration of enjoyment we also asked students to comment on whether their access requirements had been met. Again, there was 100% agreement, which given the variety of venues and style of delivery of the project, this was a positive outcome with the caveat that aside from cultural requirements (Halal meals) none of the schools asked us to make specific adjustments for individuals.

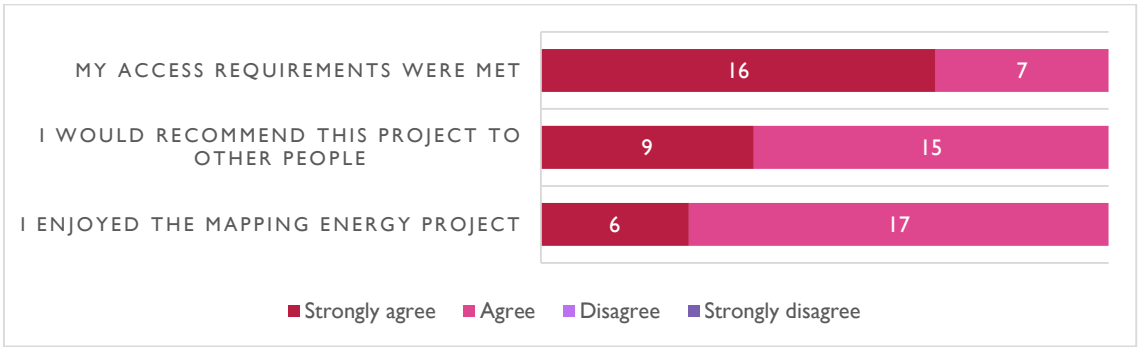

Figure 2: Student agreement with enjoyment & access statements (Survey Base: 23)

Turning to the teachers when asked if they might consider bringing another class to a similar event in the future, the two that responded at the time of writing this report said yes. Given the length of the commitment for a project, this is a positive finding.

> *"An amazing opportunity for students to work alongside young engineers and explore a passion for sustainability and develop teamwork and communication/presentation skills."*
> *(Teacher feedback)*

In the early phases of the project we did have some movement in terms of the schools involved. We were able to quickly replace those schools and dropout was as a result of pressures of the curriculum and staff changes. In our post project feedback discussion, we reviewed the recruitment timeline, communication with schools and the team at LDBS commented that they were impressed with how readily schools signed up and that this enthusiasm resulted from the uniqueness and appeal of the opportunity.

Collaboration and co-design was built into the project from the outset. Each project team – engineers, students, church – worked together with input from the project team. The final day saw these teams come together to create a collaborative 3D model, which enabled them to physically exhibit their models together and connect them to underground networks of energy.

Communication within teams to realise the individual solutions for churches and then to communicate their learning to other teams as well as the public required skills in facilitation from the engineers. critical element and the posters were structured to communicate visually as well as through verbal presentations.

Teachers were invited to reflect on how well the projects had been facilitated. At the time of writing only 2 of the 8 teachers accompanying the schools had responded to our survey. The following figures illustrates the high levels of agreement with statements about the quality of the facilitation.

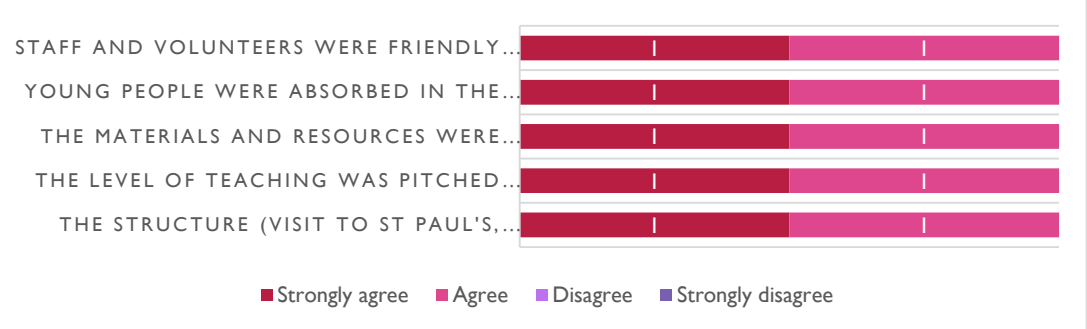

Figure 3: Teachers' agreement with statements about facilitation (Survey base: 2)

As one of the teachers commented:

> *"Facilitators were great and so helpful and encouraging."*
> *(Teacher feedback)*

The Mapping Energy project required facilitation briefings and some training in how to support pupils to present their work and clear communication. The engineers were positive about the level of support they received and in their reflections on how well pupils responded to the project:

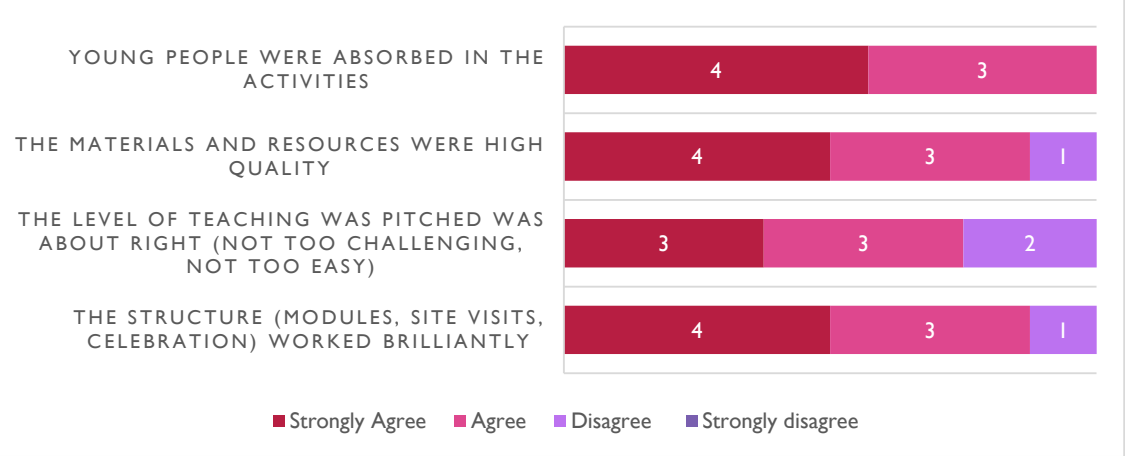

Figure 4: Engineers' ratings of the quality of facilitation and project (Base: 8)

