Lecturers

Name: Ibrahim Diab
Background: Electrical Sustainable Energy department
DC Systems, Energy Conversion, and Storage (DCE&S)
Specialisation: PhD Candidate
TU Delft /
Faculty of Electrical Engineering, Mathematics, and Computer Science (EEMCS)
Contacts: i.diab@tudelft.nl

Name: Gracia Bovenberg-Murris
Background:TBM Gamelab - TU Delft
Specialisation: Project leader
TU Delft
Contacts: G.E.J.Bovenberg-Murris@tudelft.nl

Name: Doris Boschma
Background:TBM Gamelab - TU Delft
Specialisation: Project leader
TU Delft
Contacts: D.Boschma@tudelft.nl

Name: Frank Andreesen
Background: Vice President - Safety Governance
& Logistics Advocacy at Covestro
Specialisation: Sustainability
Contacts: frank.andreesen@covestro.com

Name: Pavol Bauer
Background: Electrical Sustainable Energy department
DC Systems, Energy Conversion, and Storage (DCE&S)
TU Delft
Specialisation: Electric Vehicles
Contacts:P.Bauer@tudelft.nl

Course Description

List of Abbreviations:
PV : Photovoltaics
SS : Substation
TG : Trolley Grid
TGoF : Trolley Grid of the future
UPV : Utility-scale photovoltaics

Title: Bus-iness not as usual: creating the trolleybus grid of the future
Fields of activity: Transport Engineering, Electrical Sustainable Engineering, Sustainability Engineering, Automotive Engineering, Environmental Engineering, Power Engineering, Mechanical engineering, Computational Science, Mathematics, DC systems, Energy Conversion & Storage
Examination type: Continuous Assessment
Grading Scheme:

a) **Course Final Grade:**

Power Flow Homework	**10 %**
In-Class Quiz	**5 %**
Drop Quiz(es)	**5 %**
Group Presentation (PV in TGs)	**10 %**
Consultancy Game (TG to TGoF)	**40 %**
Final Exam	**30 %**

Final course grade is over 10 points and rounded up or down depending on the participant's engagement throughout the course. A grade of 6.0 is a pass.

BEST Delft
Kanaalweg 4
2628EB, Delft, the Netherlands

E-mail: delft-spc@best-eu.org
www.BEST.eu.org/Delft

b) Consultancy Game Grade:

Preliminary Study/City Assessment	**5 points**
Assessing PV Potential	**3 points**
Assessing RES Potential	**3 points**
Assessing IMC Potential	**3 points**
Assessing SESS Potential	**3 points**
Assessing OESS Potential	**3 points**
Assessing EV Potential	**3 points**
Proposed Final Solution	**10 points**
Answering Q&A	**5 points**
Participation Q&A with other teams	**2 points**
TOTAL	***40 points***

The group grade is not necessarily reflected as the individual grade. The team members will also assess each other's participation in the group.

Number of ECTS credits issued: 1

Learning Goals and Objectives:

At the end of the BEST Course, participants will be able to:

- Describe the trolley grid's (TG) electrical infrastructure as well as its daily/monthly/yearly demand profile trends and what influences them;
- Formulate the fundamental mathematical equations governing the power demand at a TG substation (SS) and analytically and/or computationally solve them, up to the advanced scenario *2B-0R-Bi* of two buses on a bilateral section (Power Flow calculations);
- Describe the inputs and outputs of the common modelling and sizing methods, define the challenges, and advise on the opportunities for Renewable Energy Systems (RES), Electric Vehicle (EV) chargers, Stationary and On-board Energy Storage Systems (SESS, OESS), and In-Motion-Charging (IMC) buses in the TG of the future (TGoF);

- Assess the opportunities and challenges in a TGoF project and formulate elementary advice on its feasibility by using both exact numbers and formulas as well as educated guesses and rules of thumb studied throughout the course;
- Implement acquired knowledge in the industry together with a company.

Syllabus

Name of activity	The Trolley Grid
Number of working hours	3
Type of activity	Lecture
Lecturer	Ibrahim Diab and Pavol Bauer
Short summary of content	Participants will meet the lecturers, be introduced into the topic and gain fundamental understanding of the trolley grid and the trolley bus network. Furthermore, they will be taught the flow of power in such a network via calculations.
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids & A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries (Papers Attached)
Expected effect	Participants will be familiarised with the main lecturer(s) and gain perspective on the topics that will be further developed in the Course.

Name of activity	Photovoltaics
Number of working hours	2
Type of activity	Lecture
Lecturer	Ibrahim Diab
Short summary of content	Modelling PVs, possible mismatches and its challenges
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids & A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries (Papers Attached)
Expected effect	Participants will understand how PVs work and what aspects are to be considered into their design.

Name of activity	Homework
Number of working hours	1.5
Type of activity	Individual Work
Lecturer	Ibrahim Diab
Short summary of content	Participants will work on exercises to assimilate the knowledge from the lectures
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids(Paper attached)
Expected effect	Participants will deepen their knowledge through exercises guided by the lecturer.

Name of activity	Photovoltaics in Trolleybus Grids
Number of working hours	4.5
Type of activity	Project Work
Lecturer	Ibrahim Diab
Short summary of content	The knowledge acquired in the lectures on PV in TGs will be applied in a group presentation.
Bibliography	None
Expected effect	Deepening knowledge and developing team working skills. Participants will also gather feedback on how to improve their presentation skills in the future.

