Optimal scheduling of EV charging in distribution networks

Mission Statement

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Summary and initial literature review

The transport sector accounts for a significant proportion of total energy consumption and is to date largely based on fossil fuels. With the objective to mitigate greenhouse gas emissions and become environmentally benign, the electrification of transport has progressed considerably by continuous development of hybrid and purely electric vehicles. However, conditions apply to achieve sustainability. First, the additional load of uncontrolled residential EV charging will negatively impact the low-voltage distribution network. Effects include excessive voltage drops and overloading of network components when many EVs charge simultaneously [1]. Second, a decarbonisation of electricity generation must accompany the expansion of electric vehicles. Consequently, increased intermittent renewable energy generation will add to the need for smart grid management.

While investment in major network reinforcement is an intuitive measure to incorporate additional loads, it is deemed more economically efficient to encourage EV users to charge at off-peak times. Exploiting typical load flexibility of electric vehicles by controlled charge scheduling as means of demand-side management will allow substantial penetration levels in existing distribution networks and a mitigation of the network strains they evoke. This can be achieved by simple charge rate modulation with unidirectional power flow or additionally the provision of ancillary services to the system operator with bidirectional power flow [1]. The electric vehicle unites aspects of an energy consumer and a regulation provider simultaneously.

For users of electric vehicles to engage in coordinated charging and give up part of their flexibility, attractive monetary incentives and low acceptance barriers are essential.

Real-time electricity prices and time-varying regulation market clearing prices are both, a reflection of the general network state and a source of cost minimisation potential for consumers. For the small-scale capacities of individual electric vehicles to gain access to large-scale wholesale electricity and regulation prices an intermediary is necessary to which multiple consumers surrender charging control. This so-called aggregator optimises electricity bill savings and revenue from the provision of regulation services while observing network, equipment and demand constraints [3].

Whilst the commonly stated range anxiety of users of electric vehicles has been largely solved by the advent of modern Li-ion batteries, reliability and battery degradation remain major concerns besides high investment costs [1]. The latter may be solved by participation in power markets, whereas the former highlights the need for optimised charging schedules to avoid control sequences detrimental to battery life. Examples are the avoidance of large variations in charging rate over consecutive time steps, limitations on the depth of discharge or the minimisation of frequent charge and discharge cycles.

The availability of electric vehicles is often regarded as key determinant of load shifting potential and pre-set arrival/departure times are enforced by contractual obligations [2]. Although breaches of contracts occur, these are rarely considered during optimisation and may be penalised. Planning uses fixed arrival and departure times. Even if the arrival times are stochastic, EV owners are usually asked to specify their expected departure time and required battery charge to the aggregator for optimisation purposes. A relaxation of such constraints on users of electric vehicles would facilitate widespread adaptation of EV charging control, as besides flexibility of use it omits inconvenient latency and diligence in communication. However, it also permits further uncertainty to the optimisation [5]. To ensure a reliable battery charging processes, permitted uncertainty requires consideration by accurate prediction in conjunction with other, more inherent sources of uncertainty. Assessment of their impact on the performance of centralised charge control will be a principal contribution of this dissertation project.

Whilst on an aggregate scale consumer behaviour is quite accurately predictable, forecasts on an individual basis are prone to substantial deviations [2]. Inherent uncertainties besides the indeterminate arrival/departure times and locations are the battery state of charge upon arrival, residential load including the variability of possible local PV generation, and market prices for wholesale electricity from which cost savings are obtained and regulation services from which revenue is generated. Their negligence may entail severe economic losses to consumers and, thus, require accurate modelling. Other than multiple previous research works, likely deviations from market price forecasts will be considered for optimisation [4]. Furthermore, the coupling of vehicle-to-grid application and local generation as supplemental source of variability to residential loads is novel, but its significance must yet be determined depending on their level of coincidence.

In the light of newly introduced sources of uncertainty, previously utilised optimisation approaches will be implemented, adapted and tested for their performance in minimising EV charging cost and risk of load mismatch between forecasted and actual EV loads. Amongst others, receding optimisation horizons will be applied as means of uncertainty mitigation [2]. Dynamic programming, mixed-integer non-linear programming, heuristics, particle swarm optimisation, and genetic algorithms rank high among the most commonly applied optimisation techniques [1].

