

# Technischen Hoch- Schule Ostwestfalen-Lippe – University of Applied Sciences and Arts (TH-OWL) online workshop-Report

|                               |                   |
|-------------------------------|-------------------|
| <b>Event type</b>             | <b>Workshop</b>   |
| <b>WP Number</b>              | <b>WP3, WP7</b>   |
| <b>WP Leader</b>              | <b>NTUA, HTU</b>  |
| <b>Event date</b>             | <b>20-12-2021</b> |
| <b>Number of Participants</b> | <b>100</b>        |
| <b>Total number of pages</b>  | <b>12</b>         |

## Project Coordinator

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Project website: <http://sites.ju.edu.jo/en/ECO-CAR/Home.aspx>



## 1 Event Description

Technischen Hoch- Schule Ostwestfalen-Lippe - University of Applied Sciences and Arts (TH-OWL) from Germany conducted the workshop on 20<sup>th</sup> of December 2021. The 2.5-hours workshop was conducted via ZOOM and titled “Charge Transport in Batteries and Hydrogen Vehicles”.

The workshop started with a welcoming speech and an overview of the nature of the project, its objectives and the partners working on it by the project coordinator, Prof. Ahmed Al-Salaymeh from The University of Jordan.

- “Hydrogen Vehicles; State of the Art and Perspectives”, by: Prof. Salman Ajib, TH-OWL.
- “Charge Transport in Batteries”, by: Dr. Sabine Brunklaus, TH-OWL

A discussion panel was opened for participants.

## 2 PPTs

- ECO-CAR in brief:

[https://fisjo-my.sharepoint.com/:p/g/personal/eco-car\\_ju\\_edu\\_jo/EWolYs5mu31JowxxNa0WQhUBTHbxIL-vZliOUSTXDExyEQ?e=Xl00kL](https://fisjo-my.sharepoint.com/:p/g/personal/eco-car_ju_edu_jo/EWolYs5mu31JowxxNa0WQhUBTHbxIL-vZliOUSTXDExyEQ?e=Xl00kL)

- Hydrogen Vehicles:

[https://fisjo-my.sharepoint.com/:b/g/personal/eco-car\\_ju\\_edu\\_jo/EV2qEGsbniRCgxpITyVM2KsBiCpXP\\_JHdliHhpvc2MmR7A?e=Tcek9d](https://fisjo-my.sharepoint.com/:b/g/personal/eco-car_ju_edu_jo/EV2qEGsbniRCgxpITyVM2KsBiCpXP_JHdliHhpvc2MmR7A?e=Tcek9d)

# ECO-CAR Workshop

## Charge Transport in Batteries and Hydrogen Vehicles

Presented by: Technische Hochschule Ostwestfalen-LIPPE  
(TH-OWL) - Germany



Monday, December 20, at 16:00 (Amman time)

15:45-16:00 : Registration

16:00-16:15: Welcoming Speech, by:  
Prof. Ahmed Al-Salaymeh, General Project  
Coordinator at The University of Jordan

16:15-17:15: Hydrogen Vehicles; State of the Art  
and Perspectives, by: Prof. Salman Ajib, TH-OWL

17:15-18:15 : Charge Transport in Batteries, by:  
Dr. Sabine Brunklaus, TH-OWL

18:15-18:30: Discussion and Closing



## 4 ZOOM participants list

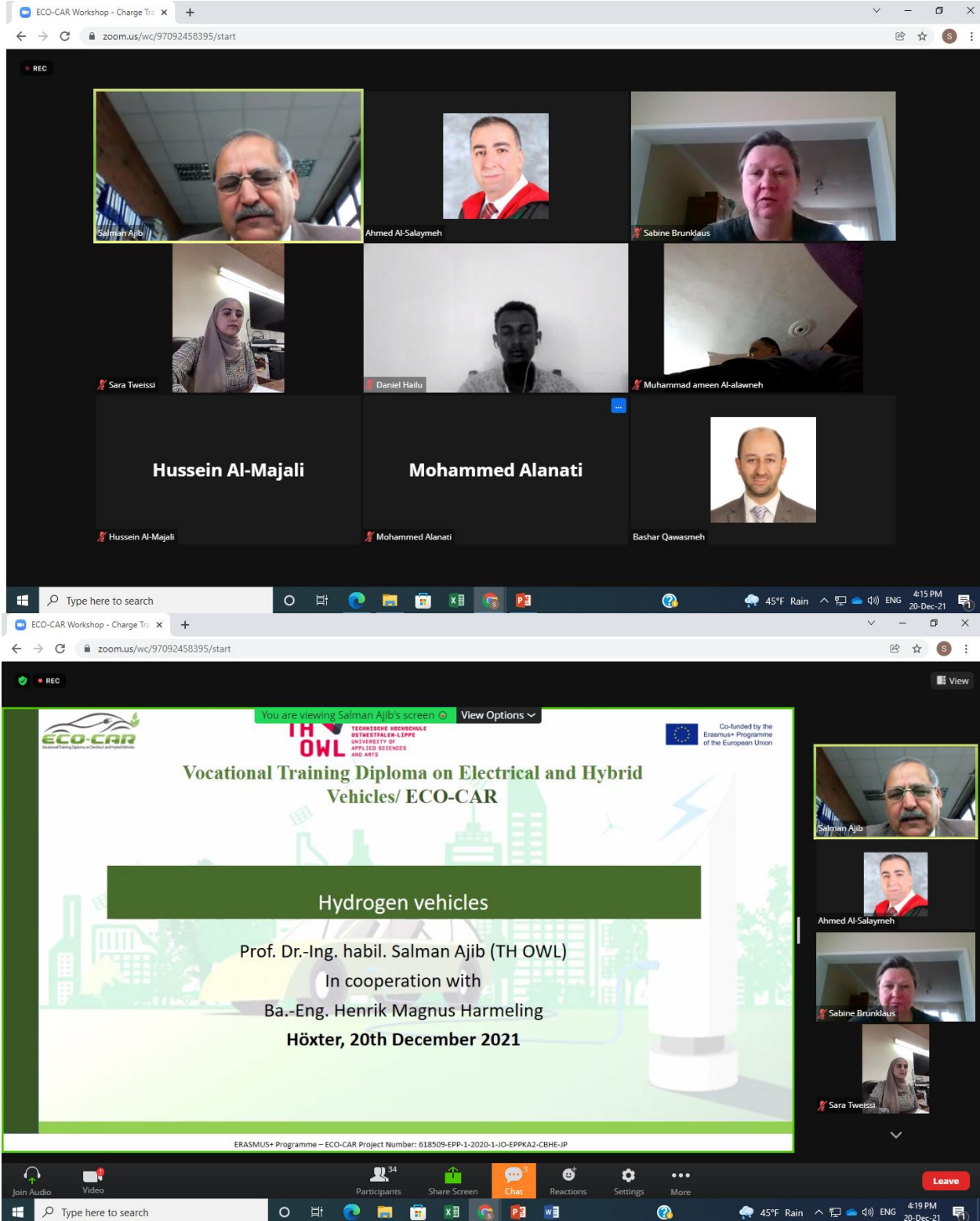
| First Name     | Last Name    | Email                       | Registration Time | Approval St |
|----------------|--------------|-----------------------------|-------------------|-------------|
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|                           |                      | <a href="mailto:mahmoudmaheralhaibi4@gmail.com">mahmoudmaheralhaibi4@gmail.com</a> | 20-12-21 8:54  | approved |