Name of activity	Photovoltaics in Trolley Grids
Number of working hours	1
Type of activity	Quiz
Lecturer	Ibrahim Diab
Short summary of content	Testing the participants' understanding of the materials discussed so far
Bibliography	None
Expected effect	Participants will be familiar with what to expect from the final exam. Knowledge will be practised for the final exam. Results of the quiz will be analysed together with the lecturer.

Name of activity	Photovoltaics Potential
Number of working hours	1.5
Type of activity	Lecture
Lecturer	Ibrahim Diab
Short summary of content	UPV in TGs
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids & A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries (Papers Attached)
Expected effect	Participants will further develop their knowledge about PVs

Name of activity	Increasing UPV
Number of working hours	1
Type of activity	Lecture
Lecturer	Ibrahim Diab
Short summary of content	Storage of energy in the grid
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids & A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries (Papers Attached)
Expected effect	Participants will develop their knowledge about storage of energy within the TG

Name of activity	Increasing UPV
Number of working hours	0.5
Type of activity	Lecture
Lecturer	Pavol Bauer
Short summary of content	Focusing on how electric vehicles(EV) interact with the grid.
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids & A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries (Papers Attached)
Expected effect	Participants will develop their knowledge about EVs' role within the TG

Name of activity	Increasing UPV
Number of working hours	1
Type of activity	Lecture
Lecturer	Ibrahim Diab
Short summary of content	In-Motion-Charging(IMC)
Bibliography	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids & A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries (Papers Attached)
Expected effect	Participants will develop their knowledge about IMC within the TG.

Name of activity	Homework
Number of working hours	1
Type of activity	Individual work
Lecturer	Ibrahim Diab
Short summary of content	Participants will get familiar with a fictional trolleybus grid. In teams, they will start analysing their given grid in light of the potential of the different smart grid technologies they learned about.
Bibliography	None
Expected effect	Participants start preparing for the case study game to follow.

Name of activity	Case Study Game Introduction
Number of working hours	1
Type of activity	Tutorial
Lecturer	Ibrahim Diab
Short summary of content	The participants are introduced in a detailed fashion to their respective case studies and to the tasks they have to fulfil during the consultancy game. They are familiarised with the tools they need for their assessments.
Bibliography	None
Expected effect	Participants will learn how to apply the knowledge acquired in previous sessions.

Name of activity	Consultancy Game
Number of working hours	4.5
Type of activity	Project work
Lecturer	Ibrahim Diab
Short summary of content	In the consultancy game, the participants are divided into teams and given a hypothetical trolley grid city. Each team has to apply the knowledge learnt in the course to assess the potential of the different smart grid technologies learnt throughout the course for their cities. They will then present their solution to the class and defend it in a Q&A session.
Bibliography	None
Expected effect	Participants will improve their understanding of the material through hands-on experience, alongside practising their teamwork skills.

Name of activity	Exam Preparation
Number of working hours	1
Type of activity	Group Seminar
Lecturer	Ibrahim Diab
Short summary of content	The lecturer will conclude the theoretical part of the course with a revision of the material and a guided discussion between the participants.
Bibliography	None
Expected effect	Participants will refresh their knowledge in preparation for the final exam. They have the opportunity to ask questions and clarify any doubts they have about the material.

Name of activity	Exam
Number of working hours	2.5
Type of activity	Examination
Lecturer	Ibrahim Diab
Short summary of content	Final examination of the course
Bibliography	None
Expected effect	The participants' understanding of the materials will be evaluated. A discussion on the exam problems will be guided by the professor once the participants have finished their work.

Name of activity	Gamelab Workshop
Number of working hours	3
Type of activity	Workshop
Lecturer	Gracia Bovenberg-Murris, Doris Boschma
Short summary of content	Participants will apply their acquired knowledge about sustainable transportation in order to create a serious game according to the Triadic Game Design model.
Bibliography	None
Expected effect	The participants will develop team working skills by designing a 'serious' game focused on the societal and public policy aspects of a smart grid and a more sustainable community.

Name of activity	Covestro Workshop
Number of working hours	2
Type of activity	Company Presentation
Lecturer	Frank Andreesen
Short summary of content	The participants will learn about the ways in which Covestro tackles sustainability in the transportations of their materials.The presentation will be followed by a discussion between the company representative and the participants about improvement points or innovative ideas the participants might have on the topic.
Bibliography	GHG Transport Emissions Management at Covestro
Expected effect	The participants will learn about the ways in which the industry is adapting their logistical needs, such as transportation of raw materials, to become more sustainable and engage in a conversation about these solutions.

Pre-materials

Name	GHG Transport Emissions Management at Covestro
Topic/field	This presentation covers the issues that the Sustainable Logistics department at Covestro is tackling. The presentation follows the company's goals in this regard as well as current initiatives.
Description	This presentation will be the basis of the workshop delivered by Frank Andreesen and will serve as a starting point for the discussion between the company representative and the participants.

Name	Placement and Sizing of Solar PV and Wind Systems in Trolleybus Grids
Topic/field	The paper discusses about different aspects of Solar Photovoltaics and Wind Systems within a smart trolleybus grid
Professor/Author	Ibrahim Diab, Alice Saffiro, Gautham Ram Chandra-Mouli, Abhishek Singh Tomar and Pavol Baur
Description	This paper is valuable for the participants as this will be the basis of their first graded homework

Name	A Complete DC Trolleybus Grid Model With Bilateral Connections Feeder Cables and Bus Auxiliaries
Topic/field	The paper discusses about different aspects of Solar Photovoltaics and Wind Systems within a smart trolleybus grid
Professor/Author	Ibrahim Diab, Bram Scheurwater, Alice Saffiro, Gautham Ram Chandra-Mouli and Pavol Baur