Main aims and objectives

- Develop a cost-minimising bidirectional scheduling algorithm for charging electric vehicles and supplying ancillary services. While observing network, equipment and demand constraints in a stochastic environment, the algorithm should combine consumer electricity bill savings with grid support. Academically, it should further enable the study of a potential trade-off between permitted uncertainty in terms of EV availability and low consumer acceptance hurdles of remote EV charging control.

- Characterise inherent and permitted uncertainties incurred with the optimal scheduling of EVs and evaluate their individual impact on optimisation at varying error margins.

- Analyse the implications of relaxing contractual obligations for the consumers' EV availability and the aggregator's allocation of final battery state of charge.

- Assess the performance of multiple optimisation methods under uncertainty and approaches to mitigate their sensitivity to prediction errors; that is to give an indication of the effectiveness and robustness of analytical, heuristic and artificial intelligence approaches.

- Evaluate the scalability of an aggregator not only in view of computational complexity but also of the interplay with varying degrees of uncertainty.

- Provide insights about the prospects of vehicle-to-grid technologies.

Interim targets

- Demonstrate the negative impact of uncontrolled EV charging on distribution networks, provide a review of electricity market mechanisms, make a case for demand-side management, and legitimate central control by an aggregator.

- Identify potential facilitators and prevalent barriers for EV owners' engagement with aggregators which require consideration in the analysed scenario.

- Compile and structure previously performed research on the optimal scheduling of electric vehicles and related research areas by summarising underlying assumptions, scenarios, approaches to system modelling, objective functions, enforced constraints, and applied optimisation methods.

- Learn or refresh methodological skills in the fields of stochastic programming, particle-swarm optimisation, genetic algorithms, dynamic programming, Markov chains and statistical applications for scenario reduction and time-series analysis.

- Decide on a suitable programming environment that equally satisfies requirements for and accurate representation of the reality and an efficient implementation of optimisation methods while maintaining a high degree of generalisability.

- Acquire empirical or representative data of mobility travel patterns, residential load, local PV generation, electricity prices, and regulation service prices.

- Build scenario via representative models of
  - a test distribution network defining network constraints allowing for variable penetration levels,
  - stochastic consumer behaviour including arrival/departure times as well as energy demand,
  - physical residential systems including electric vehicle attributes and local PV generation, and
  - electricity and regulation service markets providing information on the general network state.

- Define a fitting mathematical problem formulation.

Methodology and draft work plan

The dissertation will be an optimisation study based on a developed simulation model which forms the basis for project evaluation. It is yet to be decided which programming platform is deemed most suitable for the proposed undertaking. Because of the consecutive character of the project, the work programme builds naturally.

The main tasks will consist of

(a) a comprehensive literature review,	(0.5 weeks)	[after previous work]
(b) the mathematical problem formulation,	(0.5 weeks)	
(c) thoughtful system and behaviour modelling,	(2.5 weeks)	
(d) implementation of optimisation methods,	(2.5 weeks)	
(e) evaluation and critical analyses of results,	(1 week)	[without overlap]
(f) dissertation write-up,	(3 weeks)	
(g) final editorial works and time buffer.	(2 weeks)	

Of the tasks, only the literature review has been performed to date mostly in preparation of this mission statement. A multitude of journal articles has been reviewed and will be compiled insightfully upon commencement of the main project phase in mid-May. The sequence of subsequent activities following the exam period is outlined in the calendar on the next page.