Pitching the level of detail about heat sources was challenging. These were students at the start of their A'levels and initially some found it harder to follow the science compared to others. Over time their level of understanding of the theory and practical aspects of the project increased. As one of the engineers commented:

> *"I felt the online lecture for heat pumps was a bit too difficult for their level."*
> *(Engineer feedback)*

The change in students' ability to grasp the science was noticed by one of the teachers and another felt that their students could have managed more complex mathematics:

> *"My students could have done a more detailed analysis of the data and perhaps thought about making their analysis a bit more rigorous - how would change of season etc affect their readings? Etc."*
> *(Teacher feedback)*

This was helpful feedback for us because it speaks to the accelerated learning that school age children go through during Yr12 and the nuances between participating schools and students.

For the engineers the experience was rewarding because of it's varied site visits, the hands on nature of the interventions, the creative manifestation of their work together, professional connections as well as the opportunity to work with enthusiastic young people.

> *"Working with the students was definitely the best bit!"*
> *(Engineer feedback)*
>
> *"Speaking to the children who were inspired by the project and hearing about their plans for the future."*
> *(Engineer feedback)*

> *"The Energy Centres [Citigen & Bunhill] visits with students - because you get quickly to know them and how much some of them are interested in Engineering and their thinking skills."*
> *(Engineer feedback)*

> *"Creating the map as a physical manifestation of the work was amazing and creative."*
> *(Engineer feedback)*

Across the feedback, engineers spoke positively about the opportunities to explore, present and celebrate the achievements and potential for energy engineering of the future.

WHO WE REACHED

Image 1: Screenshot from film showing Bishop of London in conversation with students

SCHOOLS

Schools were recruited through the London Diocesan Board for Schools (LDBS) which serves and supports 155 Church of England schools and their 58,000 pupils on roll. 19 of these schools are Secondary Schools and 4 are All-through Schools. For the Mapping Energy Project, the LDBS contacted 20 secondary schools sending an information pack detailing the opportunity, commitment from schools and particularly encouraged schools with pupils on the role that were experiencing deprivation.

Eight schools quickly signed up. However, in the first half of the project, three of the original schools that signed up had dropped out. The reasons were because of staff shortages and the challenges of adding the project into a busy curriculum. Each school was replaced immediately and the replacements went slightly outside the LDBS group of schools to include two independent schools that were in close proximity to one of the churches and were known to the project team.

The profile of the schools illustrates the range of need and diversity of students. Looking at the percentage of pupils with an EHC Plan, with SEN and without an EHC Plan, as well as English as an additional language and those in receipt of Free School Meals (FSM) in the previous 6 years, we are confident that we reached diversity of need in our selection of schools. The following table details the 23/24 profiles of the schools that took part, including details of the local authority, age and gender mix. The highlighted cells indicate higher than average percentages of pupils with additional needs using the national averages for England mainstream secondary schools as the benchmark.

Participating Schools		Pupils on roll	% Pupils with EHC Plan	% Pupils eligible for SEN support	% Pupils whose first language is not English	% Pupils eligible for FSM at any time during past
The Green School for Boys (Hounslow)	11 to 18 yrs, Boys	783	2.9%	21.5%	45.0%	32.4%
The Bishop Wand CE Sch (Surrey)	11 to 18 yrs, Mixed sex	1,181	3.2%	12.2%	6.1%	7.0%
St Augustine's CE High Sch (Westminster)	11 to 18 yrs, Mixed sex	1,002	5.5%	13.1%	77.0%	55.7%
All Saints (Tower Hamlets)	11 to 18, Mixed sex	1373	5.9%	6.5%	34.7%	49.1%
Wren Academy (Barnet)	4 to 18, Mixed sex	1614	3.4%	8.2%	26.5%	16.0%
London Design & Engineering UTC* (Newham)	14 to 19 yrs, Mixed sex	763	1.4%	6.8%	57.7%	46.0%
City of London School for Girls*+ (City of London)	7 to 18 yrs, Girls	764	0.0%	13.1%	No data	No data
The John Lyon School *+ (Harrow)	2 to 18 yrs, Mixed sex	866	0.1%	10.9%	No data	No data
England mainstream secondary schools		3,671,427	3.1%	13.4%	19.2%	25.8%

Table 1: Profile of participating schools

* Joined after the start of the project + Independent school

Students that took part were reported by staff as studying a variety of STEM subjects and the subjects given included: Physics, Engineering, Maths/Further Maths, Biology and Design & Technology.

Overall, 70 young people participated in the project as a whole from eight schools which includes 2 young people from Bishop Wand school using the project as part of their EPQ (one used the project as inspiration for an eventual choice in topic) and we know of at least 2-3 more EPQs that included the project. An additional 10 students started the project and then withdrew with their schools.

ENGINEERS

In our original application to the RAE, the aim was to attract eight engineers. When the partnership with CIBSE matured, their existing cohort of STEM Ambassadors were an obvious fit for the project and 17 took up the offer to take part in the project. Some of the Ambassadors are older than 25, but were extremely keen to get involved and we extended the age limit to meet the demand. The majority were early career engineers. All engineers had an interest and commitment to public engagement and particularly working in school and college settings to encourage young people to explore engineering, its presence in our daily lives and its potential as careers.

The partnership with CIBSE led to a much smoother recruitment process and one that enabled the project team to reach a much broader pool of interested young professionals. Engineers' participation was voluntary, with travel expenses paid. Their contribution was conceived as evidence towards their annual Continuing Professional Development, emphasizing engineer's need to communicate clearly with the public. The opportunity to create a Citizen's Science Handbook was taken up by two of the young engineers and this resource will be shared.

