



EPSRC CENTRE FOR DOCTORAL TRAINING
**NEW AND SUSTAINABLE
PHOTOVOLTAICS**

Student Handbook

www.cdt-pv.org

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1 Introduction

Welcome to the Centre for Doctoral Training in New and Sustainable Photovoltaics. You are embarking on a unique PhD programme and by the time you attain your degree after four years you will have received bespoke training from seven of the UK's leading PV research groups, engaged with a very wide range of academic and industry experts with the field and formed an extensive network of colleagues and research contacts. Photovoltaics is currently undergoing a rapid expansion in the UK and following the attainment of your PhD you will be extremely well placed to begin a very rewarding career in this field should you choose.

The following handbook has been put together to introduce you to the shape and style of the CDT and to provide an outlook of what is to be expected once you begin your studies. This handbook should be used in conjunction with your own institution's guidelines for PhD candidates (see Appendix A). Up to date information will also be available at the Centre's website www.cdt-pv.org.

PhD students are a rich source of new ideas for any expanding field of research. Your contributions throughout your research and studies will be highly valued within the field of Photovoltaics.

2 About the CDT

This Centre for Doctoral Training is part of a much broader UK research initiative funded by the Engineering and Physical Sciences Research Council (EPSRC). In total the EPSRC, in conjunction with University and Industry partners, has invested over £950m in 115 separate Centres¹ with research focusses that include Advanced Materials, Energy, Healthcare and Manufacturing.

This CDT constitutes an investment of £8m which will fund a total of 65 students spread across 5 distinct cohorts. This represents an unprecedented dedication to graduate training and the generation of new research within the

¹<http://cdt-pv.org/files/EPSRCFactsheet.PDF>

field of photovoltaics.

2.1 Aims and Objectives

The over-riding aim of the centre is to provide an enhanced and highly specialised training programme for doctoral students in the field of photovoltaics.

More specific objectives include:

- Further improving the PhD experience through a cohort-based approach to student training.
- Exposing doctoral students to state of the art facilities and laboratories across the UK and encouraging the development of multi-institutional collaborative research.
- Creating future leaders within the next generation of scientists and engineers in the field of photovoltaics.
- Enhancing the mobility of researchers moving between academia and industry to promote the transfer of new knowledge and enable greater innovation in the economy.
- Delivering research that enables the UK economy to develop and adopt sustainable, resource-efficient, low-carbon, low pollution and low-waste technologies.

2.2 Project Partners

The CDT in New and Sustainable Photovoltaics is a multi-centre project that will operate across 7 universities: Bath, Cambridge, Loughborough, Liverpool, Oxford, Sheffield and Southampton. Funding for the CDT is also coupled with industry support which will allow the centre's research outputs to have a direct impact on the skills and knowledge base of the energy sector. To date, the consortium of companies involved in the centre includes BAE systems, Eight19,

Echerkon, LSA Ltd, SiliconCPV, Ossila, Oxford PV, PowerVision, M-Sovl, Mc-Camley Middle East Ltd and Taylor Hobson.

2.3 Directory

For most day to day issues associated with your project all enquiries should be directed towards your supervisor. If however you have any other problems/questions then please contact the most appropriate person below.

Table 1: Useful Contacts

Responsibility	Name	Location	e-mail	Tel
Director	Prof. Ken Durose	Liverpool	ken.durose@liverpool.ac.uk	0151 795 9048
Academic Director	Prof. Alison Walker	Bath	a.b.walker@bath.ac.uk	0122 538 3322
Academic Manager	Dr. Robert Treharne	Liverpool	R.Treharne@liverpool.ac.uk	0151 795 8125
Quality Reviewer	Dr. Adam Manis	Liverpool	a8mannis@liverpool.ac.uk	0151 794 5823
Cohort 1 Mentor	TBA			
Cohort 2 Mentor	TBA			
Cohort 3 Mentor	TBA			
Cohort 4 Mentor	TBA			
Cohort 5 Mentor	TBA			
Coordination Support	Suzanne Fitzpatrick	Liverpool	suzfitz@liverpool.ac.uk	0151 765 0673

3 You and Your Supervisor

The student-supervisor relationship is a key element in your success as a PhD student. It is important that both you and supervisor make sufficient effort to maintain a good relationship throughout your studies. Here are a list of guidelines as to what you can expect from your supervisor and in turn what your supervisor can expect from you. The supervisor's defined role will vary between institutions and remember that the relationship between you and your supervisor will be unique.