Week	Day	Date	Month	Activity
1	Mo	15	May	Finalise literature review
	Tu	16	May	
	We	17	May	
	Th	18	May	Define setting/assumptions
	Fr	19	May	Problem formulation
	Sa	20	May	
	Su	21	May	
2	Mo	22	May	Modelling
	Tu	23	May	
	We	24	May	Torness plant visit
	Th	25	May	
	Fr	26	May	
	Sa	27	May	
	Su	28	May	
3	Mo	29	May	
	Tu	30	May	
	We	31	May	
	Th	1	June	
	Fr	2	June	
	Sa	3	June	
	Su	4	June	
4	Mo	5	June	
	Tu	6	June	
	We	7	June	
	Th	8	June	Implement optimisations
	Fr	9	June	Project presentation
	Sa	10	June	
	Su	11	June	
5	Mo	12	June	
	Tu	13	June	
	We	14	June	
	Th	15	June	
	Fr	16	June	
	Sa	17	June	
	Su	18	June	
6	Mo	19	June	
	Tu	20	June	
	We	21	June	
	Th	22	June	
	Fr	23	June	Scholarship seminar
	Sa	24	June	(tentative)
	Su	25	June	
7	Mo	26	June	
	Tu	27	June	
	We	28	June	Holiday
	Th	29	June	
	Fr	30	June	
	Sa	1	July	
	Su	2	July	
8	Mo	3	July	Evaluation / Analysis
	Tu	4	July	(extends into write-up)
	We	5	July	
	Th	6	July	
	Fr	7	July	Examiner interview
	Sa	8	July	Write-up
	Su	9	July	
9	Mo	10	July	
	Tu	11	July	
	We	12	July	
	Th	13	July	
	Fr	14	July	
	Sa	15	July	
	Su	16	July	
10	Mo	17	July	
	Tu	18	July	
	We	19	July	
	Th	20	July	
	Fr	21	July	
	Sa	22	July	
	Su	23	July	
11	Mo	24	July	
	Tu	25	July	
	We	26	July	
	Th	27	July	
	Fr	28	July	
	Sa	29	July	
	Su	30	July	
12	Mo	31	July	Submission of final draft
	Tu	1	August	Editorial and review
	We	2	August	
	Th	3	August	
	Fr	4	August	
	Sa	5	August	
	Su	6	August	
13	Mo	7	August	Poster design
	Tu	8	August	
	We	9	August	
	Th	10	August	
	Fr	11	August	Final review
	Sa	12	August	
	Su	13	August	
14	Mo	14	August	Dissertation printing
	Tu	15	August	Submission dissertation/poster
	We	16	August	Preparation of presentation
	Th	17	August	
	Fr	18	August	
	Sa	19	August	
	Su	20	August	
15	Mo	21	August	Poster printing
	Tu	22	August	Poster presentation

Required resources

None whatsoever.

Health and safety implications

(a) A preliminary health and safety assessment anticipates no extraordinary risks involved in conducting the proposed project other than prolonged use of computers. Since no laboratory work is required and dissertation results will stem from computer simulations only, potential risks that deviate from ordinary office work are non-existent. This issue, however, was addressed in the General Risk Assessment Form RA1 as attached and further supplemented by the Display Screen Equipment Risk Assessment Form DSE.

(b) An actual implementation of the project outcomes is not expected to add major health and safety risks to the operation of low-voltage distribution networks. This is because no equipment with safety standards and risk implications deviating substantially from equipment in use is required. Naturally, failure of the proposed control scheme entails similar if not higher risk implications as ordinary distribution network failures. However, as under normal conditions intelligent control aims to mitigate detrimental impacts on the network, a decrease rather than an increase in hazards is anticipated overall. Nonetheless, at the current stage no informed statement on the change in reliability can be made.

References

[1] Kang Miao Tan, Vigna K. Ramachandaramurthy, Jia Ying Yong, "Integration of Electric Vehicles in Smart Grid: A Review on Vehicle to Grid Technologies and Optimization Techniques," in *Renewable and Sustainable Energy Reviews*, vol. 53, pp. 720-732, January 2016.

[2] A. O'Connell, D. Flynn and A. Keane, "Rolling Multi-Period Optimization to Control Electric Vehicle Charging in Distribution Networks," in *IEEE Transactions on Power Systems*, vol. 29, no. 1, pp. 340-348, Jan. 2014.

[3] S. Han, S. Han and K. Sezaki, "Development of an Optimal Vehicle-to-Grid Aggregator for Frequency Regulation," in *IEEE Transactions on Smart Grid*, vol. 1, no. 1, pp. 65-72, June 2010.

[4] Wenbo Shi and V. W. S. Wong, "Real-time Vehicle-to-Grid Control Algorithm Under Price Uncertainty," *2011 IEEE International Conference on Smart Grid Communications (SmartGridComm)*, Brussels, pp. 261-266, 2011.

[5] F. Soares, J. Lopes, P. Almeida, C. Moreira, and L. Seca, “A Stochastic Model to Simulate Electric Vehicles Motion and Quantify the Energy Required From the Grid,” in *Proc. 17th Power Systems Computation Conf.*, 2011.

Declaration

The supervisor and the student are satisfied that this project is suitable for performance and assessment in accordance with the guidelines set out in the course documentation.

Signed: 21 April 2017

Wei Sun – *Supervisor* Fabian Neumann – *Student*

General Risk Assessment

Form RA1

(Refer to Notes for Guidance before completing this form)

School Assessment No:	
Title of Activity:	MSc Dissertation
Location(s) of Work:	University accommodation, university library, supervisor's office for meetings.