Of the 8 Engineers that completed our equalities monitoring, the majority were aged 25-34. Six of the participants identified as female, four identified with ethnicities other than White British. One person identifies as neurodivergent, none as disabled.

OTHER AUDIENCES

During the lifetime of the project and particularly during the final day's celebration event the SMC team created several posts for social media and these were successful in their reach in relation to other social media reach of the wider project.

Platform	Square Mile Churches Posts	Engagement (Interactions)
Instagram	8	82
Facebook	8	65
Twitter	6	2490
LinkedIn	13	421
TOTAL	**35**	**3058**

Table 2: Social media engagement (Jan - Jul 2025)

The model has been installed at the Green Energy Hub and we have conservatively estimated that 100 people had seen it by the end of July 2025. As part of that touring exhibition one of the engineers took part in an educational day organized by our E.ON on 31 July 2025 called Mapping Energy Day.[1]

> *"The Mapping Energy Education Day is a shining example of how collaborative efforts can make a significant impact on young minds and the broader community."*
> *(E.ON press release)*

This immersive day was aimed at KS3 pupils (Yr7) from London-based Chelsea Academy, Ormiston Latimer Academy and Stepney All Saints. Students explored the map during our engineer's presentation. Other sessions included: A Net Zero Academy workshop (games aimed at 11-12 yr olds to explore decarbonisation), Sustainability in schools (exploring ideas for their own schools and

[1] https://news.eonenergy.com/news/inspiring-london-students-about-green-careers-sustainability-and-stem

communities), Mapping Energy with Ruth Tatanga (her career and introducing the Mapping Energy project) and a Careers carousel (E.ON professionals describing careers in energy and engineering).

Image 2: Screenshot from E.ON's press release on Mapping Energy day

We estimate that the project reached 70 Yr7 pupils from each of the schools during the day.

On the final celebration day of the Mapping Energy Project, the Bishop of London, the Rt Revd and Rt Hon Dame Sarah Mullally DBE was invited to see the completed project, including the map, student posters. This was filmed and has been shared on social media. Since it has been uploaded on Vimeo (31 July 2025) it has had 50 views and we anticipate that this will grow over the remaining of 2025 as the map tours and as other part of the SMC Sustainability project come to fruition.

A brief search on Google shows that there has been modest media interest in the project. For examples Church Times, with 16,000 circulation, CIBSE and E.ON articles, plus heritage site IanVisits.

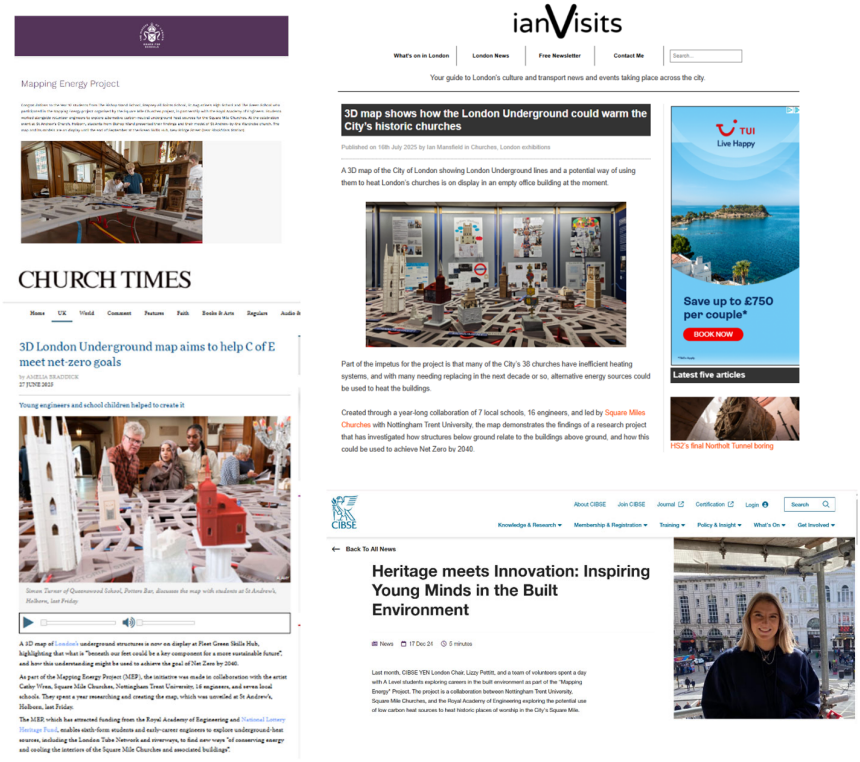

Image 3: Screenshots of websites referencing the project (accessed Aug 25)

OUTCOMES FOR ENGINEERS

HERITAGE LEARNING

When asked about the value of the day in relation to heritage, 8 out of 10 of the engineers that responded evidenced that the project had inspired them to include historic buildings in their future work.

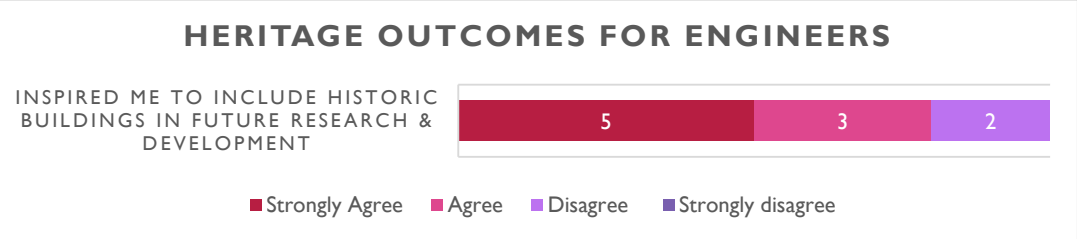

Figure 5: Engineers' further interests in heritage (Survey base: 10)

This strong agreement indicates that there is potential to bring attention to the role that historic places of worship play in civic society, both as places of worship but important elements of local infrastructure and the heritage of an area.