3.1 What you can expect from your supervisor

1. Regular contact: You can expect either formal or informal interaction with your supervisor on a regular basis, e.g. once a week (although once a fortnight is not unheard of).
2. Guidance: When you start your PhD your supervisor should give you a good idea as to how you should initially proceed with your project. After this, your supervisor should provide further guidance as and when required. However, do not expect to receive a list of instructions on what to do - that's very much up to you.
3. Feedback: It is important that you receive feedback on how you are progressing with your project. Any work that you present to your supervisor in the form of a presentation or report should receive some response in the form of verbal or written comments. Some supervisors request reports at regular intervals throughout your studies, others are happy to receive updates at intervals dictated by you (within reason - daily is too often, annually is not often enough).

If there is a problem, if you are blocked or stuck in your work, if you have lost confidence, if you are experiencing domestic troubles of whatever kind, or if anything else at all is interfering with the continuation of your work, then do let your supervisors know about it. They will be able to help.

3.2 What your supervisor can expect from you

1. Regular contact: Even if a supervisor does not request formal meetings with you on a regular basis then you should still touch base with them frequently and let them know what you're up to. Remember, supervisors are not idiots - if you actively avoid your supervisor for weeks on end because you've hit a snag and can't present them with new results then they will know something's up. Always be honest with your supervisor.

Most will be acutely aware of the pitfalls of a PhD - they've had to do one too!

2. Independence and Initiative: Your supervisor will expect you to be able make decisions based your own judgement, e.g. What temperature range should I investigate? How many samples should I make? ... etc. Also, If you ever have to ask yourself “*what should I do now?*”, then don't be afraid to act on your own ideas. If you wander too far off track your supervisor will tell you so the next time you discuss your work.
3. Enthusiasm: If you are not excited about your research who else will be? When postgraduates are really excited about what they are doing, it stimulates those around them. Excitement is infectious,² and an enthusiastic student can provide a shot in the arm for even a well established research group. All research projects within the CDT have been selected by the academic partners for their high potential impact within the field of PV. This means that any new research generated by you will be highly significant to a wide community of scientists and industries.

3.3 Your second supervisor

If you have not been appointed a second supervisor before the start of your project then you should request that your supervisor find one for you when you do start. Your second supervisor has an important role: they should be there to give help and advice when your first supervisor is unavailable and should also be able to provide further feedback on your progress. A second supervisor is not some passive entity that only exists to satisfy the paperwork, don't be afraid to approach them with questions of either a technical or pastoral nature if you feel the need.

Very often, a second supervisor will mediate should the relationship between a student and their first supervisor become fraught. It is not uncommon for a

²E. M. Phillips and D. S. Pugh, *How to get a PhD*, Open University Press, Chap. 8, p. 101

student's first and second supervisors to swap roles during a project or for the second supervisor to find the student a new first supervisor.

Sometimes a student may wish to discuss a matter in confidence with someone who is not their first or second supervisor. In this case it is recommended that you contact the person in your department that oversees postgraduate study. Your cohort mentor (see below), the CDT's Academic Director or its Academic Manager will also be happy to provide confidential advice if it is asked for.

4 Your Cohort

Obtaining a PhD can sometimes be a lonely endeavour, particularly as a student progresses through their penultimate and final years of study. The purpose of grouping the centre's students into distinct cohorts is so that there will always be a group of like-minded individuals on hand to discuss your work and problems with. A vital objective of the CDT is that a high level of communication is maintained amongst the cohorts. Members of your own cohort, and indeed subsequent cohorts, will share in a lot of your experiences and will be able to provide support if and when you need it. Remember, this support is a two way street and all cohort members have a responsibility to help ensure the well being of their fellow students.

4.1 The Role of the Cohort

The cohort system is unique to the Centres for Doctoral Training initiative and in addition to providing a support network for students they present significant advantages compared to those afforded to students embarking on more conventional PhD programmes. Such advantages include:

1. Solving technical troubles: It is likely that any technical problems you encounter will also be experienced, and perhaps even solved, by other members of the cohort. It is unlikely that in these instances, where your prob-

lem involves the nitty gritty of day to day labwork that your supervisor will have the practical experience to advise you. The cohort will act as an open technical forum and be a terrific resource for problem solving. Note that this will be facilitated by the cohort network that will operate through the www.cdt-pv.org website.

2. Feedback: You will have plenty of opportunities to present your work to your cohort and engage in detailed technical discussions during more informal seminar events. Your peers within the cohort will be able to provide honest and constructive feedback on your work and will expect you to provide them with the same. This type of group feedback often picks up on aspects of your work that has been overlooked or sometimes misinterpreted by a supervisor and can be extremely useful.
3. Collaboration: Each of the University Groups associated with the centre have a distinct set of capabilities, e.g. specific characterisation or deposition equipment, computing resources, etc. Students within the CDT are encouraged to visit cohort members at other institutions in order to engage in collaboration on an informal basis. This allows students the opportunity to greatly strengthen their own research and encourages knowledge transfer between the CDT's research groups.