Brief Description of Work:

The dissertation is on the optimal charging control of electric vehicles in distribution networks. While the topic is based in electrical engineering, no laboratory work is required, but the project is solely based on computer simulations. Prolonged use of computers is anticipated.

Hazard Identification: Identify all the hazards; evaluate the risks (low / medium / high); describe all existing control measures and identify any further measures required. Specific hazards should be assessed on a separate risk assessment form and cross-referenced with this document. Specific assessments are available for hazardous substances, biological agents, display screen equipment, manual handling operations and fieldwork. See http://www.ed.ac.uk/schools-departments/health-safety/risk-assessments-checklists/risk-assessments for details.

Hazard(s)	**Present Risk Evaluation** L/M/H	**Control Measures** (i.e., alternative work methods / mechanical aids / engineering controls, etc.)	**Risk Evaluation after control** L/M/H
Prolonged use of computer; work on computer screen.	M	- Daily check on time spent in front of computer screen. - Limit affected working hours to 8 hours per day. - cf. Display Screen Equipment Risk Assessment Form for more detailed assessment and mitigation proposals.	L

**Continue on separate sheet if necessary*

Engineering Controls: *Tick relevant boxes*

Guarding		Extraction (LEV)		Interlocks		Enclosure	
Other relevant information (incl. testing frequency if appropriate):							

Personal Protective Equipment (PPE): Identify all necessary PPE.

Eye / Face		Hand /Arm		Feet / Legs		Respiratory	
Body (clothing)		Hearing		Other (Specify)			
Specify the grade(s) of PPE to be worn:							
Specify when during the activity the item(s) of PPE must be worn:							

Non-disposable items of PPE must be inspected regularly and records retained for inspection

Persons at Risk: Identify all those who may be at risk.

Academic staff		Technical staff		P'Grad students	x	U'Grad students	
Maintenance staff		Office staff		Cleaning staff		Emergency personnel	
Contractors		Visitors		Others			

Additional Information: Identify any additional information relevant to the activity, including supervision, training requirements, special emergency procedures, requirement for health surveillance etc.

None required whatsoever.

Assessment carried out by:

Name:	Fabian Neumann	Date:	21/04/2017
Signature:		Review Date:	21/04/2017

Display Screen Equipment/Workstation Risk Assessment:

Introduction

The following checklist is designed to allow an assessment of individual Display Screen Equipment (DSE) workstations to be carried out, in terms of the Health and Safety (Display Screen Equipment) Regulations 1992, and associated guidance.

Users should be encouraged to carry out their own risk assessment, which will then be checked by the Local Safety Adviser. A new risk assessment needs to be carried out if there is a change of user, a change in equipment, or in location/set up.

Work through the checklist, ticking either the "yes" or "no" column against each risk factor:

- "yes" answers require no further action.
- "no" answers will require investigation and/or remedial action by the Local Safety Adviser. They should record their decisions in the "Action to take" column. Assessors should check later that actions have been taken and have resolved the problem.

Please note that, though a characteristic of the workstation may not precisely match the advice given in the Regulations and Guidance, remedial action will not require to be applied if the user in question is satisfied with the item, and desires no change.

Remember the checklist only covers the workstation and work environment. You also need to make sure that risks from other aspects of the work are avoided, for example by giving users health & safety training, and providing for breaks or changes of activity. Advice on these is given in the main text of the guidance.

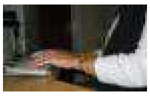
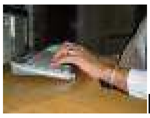
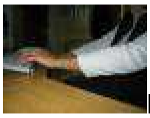
Record of Assessment

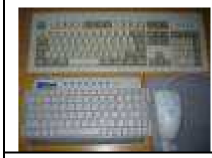
Workstation location: (School, Division, Unit etc., building, room no & floor)	*Primary: University accommodation* *Secondary: University libraries*
Name of User:	*Fabian Neumann*
Assessment completed by:	*Fabian Neumann*
Assessment checked by:	
Date of Assessment:	*21/04/2017*
Any further action needed? Yes / No Please specify action required.	*No*
Follow up action completed on:	

Assessment Checklist

Risk Factors	Yes / No		Things to Consider	Action to take
1. DISPLAY SCREENS				
Are the characters clear and readable?	X		Make sure the screen is clean and cleaning materials are made available. Check that text and background colours work well together.	
Is the text size comfortable to read?	X		Software settings may need adjusting to change text size.	
Is the image stable, i.e. free of flicker?	X		Try using difference screen colours to reduce flicker, e.g. darker background and lighter text, increase refresh rate of monitor setting. If problem persists, contact your IT.	
Is the screen's specification suitable for its intended use?	X		For example, intensive graphic work or work requiring fine attention to small details may require large display screens.	
Are the brightness and /or contrast adjustable?	X		Separate adjustment controls are not essential, provided the user can read the screen easily at all times.	