In her comment, one of the engineers reflected on the positive impact that the project and the unusualness of the focus for the project had brought for her professionally.

> *"This project allowed me to get involved in E.ON academy and gave me nice visibility even internally (in my company) regarding engineering work on Historical Buildings."*

CIBSE also reported to us that engineers had found working in the churches interesting, not only because of the conservation needs of the buildings, but also because of their unique architecture and how heat is captured and lost in their internal spaces.

PUBLIC ENGAGEMENT SKILLS

The project invited Engineers to engage with students in different ways. The first was as facilitators, supporting the students through different aspects of the project, following briefing from the project team. All schools were given the same information and resources (heat sensor, rulers, floorplans of the churches and timescales) and taking them students through learning iteratively. Some of the students were delighted that the engineers brought their own measurement tools.

The second was as a co-presenter of the posters and models, supporting students in their career paths and build a rapport with students.

The engineers particularly valued the site visits to CitiGen and Bunhill as a way to build rapport with the students. This they reported to us, enabled them to build trust ahead of the more specific tasks they needed to undertake at their allotted churches and in the run up to the final presentation day.

It is clear that some of the schools and engineers relished the opportunity to give more time than we asked for and there were examples of engineers making additional visits to schools to share their career journeys as well as supporting the development of the models. Another example, detailed in the previous section was the participation of one of our engineers in the E.ON Mapping Energy day aimed at KS3 pupils.

> *"I really enjoyed the day with the students, they were really engaged and curious about the history of the buildings, the architecture, and the science of building physics. I loved seeing the heat pump with them and answering such a wide variety of questions about how it works and why it is such an innovative solution! It was inspiring to see how passionate they were about climate change and so motivated to embark on careers that would have an impact."*
> *(CIBSE Case Study)*

8 of the 10 engineers that responded to our survey documented a development in their facilitation skills resulting from taking part in the project.

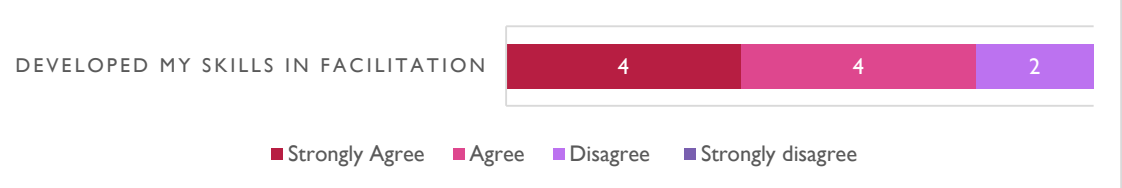

Figure 6: Engineers agreement with statement about facilitation skills (Base: 10)

When asked for their impressions of the engineers' facilitation, students responded positively to each of the three statements they were given. None of the students indicated disagreement with the statements:

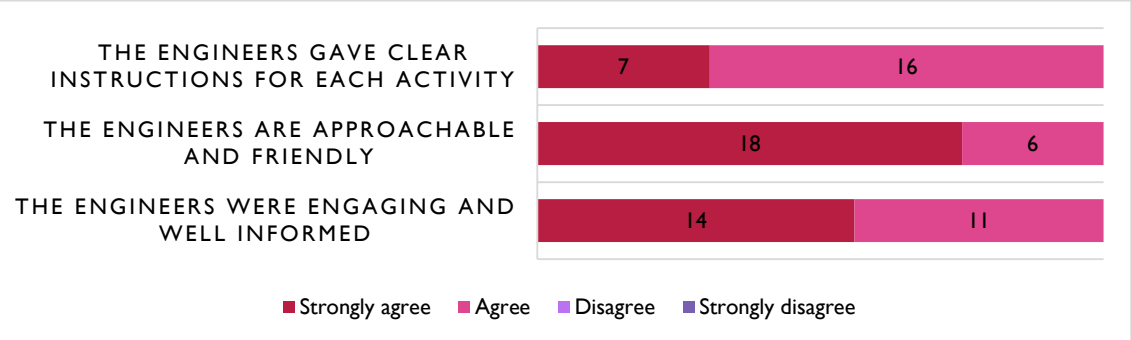

Figure 7: Student impressions of engineers' facilitation (Survey base: 23)

Their friendliness and approachability were the most agreed with statement, followed by a perception that the engineers were well informed and engaging.

This is very positive feedback for all the engineers involved not only because of the levels of agreement but also because it came from a third of the cohort attending the day (23 of the 70 students attending completed a feedback form) and from every school that attended. Moreover, it suggests that both the selection and matching of engineers to schools was a good fit. The engineers themselves particularly enjoyed working with this age group as these comments illustrate:

> *"I already have quite extensive experience in facilitation. The additional benefit was STEM outreach and interacting with the children."*
> *(Engineer feedback)*

> *"It was nice to work with older students and learn better ways to introduce them to energy sources and technical calculations"*
> *(Engineer feedback)*

The engineers were recruited from CIBSE's STEM Ambassador group so they were starting from a different point in relation to public engagement skills compared to the engineers that took in our Dome Building Day project last year. In their feedback survey we asked them if taking part in the project had led to any improvement in their public engagement skills. The question was a star scale with one star indicating no improvement and five stars indicating significant improvement.

The Mapping Energy Project required ongoing communication and interaction with students in multiple ways: liaising with teachers ahead of site visits, supporting them on-site, co-facilitating during visits, co-writing and presenting projects and being prepared to speak about careers.

Overall, the group of engineers reported strong improvement in their public engagement skills.