4.2 Cohort Mentors

Each cohort will be assigned a mentor. The role of your cohort mentor is that of a trusted advisor who can provide counsel, encouragement and career advice, and also take a general interest in your development. The mentor is independent of your supervisors and takes no responsibility for the performance or assessment of your progress. Mentors may also organise social and other events for the cohort. Where students need more pastoral support the mentor may refer them to appropriate sources.

4.3 Cohort Student Representatives

Each cohort will elect a student representative at the end of the first CDT training event (i.e. Liverpool, November). The cohort is responsible for administering the election itself, i.e. handling nominations and votes, and ensuring that the process is independent of the academic members. The role of student representative will be to provide feedback on training, flag up any problems within the cohort or make requests on behalf of the cohort to the CDT board. They will be expected to attend at least one CDT board meeting annually.

5 PhD Timetable

5.1 Year 1

A significant portion of your first year of study (14 weeks between November and June) will be taken up by the CDT training programme (see section 6). This will involve travelling to each of the partner institutions in turn and spending up to two weeks at each location. You will also attend several showcase, seminar and industrial events throughout the year. When you are not away from your host university you will be free to work on your project. In your first year, particularly the first month or so, expect to do a lot of reading. You will need to get up to speed on the literature relevant to your project and get to grips with any bits of physics or chemistry required for you to form a critical appreciation of other people's work within the field. At the end of the first year you will be required to submit a brief literature review or report on your work to the CDT board.

5.2 Year 2

In your second year of study you will be free to really get to grips with your project. It is likely that you will start to plan and perform extended experiments and make deep investigations into your topic of study. You will still attend frequent training events organised by the CDT and will be required to

travel around the partner institutions, however these events will be less intensive compared to those within the first year training programme and you should expect to spend no more than a few nights away from your host university each time. You might also want to think about attending national conferences and workshops to present your work. Conferences are a great way to build your list of academic contacts and to put yourself on the map within the field of PV. An updated list of upcoming PV events will be maintained at cdt-pv.org. Conferences often organise researcher workshops that are usually immediately before or after the main conference. Attending these events is a great way to meet other PhD students and form further collaborations at institutions outside the CDT.

At the end of your second year you will be subject to a review that will be reported to the CDT board just so that we know that you're still on track. Your supervisor will be responsible for instigating this review.

5.3 Year 3

Now it is likely that you will know more about the issues surrounding your specific project than anybody one else (including your supervisor). Any new research that you generate at this point will certainly be of great interest to the PV community and you should consider submitting abstracts to both national and international conferences to present your work either orally or as a poster. You will continue to perform experimental/theoretical investigations although you should be starting think about the final shape of your project and how it might look in thesis form. It is definitely recommended that you have a rough thesis plan by the end of your third year.

You should also be encouraged to formalise your work for publication in an academic journal. Writing a scientific paper is a demanding task but is an important skill to learn. If you can publish a paper in your third or fourth years then this will significantly help you when you write your thesis. Often, it is very easy to re-work a published journal article into a distinct thesis chapter

5.4 Year 4

Now is the time to start finishing off your investigations and collating your research. If you are an experimentalist, try to resist the temptation to start new experiments. Remember, it's only a PhD! You will have plenty of opportunities to perform more experimental work if you choose to pursue an academic career. The sooner you collect your research and flesh out your thesis plan the better. It is almost certain that writing your thesis will take longer than you think. As a rule of thumb, plan how long you think it will take and double it. Also, be reassured that although writing your thesis is probably one of the hardest things you will ever do, the sense of accomplishment that you get once its completed is phenomenal.

6 First Year training

The purpose of the first year curriculum is to provide specific training that is both relevant to your project and that will equip you with additional knowledge and skills that might not be gained through independent research and study. While the curriculum is specifically designed to address the field of Photovoltaics you will cover a wide range of subjects including: semiconductor and device physics, UK energy policy, entrepreneurship, nanotechnology and advanced materials. It is hoped that this training, placed within the context of your own research activities, will provide you with a very broad research outlook that most PhD candidates do not get. Furthermore the modules are specifically designed to promote student interaction within the cohort, on both professional and social levels, and it is hoped that sharing the training experience with the rest of your cohort will be an enjoyable experience.