Does the screen swivel and tilt?	X		Swivel and tilt need not be built in; you can add a swivel and tilt mechanism. However, you may need to replace the screen if: - Swivel/tilt is absent or unsatisfactory - Work is intensive; and/or -The user has problems getting the screen to a comfortable position. The height of the screen should be roughly at eye level. A monitor stand may be required. If using an LCD screen, ensure it is adjustable in height, alternatively use a monitor stand.	
Is the screen free from glare and reflections?	X		Find the source of the reflections. You might need to move the screen or even the desk and/or shield the screen from the source of the reflections. Screens that use dark characters on a light background are less prone to glare and reflections.	
Is the user facing the screen.	X		Position the screen in front of the user, to avoid any twisting.	
Are adjustable window coverings provided and in adequate condition?	X		Check that curtains/blinds are in good working order. If not, report to Estates and Buildings. If these measures do not work, consider anti-glare screen filters as a last resort and seek specialist help.	
2. KEYBOARDS				
Is the keyboard separate from the screen?		X	This is a requirement, unless the task makes it impracticable (e.g. where there is a need to use a portable computer).	Use of portable computer and changing workplaces makes separate keyboard impracticable; primarily separate keyboard when university library monitor is used as secondary screen.

Does the keyboard tilt?		X	Tilt need not be built in	Possibly achieved with lapdesk.
Is it possible to find a comfortable keying position?  YES NO NO	X		Try pushing the display screen further back to create more room for the keyboard, hands and wrists. Keep elbows close to the body, do not overstretch the arms. Users of thick, raised keyboards may need a wrist rest. Users may find the use of a compact mini-keyboard more comfortable.	
Does the user have good keyboard technique?	X		Training can be used to prevent: - hands bent up at wrist - hitting the keys too hard - overstretching the fingers	
Are the characters on the keys easily readable?	X		Keyboards should be kept clean. If characters still cannot be read, the keyboard may need modifying or replacing. Use a keyboard with a matt finish to reduce glare and/or reflection.	
3. MOUSE, TRACKBALL, ETC				
Is the device suitable for the tasks it is used for?	X		If the user is having problems, try a different device. The mouse and trackball are general-purpose devices suitable for many tasks, and available in a variety of shapes and sizes. Alternative devices such as touch screens may be better for some tasks (but can be worse for others). Check the device has been set to suit the user (for right or left hand user).	
Is the device positioned close to the	X		Most devices are best placed as close as possible e.g. right beside the keyboard.	

user?  NO  YES 			Training my be needed to: -prevent arm overreaching -tell users not to leave their hand on the device when it is not being used - encourage a relaxed arm and straight wrist. A compact keyboard will help the user to avoid overreaching.	
Is there support for the device user's wrist and forearm?	X		Support can be gained from, for example, the desk surface. If not, a separate supporting device (gel filled) may help. The user should be able to find a comfortable working position with the device.	
Does the device work smoothly at a speed that suits the user?	X		Check if cleaning is required (e.g. of mouse ball and rollers). Check the work surface is suitable. A mouse mat may be needed.	
Can the user easily adjust software settings for speed and accuracy of pointer?	X		Users may need training in how to adjust device settings.	
4. SOFTWARE				
Is the software suitable for the task?	X		Software should help the user carry out the task, minimise stress and be user-friendly. Check users have had appropriate training in using the software. Software should respond quickly and clearly to user input, with adequate feedback, such as clear messages.	