No improvement					Improved Significantly
	1	2	3	4	5
Engineers	★	★	★	★	☆

Figure 8: Improvement in engineers' public engagement skills (Survey base: 9)

Asked to comment on their ratings the engineers (as discussed earlier) appreciated the opportunity to work with an older age group than they had typically worked with as CIBSE STEM Ambassadors. They also appreciated the opportunity to move away from 'chalk and talk' towards a hands on, less formal style of engagement:

> *"Being more interactive when explaining how things work rather than relying on powerpoint or technology as I would in work."*
> *(Engineer feedback)*

> *"Hands-on sessions such as heat measurement workshops, which encouraged participants to engage directly with the equipment and data, fostering active learning and curiosity."*
> *(Engineer feedback)*

> *"Building trust through informal conversation by taking time to connect with participants before and after sessions helped break down barriers and made people feel more comfortable contributing."*
> *(Engineer feedback)*

> *"Using visual and hands-on tools, especially in heat measurement sessions, using tangible tools and visual aids made complex topics more relatable and accessible, regardless of participants' educational or technical backgrounds."*
> *(Engineer feedback)*

Creating more natural ways to have conversations with students and collaborative interactions were both enjoyable and successful in creating professional relationships between students and engineers.

PROFESSIONAL DEVELOPMENT

The project was not deliberately aimed at building engineers' theoretical knowledge about sustainable energy. The engineers that volunteered were self-selecting and already had interests and been educated in sustainable energy uses. We were, therefore, pleased to learn that at least one of the engineers had taken some of the examples back into their workplace as part of an inhouse CPD session:

> *"Used some information on an internal company CPD on mechanical services as examples of energy production."*
> *(Engineer feedback)*

The project majored on developing engineers' skills in communicating with the public, which in our project included explaining engineering concepts to teenagers and then co-presenting projects to a broader audience. In addition, we wanted to connect engineers to one another, to educators as well as the professionals leading the different elements of our project. Lastly, we wanted to create an opportunity for a small number of participants to create a Citizen Science handbook, to benefit their written skills in communicating complex ideas to a non-professional and non-scientific audience.

When asked specifically about learning outcomes, there was some evidence that the engineers could use the experience as part of their annual CPD evidence and that the day had given them an opportunity to develop skills they had identified as important.

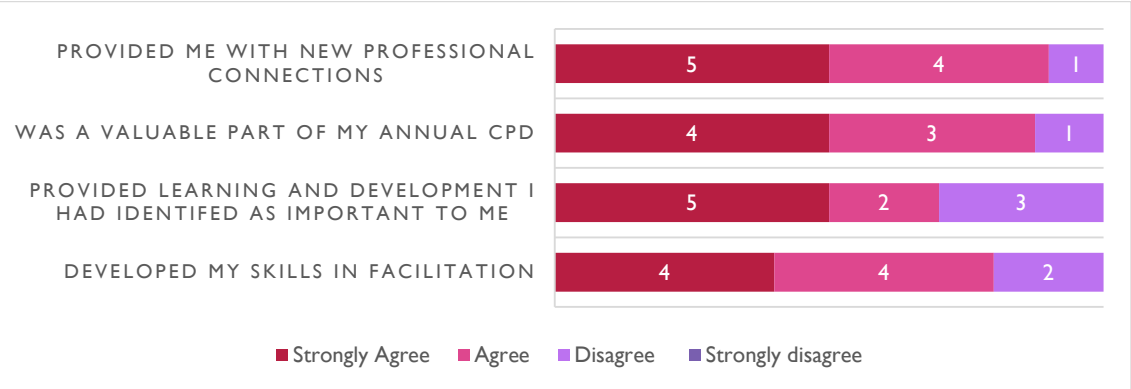

Figure 9: CPD outcomes for engineers (Survey base: 10)

Only one of the engineers disagreed with all of the statements but went on to comment on the value of the project as a highlight of taking part:

> *"Professional Development - working in a team built soft skills such as communication, leadership, and conflict resolution. I was also able to build a professional network that could support future career opportunities for myself and my new connections."*
> *(Engineer feedback)*

Taking part in the project, was of value professionally to the participating engineers, who were able their contribution as part of their annual professional development in most cases. As the last comment illustrates, while some may not have seen as much impact in terms of professional CPD validation or facilitation skills development, there were gains in interpersonal skills.

Two engineers wrote to us separately about being accepted as PhD students. The authors of the Citizen Science Handbook have both been accepted onto PhD courses one with a scholarship to do a PhD at Nottingham Trent University (based around the SMC churches) and the other at London South Bank University. She writes:

> *"I have received a PhD offer from London South Bank University for a project titled:* "Advanced Analysis of Historic Building Construction, Performance, Indoor Comfort, and Regulatory Compliance."
>
> *As I mentioned in my proposal, the project will involve case studies, and I would be very happy if there's an opportunity to collaborate with you and select one of the City of London churches as a case study."*
> *(Email from Engineer)*

We will track the downloads of the Handbook during 2025 and explore how else we can share it within the LDBS school family.

Figure 10: Screenshots from the Handbook

NETWORKING

Having a project that took place over a longer period of time, compared to our Dome Building Project, enabled participants to get to know one another and the professionals leading the project. As two of the engineers commented:

> *"It is delightful to have worked with Dr Yangang Xing (Yan), BSc, MSc, PhD, MCIBSE, FHEA and I look forward to a continued relationship via CIBSE in addition to the organisers of the Mapping program."*

> *"Thanks to the Mapping Energy Project, which has opened new opportunities for me and served as a bridge for networking and connecting with valuable members throughout the project."*

We asked the engineers to specifically document how they had networked with other participants since the final workshop day and it is evident that they are independently making contact:

Figure 11: Engineers' networking activity since the project (Base: 8)

In their comments the engineers explained further how their networking has proved beneficial beyond the timeline of the project and for one person, this contact has matured into valuable per support and potential collaborations in the future.

> *"Maintained contact with other engineers, and hopefully the school I worked with. Its really motivated me to get more involved in other projects with engaged young people."*
> *(Engineer feedback)*

> *"Taking part in the project has had a meaningful impact on my development, and I've built on the experience in several ways. I've stayed in contact with several of the engineers and participants from the project. These connections have provided informal peer support and opened up opportunities for future collaboration."*
> *(Engineer feedback)*

> *"Collaborating with other young engineers on this project provided several key benefits. It fostered great teamwork, allowing us to combine our strengths and support each other throughout the activities. Working together also encouraged the sharing of new and fresh ideas, which helped improve our approaches and problem-solving. Additionally, collaborating enabled us to share findings and insights, enhancing everyone's learning experience and contributing to the overall success of the project."*
> *(Engineer feedback)*

Other benefits of meeting colleagues through the project referenced by engineers, also included gaining insight into other areas of the profession.