The training consists of 7 two week modules given at each of the partner institutions (see table 2 for dates and locations). Up to date information regarding the training modules can be found at <http://cdt-pv.org/training.php>. In general, each module will consist of a lecture course of 8 - 10 lectures fol-

Table 2: Module Calendar 2014/15

Module Title	Location	Dates	Module Coordinator
Fundamentals for New and Sustainable PV	Liverpool	Nov 3 - 13	Dr. Robert Treharne
Renewable Energy, The Developing World, Entrepreneurship	Cambridge	Dec 1 - 12	Prof. Neil Greenham
Research Skills in Photovoltaics and PV in action	Sheffield	Jan 12 - 23	Prof. David Lidzey
Nanotechnology and Winning Technologies	Southampton	Feb 2 - 13	Dr. Giles Richardson
Design for High Performance and Business Skills	Bath	March 2 - 12	Prof. Alison Walker
Advanced and Sustainable Materials	Oxford	April 6 - 17	Prof. Henry Snaith
Systems, Real PV Performance and PV in Business	Loughborough	May 4 - 15	Prof. Mike Walls

lowed by related labwork, a Team Challenge and various other masterclasses and workshops. You will be assessed (see 6.1) throughout in a variety of ways. This will include a brief examination at the end of each lecture course given within each module. Although assessment is necessary, it should not detract from what will be a highly unique and rewarding training experience.

6.1 Assessment

It is important that you are assessed throughout your training and that you demonstrate to the module coordinators that your learning objectives for each module have been met.

Credits

By attending the training modules and completing the associated assessments you will be awarded 20 credits per module. A total of 140 credits will be gained by fully completing the training curriculum after the first year.

Examinations

Exams will typically last for 1 hour and will be sat immediately after receiving a module's lecture course. Every exam will be designated a pass mark of 50%. On passing, students will be awarded 5 credits.

Written Reports, Group Reports and Presentations

Written reports and Group reports will adhere to the format specified by each of the module coordinators and will be submitted either directly to the coordinator or through the student portal on the CDT website. Presentations will be given in front of the whole cohort and any other people involved with the organisation of the module. Students will receive immediate verbal feedback on their presentations from their peers within the cohort and, if the module leader finds them acceptable, they will be awarded 5 credits.

6.2 Requirements for passing the first year

After your training you will be expected to have attained a credit score of at least 120/140. There will be no minimum level set to determine a student's progression to the second year but the records of students with scores below 120 will be reviewed by the Academic Director. You will also have to meet the progression requirements set by each of your own university - this typically involves a written report, viva or presentation. Students will be required to provide a brief report of their research and training progress by **30 Sept 2015** to the Academic Director. A document explaining the requirements for this report will be emailed to all students by 30 November 2014. With this report, students are encouraged to submit to the Academic Director any reports on their research that they have written for their own institutions.

6.3 Student Feedback

At the end of every module you will be given the opportunity to provide honest, constructive feedback on the training that you receive through the CDT website and can do so anonymously if you wish. Any comments, complaints, suggestions that you provide will be greatly appreciated. If, for example, you feel that a particular aspect of a module doesn't work it's important that you let the us know exactly what you thought was wrong with it. We can then make then make the necessary improvements for subsequent cohorts. Also, if at any point

throughout your PhD you think that you and your cohort might benefit from training in a specific subject or area that the CDT does not currently provide then please let us know via your cohort representative.

7 Workshops, Showcases and Conferences

You will be required to attend a variety of workshops throughout years 2 and 3 of your studies. The CDT website will be updated regularly with information concerning upcoming events and you will also be kept up to date via e-mail.

The annual CDT Showcase will be held at each of the partner institutions in turn. All cohorts, academic partners and industry partners will be invited to attend and the event will take the form of a mini conference. All students will be expected to present their work at least once at a Showcase event.

As mentioned above, you are free to attend national conferences and meetings throughout your PhD. It will also be your responsibility to provide your cohort with feedback on the conferences and report on any new developments within the field. Your conference reporting needn't be too formal and you are encouraged to make good use of social media (see below) to communicate with your cohort.

The CDT is linked to the activities of the SUPERGEN PV 'SuperSolar' Hub³. This will enable students to engage more widely with the PV research community by providing access to further training events, national and international research conferences and industry forums.

8 Outreach

Being able to communicate the issues surrounding your field to non-academic audiences is an incredibly important skill to learn. The CDT encourages its students to maintain an active outreach profile throughout their studies and engage frequently with public groups, particularly schools. One excellent way

³<https://connect.innovateuk.org/web/supersolar-hub>

of doing this is to become a STEM ambassador⁴. The STEM network will provide you with plenty of opportunities within your local area to engage in outreach. For more information visit <http://www.stemnet.org.uk>.