5. FURNITURE				
Is the work surface large enough for all the necessary equipment, papers etc?	X		Create more room by moving printer, reference materials etc elsewhere. Use multilevel trays for papers/documents. If necessary, consider providing new power and telecom sockets, so equipment can be moved. There should be some scope for flexible rearrangement.	
Can the user comfortably reach all the equipment and papers they need to use?	X		Rearrange equipment, papers etc to bring frequently used things within easy reach. A document holder may be needed, positioned to minimise uncomfortable head and eye movements.	
Are the surfaces free from glare and reflection?	X		Consider mats or blotters to reduce reflections or glare.	
Is the chair stable & suitable for the user? Does the chair have a working: - seat back height and tilt adjustment? - Seat height adjustment? - Swivel mechanism? - Castors or glides?	X		The chair may need repairing or replacing if the user is uncomfortable, or the adjustment mechanisms are faulty. Contact the University Furniture Office.	
Is the chair adjusted correctly?	X		The user must be familiar with the chair adjustments. Adjust the chair height to sit with elbows at approx. 90º & 2cm above the desk when touching the G & H keys.	

			The user should be able to carry out their work sitting comfortably. Consider training the user in how to adopt suitable postures while working. The arms of chairs can stop the user getting close enough to use the equipment comfortably. Consider chairs without armrests or alternatively, adjustable armrests. Move any obstructions from under the desk.	
Is the lower back supported by the chair's backrest?	X		The user should have a straight back, supported at all times by the chair, with relaxed shoulders.	
Are forearms horizontal and eyes at roughly the same height as the top of the screen?		x	Adjust the chair height to get the user's arms in the right position; adjust the monitor height/tilt if necessary.	Not achievable with laptop unless secondary screen used.
6. ENVIRONMENT				
Is there enough room to change position and vary movement?	x		Space is needed to move, stretch and fidget. Consider reorganising the office layout and check for obstructions. Cables should be tidy and not a trip or snag hazard.	
Is the lighting suitable, e.g. not too bright or too dim to work comfortably?	x		Users should be able to control light levels, e.g. by adjusting window blinds or light switches. Consider shading or repositioning light sources or providing local lighting, e.g. desk lamps (but make sure lights don't cause glare by reflecting off walls or other surfaces).	
Does the air feel comfortable?	x		VDUs and other equipment may dry the air. Green plants may help to increase moisture levels in the air.	

			Circulate fresh air if possible. As a last resort, if discomfort is severe, consider a humidifier.	
Are levels of heat comfortable?	x		Can heating be better controlled? More ventilation or air-conditioning may be required if there is a lot of electronic equipment in the room. Or, can users be moved away from the heat source?	
Are levels of noise comfortable?	x		Consider moving sources of noise, e.g. printers, away from the user. If not, consider soundproofing.	
7. ELECTRICAL				
Have you carried out a user check (visual inspection) of the visually accessible parts of the equipment and it's cable, plug and extension cable.	x		See http://www.docs.csg.ed.ac.uk/Safety/Policy/Part3.pdf for more information on user checks. Carry out a user check when the equipment has been relocated. Any faults or significant wear and tear, must be reported and repaired as soon as possible (contact your local computing support) Do not use any equipment if defective. Remove from operation and label 'DO NOT USE - EQUIPMENT FAULTY'.	

Final Questions to Users:

- Is a portable computer being frequently used? If so, reduce its use to a minimum. Alternatively, have a docking station (separate keyboard, separate screen or screen elevated, separate mouse or tracking device). More detailed guidance on working with laptop computers is available at http://www.docs.csg.ed.ac.uk/Safety/health/DSE.pdf.
    - Yes, but use of university library monitors as secondary screen.
- Has the checklist covered all the problems the user may have working with the DSE?
    - I find no extensions whatsoever.

- Has the user been advised of their entitlement to eye and eyesight testing, and advised to contact the Occupational Health Unit or the Health and Safety Office to arrange appropriate eye sight testing?
    - No, but I already get my eyesight checked regularly.
- Does the user take regular breaks working away from the DSE?
    - Yes, a sensible work-life balance is naturally kept.
- Has the user read the leaflet "Are you keying comfortably"?
    - Yes, I have seen it at the university library.

Who to Contact:

- For furniture replacement or repair, contact Furniture Office, Estates and Buildings 50 2077
- For Blinds, curtains, etc EBIS Repair, Works Division
- For Computing equipment / software contact Information Services (i.e. normal contact)
- For Electrical defects contact Works Division 50 2485
- For Work environment factors (ventilation, noise, etc) contact Occupational Hygiene Unit Occupational.Hygiene@ed.ac.uk
- Following implementation and trial of any changes - For on-going Health issues related to DSE use contact the Occupational Health Unit 50 8190 / Occupational.Health@ed.ac.uk