OUTCOMES FOR SCHOOLS

HERITAGE LEARNING

The churches were central to how schools engaged with how to think about energy and investigation solutions for managing heat in these historic buildings. The historic context of the Wren churches was shared with the young people both in terms of the time when they were built, including the technologies that were available during previous centuries. They were then introduced to their churches and the specifics of the fabric and location of that building. One of the students wrote that the stand out thing they had learned through the project was:

> *"The special situations regarding some structures (e.g. for Grade I heritage churches)."*
> *(Student feedback)*

Teachers fed back to us that the use of historic places of worship and their contemporary role in civic life in a STEM project was unusual for their students. As one teacher commented:

> *"The way in which they engaged with the churches themselves, the curiosity around the purpose and design of the buildings and the history and social significance."*
> *(Teacher feedback)*
>
> *"Finding out what the varied uses were of the different churches now."*
> *(Engineer feedback)*

In their feedback students mainly focussed on the engineering element of their learning (see below), but when they did reference the value of carrying out their analysis in a historic church, they wrote about them as part of civic infrastructure.

> *"How different features of a city such as churches and the underground can work together to solve energy issues."*
> *(Student feedback)*
>
> *"That wasted heat from abandoned train stations can be used in churches and civic buildings."*
> *(Student feedback)*

PUBLIC ENGAGEMENT SKILLS

Image 4: Students giving presentation at the celebration day

The public engagement skills development by students included not only meeting and questioning professional engineers, church incumbents and administrators during their site visits, but also in creating written and verbal presentations of their findings.

The written element of their work was in the form of a poster. The poster needed to include visuals as well as summaries of each part of their work, their calculations and conclusions. Guidance was provided by the project team and sent to the school as well as explained in a webinar.

The following posters illustrate some of their work.

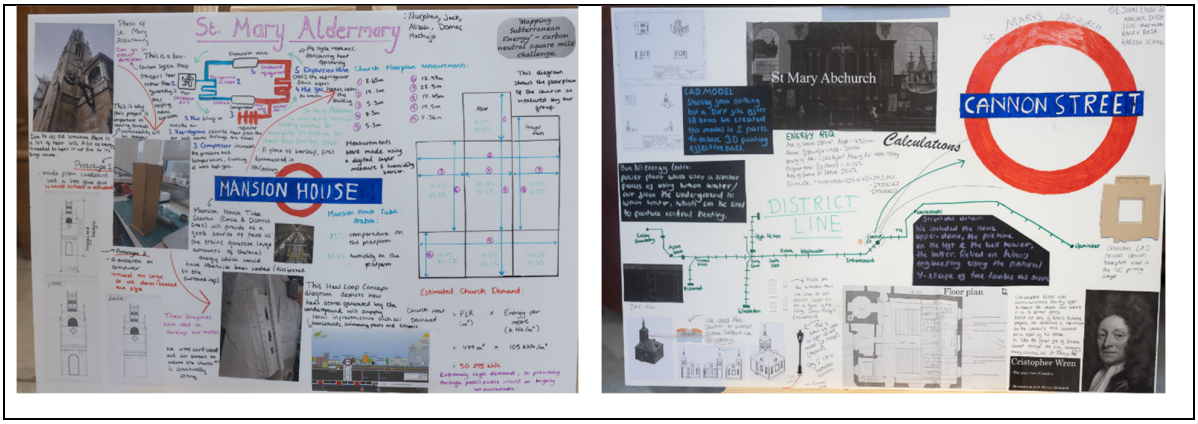

Figure 12: Posters created by schools

Some of the projects were selected for a verbal presentation during the final day celebration. It was commented on by both the engineers and their teachers that this was not something that came naturally.

> *"Standing up to present their findings at the end of the project was a really helpful experience for them, it was a real challenge for a lot of them, but they gained so much from it."*
> *(Teacher feedback)*

With encouragement and with some advice from the project team (how to give a presentation, speaking in a church space – pacing, volume, allowing for reverberation) and also practice using powerpoint and microphones.

ENGINEERING LEARNING

The Engineers were impressed by how much the students committed to the project. The model making was a particularly surprising element of the project and some students drew on their creative as well as scientific talents to represent their churches on the maps. As the engineers noted:

> *"What surprised me most was the depth of interest and enthusiasm participants showed for a topic that can seem quite technical."*
> *(Engineer feedback)*
>
> *"The level of commitment from some of the groups to create amazing models as well as their interest in engineering."*
> *(Engineer feedback)*
>
> *"The technical detail and extra research the students did was incredible and showed their passion."*
> *(Engineer feedback)*

The working model of the organ to represents how the project expanded into areas of creativity that led to a project that could easily have included Arts in the definition – a STEAM project.

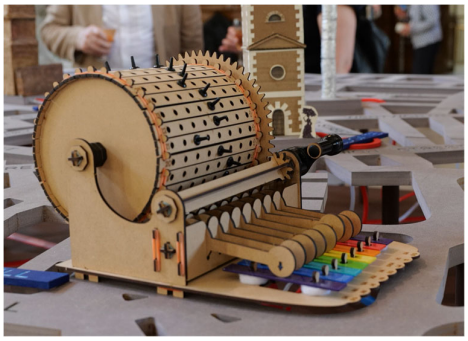

Image 5: Student creation of working organ

The 'organ' created to represent St Katherine Cree church, was not only a visual representation of the building, but it also played a tune that had been specifically written for the Wren300 celebrations.[2]

Unsurprisingly, the most frequently cited element learning that students mentioned in their comments was the use of heat pumps or the potential of energy exchange:

> *"How exchange is a fascinating way to use energy efficently, it is a great resource waiting to be fully utilized."*
> *(Student feedback)*

They also enjoyed seeing the workings of heat pumps during their visits to Bunhill and CitiGen and learning about citywide initiatives moving towards Net Zero Carbon.