Performing outreach is an incredibly rewarding experience and your input will directly encourage young people to consider pursuing qualifications and careers in science and engineering. It is also an excellent opportunity for you to develop confidence and new skills that will greatly enhance your future employability.

9 Social Media

The use of social media through your PhD is a double edged sword. Using sites such as LinkedIn, Research Gate and Facebook can be an excellent way to develop a network of research contacts, publicise your work and establish a reputation in the field. However, remember that your attention is a limited resource, and a PhD requires that you focus your attention intensely on the problems that arise in your research and writing. **This has to take priority**, so be careful when investing your time and attention in social media. Make sure it does not distract you from the main task at hand - your PhD.

That said, here are a few examples of how social media can be of benefit to the CDT:

1. Conference Reporting: It is impossible for the CDT to send every student to every PV conference. Using Twitter to report directly on talks that you attend during a conference mean that the rest of your cohort can share in your experience without leaving their own host institutions.⁵
2. Videos and podcasts: Sometimes, describing a tricky technical process via e-mail can be difficult. Posting video or audio recordings that document technical aspects of your work can be of great benefit to other members of

⁴<http://cdt-pv.org/files/STEM.pdf>

⁵<http://blog.sli.do/ultimate-guide-to-live-tweeing-at-conferences/>

the cohort engaged in similar work. More general videos that provide an overall outlook on your research or a description of your group's capabilities can also greatly improve your collaboration potential.

3. Feedback: Through twitter, you can provide instant feedback on your CDT experience. Your comments and suggestions will be appreciated. By following @cdtpv you can also be kept up to date with all developments within the centre.

A Graduate Handbooks

University	Link
Bath (Physics)	http://www.bath.ac.uk/science/gradschool/links/Physics_PGR_Handbook_2012_CVY_edit.pdf
Bath (Chemistry)	http://www.bath.ac.uk/science/gradschool/links/Chemistry_PGR_Handbook_2012_CVY_edit.pdf
Cambridge	http://www.phy.cam.ac.uk/internal_resources/admin/cav-lab-handbook.pdf
Loughborough	http://www.lboro.ac.uk/students/welcome/handbook/postgraduateprogrammes/
Liverpool (Physics)	https://www.liv.ac.uk/media/intranet/physics-intranet/Physics_PGR_Handbook.2013-14.pdf
Oxford	https://www2.physics.ox.ac.uk/research/atmospheric-oceanic-and-planetary-physics/graduate-handbook
Sheffield	https://www.shef.ac.uk/polopoly_fs/1.210785!/file/PhD-physics-handbook-13-14.pdf
Southampton (Maths)	http://students.maths.soton.ac.uk/documents/regulations/pghandbook.pdf
Southampton (Physics)	http://phyweb.phys.soton.ac.uk/pgadmin/files%20for%20phd%20webpage/PG%20Handbook/PG%20Handbook.pdf

B Project List

University	Project Title	Student	First Supervisor
Bath	Investigation of non-standard materials and materials deposition methods for hybrid perovskite solar cells	Peter Kubiak	Dr. Petra Cameron
Bath	Mesoscale model for hybrid solar cells employing sulfides and perovskite structure materials	James Cave	Prof. Alison Walker
Cambridge	Recombination in solution-processed photovoltaics studies by magnetic field effects	Edward Booker	Prof. Neil Greenham
Cambridge	Doped binary oxides for enhanced performance solar cells	Lana Lee	Prof. Judith Driscoll
Liverpool	Microstructure and functionality in thin film solar cells from sustainable materials	Peter Yates	Prof. Ken Durose
Liverpool	New heterostructures for perovskite solar cells	Silvia Mariotti	Prof. Ken Durose
Loughborough	Mapping spectral characteristics of a PV module	Vincent Tsai	Prof. Ralph Gottschalg
Loughborough	New back contacts for thin film CdTe solar cells	Christos Potamialis	Dr. Jake Bowers
Oxford	Photophysics of organometal halide perovskite materials for next-generation solar cells	Elizabeth Parrott	Prof. Laura Herz
Oxford	Organic solar cells based on small molecules	Giulio Mazzotta	Dr. Moritz Riede
Sheffield	Modelling charge transport in perovskite solar cells	Michael Stringer	Prof. David Lidzey
Sheffield	Evaluating new polymeric materials for photovoltaic devices	Benjamin Freestone	Prof. David Lidzey
Southampton	Modelling charge transport in perovskite solar cells	Nicola Courtier	Dr. Giles Richardson
Southampton	Ultrathin hybrid photovoltaics	Giacoma Piana	Dr. Stuart Boden