In their other feedback to things they learned in regard to engineering, they talked about the application of heat pumps to resolving the climate crisis:

> *"The implementation of alternative energy sources under specific conditions."*
> *(Student feedback)*
>
> *"We need to learn how to be more sustainable especially with the changing climate."*
> *(Student feedback)*
>
> *"How heat pumps work and how they can be implemented in buildings to reduce heat lost and transfer thermal energy in a sustainable way."*
> *(Student feedback)*

Additionally, two of the students referenced the complex calculations and planning required of engineering in their work, as this example attests:

> *"Engineering requires a very thought out process and a lot of insight."*

What is striking is the lack of negativity in the students' feedback. Only one student wrote a comment that could be construed as less positive and this was about their interest in civil engineering.

ATTITUDES TOWARDS ENGINEERING

The project built in multiple opportunities to learn about engineering and speak to academics, professionals during site visits as well as young engineers about careers, their day to day work alongside the project deliverables.

In their feedback forms, students were given a series of statements about engineering to rate according to their agreements. Average ratings against theses statements are shown in the figure below as follows: Strongly agree = 2, Agree = 1, Disagree = -1 and Strongly disagree = -2.

[2] https://www.stkatharinecree.org/post/distance-between-singing-and-solidarity-in-the-wrenathon

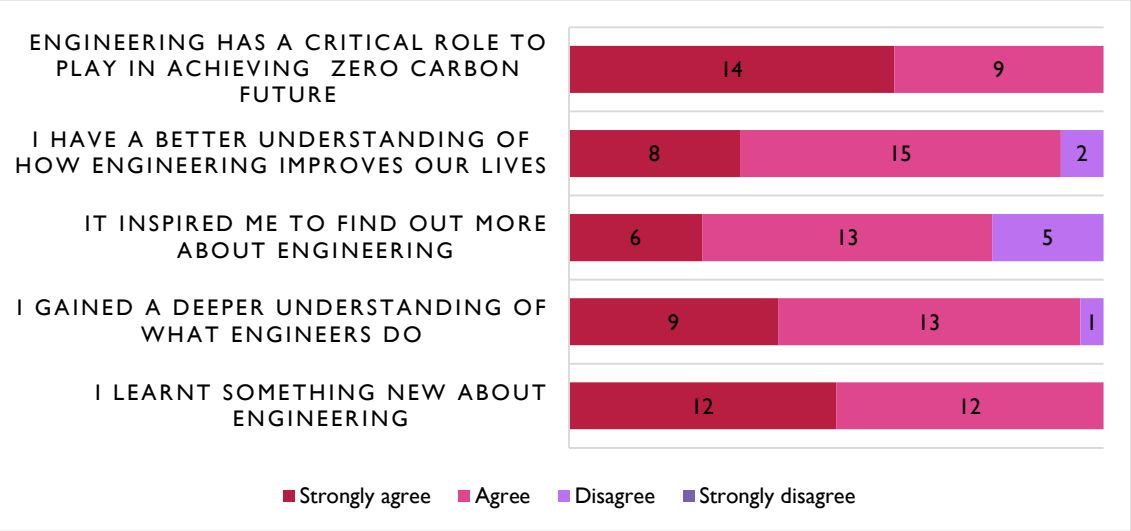

Figure 13: Student agreement with statements linked to engineering (Survey base: 25)

What the figure illustrates is that overall students were in agreement with all the statements about engineering, with the majority ticking agreement or strong agreement. Only five students disagreed with any of the statements.

In their feedback one of the teachers wrote that all of the participants had included the project in their UCAS personal statements, three had been convinced that engineering was the right course to apply for at university and two included the project in the EPQs.

The *This is Engineering* website was shared with schools to pass on to their students verbally and by email at the end of the project.

WHAT WE LEARNED

Image 6: Screenshot of exhibition at Green Hub

SELECTION & RECRUITMENT

Working in partnership was the best way to engage both schools and engineers. We learned that the geographic distance and transport links between schools and the project didn't play a hug factor in engagement. The key to success is the buy in of the teacher leading the project. Drop out really hinged on teachers' availability and space within the curriculum and not on pupil's interests.

Locating the project in London and having existing relationships with schools through the LDBS helped the project to reach schools that were based in areas of significant deprivation. Based in a location with good transport links reduced some of the challenges for participation and in one instance, where a teacher was unable to attend one of the site visits, it was possible for students to travel to the site independently, meeting a volunteer and the young engineer they'd been matched to. (We were able to find a volunteer with a suitable DBS to support the students.)

PARTNERSHIPS

The partnerships we developed in the planning and delivery of the project are ones that we hope to continue in the future. The CIBSE partnership enabled us to reach a group of engineers with an altruistic mindset and interest in educating. These STEM Ambassadors were incredibly engaged with the project and open to learning. Our connections with industry have also led to ongoing

conversations as part of our wider Sustainability work with the Square Mile Churches. We began working with Nottingham Trent University during the Wren300 celebrations and this enabled us to co-develop an application to both RAE and NHLF. The project has catalysed and strengthened these connections.

Partnerships were a key factor for success of this project and this created a strong project leadership team, able to meet and solve challenges collaboratively.

HERITAGE

The use of heritage as a lens through which to explore engineering brought participants into contact with historic churches and the Net Zero aspirations of the Church of England. Considering the historic fabric of buildings and their location (some had plague burials in close proximity) as well as the historic ways in which buildings were heated and cooled all needed to be taken into consideration by participants. The breadth of models made by students, evidences that they had thought carefully about the character of the buildings and made significant efforts to create them to scale, some with moving parts.

Image 7: Images of models created by students

The unusualness of the building types that the churches offered - large open spaces, high ceilings, historic decoration, hard surfaces – posed new questions and challenges for engineers and students when considering how heat moves within a space. Other considerations, such as the seasonality of the church calendar as well as the environmental seasons, also needed consideration.

In the early phases of the project, learning from the Wren300 project about how the architecture originally dealt with heating and cooling buildings (box pews, towers, wall hangings) were presented to students so they could consider how best to keep people warm rather than buildings. The school packs included some of this information as well as information on how to harvest heat.

Social media

We did not encourage participants to share their progress and experiences on social media. As the project developed, particularly the model making we realized how visually interesting the project was and its potential for attracting interest from school communities as well as the networks of participants. In future, we will encourage participants to document and share their work using hashtags that the team can easily track. This would also support STEM teachers to share their participation with colleagues, raising the profile of engineering in real world scenarios solving real world issues.

Other historic places of worship

At the start of the project the team had approached the religious leaders of a mosque and synagogue to enable students to consider other historic places of worship. Unfortunately, discussions did not move forwards from those early discussions made at the point of application. Our learning here is that if we want to include places of worship from other faiths, then we need to consider how best to embed those buildings in a project of this nature. Our primary schools work in the Wren300 project illustrated to us the value of bringing people from other faiths and cultures into the Wren churches. Students were interested to go into a church and could make comparisons with their own places of worship. We will consider how to build in an interfaith element to our project and consult with schools that represent other faiths (London Islamic School or the Jews Free School, for example) to see if a similar project would connect with their STEM objectives as well as community objectives.

Preparing engineers

We learned from the Wren300 project about how much time we could expect from engineers, particularly because of their work commitments. We were extremely grateful to those engineers that took part in the Mapping Energy project that were willing to take a days leave in order to attend the final celebration day and we were aware that not every employer was willing to see their participation as part of their paid employment.

This tension remains between a perception that the project is volunteering versus an important element of CPD and in future we think it might be useful for us to work with engineers to bring their employers onside. We could make even more specific the value of our projects in relation to their professional standards referencing, for example, the UK Standard for Professional Engineering Competence (UK-SPEC). One of these standards is:

> Support the learning and development of others through activities such as mentoring, and sharing professional expertise and knowledge.

Having the engineers speak about their work and career options, is a much valued aspect of the project by all concerned and while not universally an issue, there remain some employers that need convincing of the value of their employee's involvement in similar projects.

PROJECT LEGACY

THE MAP & EXHIBITION

The completed map with its energy systems and the posters are now on display at the Fleot: Green Skills Centre, New Bridge Street, EC4 (Fleet St area) until the end of September. E.ON ran a successful Mapping Energy day using the map to talk about sustainability aimed at KS3 pupils and there are plans to run further sessions during the year. These are funded by E.ON with a team of engineers from E.ON as well as our young engineers. A video of Ruth Tatagna with a school group is showing there alongside the map and poster display. We will stay in touch with E.ON to track the reach of these sessions and our project's reach to this younger age group of school children.

The display will be moved to the Wren City church, St Michael Paternoster Royal at the end of September. A stand/skirt will need to be constructed for the map. The posters will also be displayed and with the map will be used as a backdrop for further educational sessions for clergy, administrators and the wider public to raise awareness for NZC solutions in historic buildings.

CITIZEN'S SCIENCE HANDBOOK

This is now available to download and a QR code is being circulated via our networks and through our project partner, Nottingham Trent University. We will monitor downloads and collate feedback.

Partnership Activity

Many of the partnerships formed and strengthened through this project have been shared with the wider SMC Sustainability team. These have in turn been shared with the Diocese Net Zero Carbon team. The young engineer team will be offered the opportunity to be engaged in any extension of the project.

University applications

We are aware that participating students use the project as part of their personal statements and UCAS applications. We will attempt to track the outcomes of those applications from students, from our stronger school partners.

Two of the young engineers are now progressing to PhD degrees; one on a scholarship at Nottingham Trent University and one at Southbank University who will work with one of the church architects and use a church as a case study.

SUMMARY & RECOMMENDATIONS

SUMMARY

The Mapping Energy Project delivered a high quality learning experience for participants through a project that spanned a school year and gave them multiple learning experiences. The style of delivery enabled engineers to engage with the students and to form trusted relationships with the schools. Having CIBSE as a partner provided an additional layer of trust for the project and the partnership made the recruitment of engineers much smoother compared to Wren300.

Marrying heritage, engineering with sustainability created a project with real world application of decarbonisation of energy. The heritage element created a unique context into which students and engineers could test their ideas and apply their learning. Feedback from participants was extremely positive. While we had some doubts about the length of the project, in the final feedback neither the students, teachers or engineers wrote that it had been a barrier to overcome. We did lose three schools in the first half of the project, however, but their change of heart feels less a problem with the project and more an issue with timing and staff availability.

Pitching the project at Yr 12 students was not questioned by the participating young people or their teachers. Where there were questions about the students' ability to follow the science seems to be an issue of differentiating learning and iterating the resources to match their progress through subjects during Yr 12. Having a teacher on the project team might mitigate this judder in the taught element of the project and provide resources that reflect the development of pupils over time.

The strength of partnerships developed to create and deliver this project was a significant factor in its success and ongoing legacy. It is clear that while this is a summary of the project to date, the Mapping Energy Project will realise additional impact over the coming months if not years.

RECOMMENDATIONS

1. Recruit a project team to include a sixth form science teacher and representatives of other faith groups.
2. Maintain communication with schools to pick up remaining feedback and track outcomes for students.
3. In future projects, look for opportunities to create more social media and media attention for the project.
4. Track the reach of Citizen Science Handbook and solicit feedback where the audience is known.
5. Track the ongoing relationships with partnerships formed through this project and articulate how they have contributed to the wider SMC Sustainability project.

6. Track the reach of the Map & Exhibition through the partnership with E.ON. Look for opportunities to share feedback and quantify the number of pupils & schools.
7. Invite the engineers to a final project celebration event and use it as an opportunity to explore their ongoing networking and engagement to the schools and professional partners.