## 5 Photos



The image shows a Zoom meeting interface. The top part displays a grid of nine video thumbnails for participants: Salman Ajib, Ahmed Al-Salaymeh, Sabine Brunklaus, Sara Tweissi, Daniel Hailu, Muhammad ameen Al-alawneh, Hussein Al-Majali, Mohammed Alanati, and Bashar Qawasmeh. The bottom part shows a shared presentation slide with the following content:

You are viewing Salman Ajib's screen View Options

**ECO-CAR**  
Vocational Training Diploma on Electrical and Hybrid Vehicles/ ECO-CAR

**Hydrogen vehicles**

Prof. Dr.-Ing. habil. Salman Ajib (TH OWL)  
In cooperation with  
Ba.-Eng. Henrik Magnus Harmeling  
Höxter, 20th December 2021

ERASMUS+ Programme – ECO-CAR Project Number: 618509-EPP-1-2020-1-JO-EPPKA2-CBHE-JP

The Zoom interface also shows a Windows taskbar at the bottom with the system clock at 4:19 PM on 20-Dec-21.

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Zoom Meeting | You are viewing Salman Ajib's screen | View Options

Recording... | Participants (36)

Find a participant

Ahmed Al-Salaymeh (Host, me) | SA Salman Ajib | Ahmed Al-Salaymeh (Co-host) | Ahmed Al-Salaymeh (Co-host) | Ahmad Mostafa | AS alaa shaker | BJ Bilal Jarrah | CV Clio Vossou | DH Daniel Hailu | DA Dr altham Yasin | DA Dr. Ali Alahmer | EA Eman Abdelhafez | HA Hussein Al-Majali | JA Jamal Al-Belbesi | KM Khalid Mohamad | LD Loai Dabbour | LD Loai Dabbour

# 1. Introduction

How can WE tackle the net zero emission goal?

1. Stop driving internal combustion engine vehicles (ICEV)
2. Technology shift
  - Biofuels
  - Battery electric mobility (BEV)
  - Fuel cell electric vehicles (FCEV)

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Audio | Start Video | Security | Participants | Polls | Chat | Share Screen | Pause/Stop Recording | Reactions | More | End

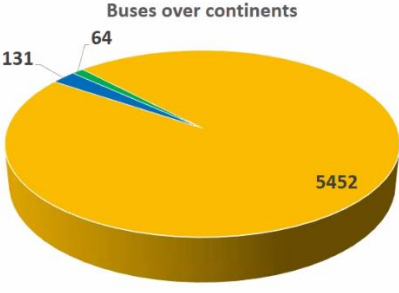
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zoom.us/j/97092458395/start

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# 4. State of the art worldwide

Buses over continents



| Continent     | Number of Buses |
|---------------|-----------------|
| Asia          | 5452            |
| Europe        | 131             |
| North America | 64              |

- 5290 of these buses are located in China
- Major Original Equipment Manufacturer (OEM):
  - Foton AUV (China)
  - Zhengzhou Yutong Bus Co., Ltd. (China)
  - Toyota (Japan)
  - Hyundai (South Korea)

Source: 6 / own design

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Join Audio | Video | Security | Participants | Polls | Share Screen | Chat | Breakout Rooms | Reactions | Settings | More | Leave

4:38 PM 20-Dec-21

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## 9. Security measures

- Use noncombustible materials for the buildings of the refuel station
- Install Hydrogen sensors at the exhaust of the tank station and the car
- Avoid ignition sources near the storage area
- If a fire or a leak is detected an automatic shutoff is activated
- Near the storage system classified electrical equipment should be used
- Mechanical ventilation to decrease the likelihood of a flammable mixture


Source: 26



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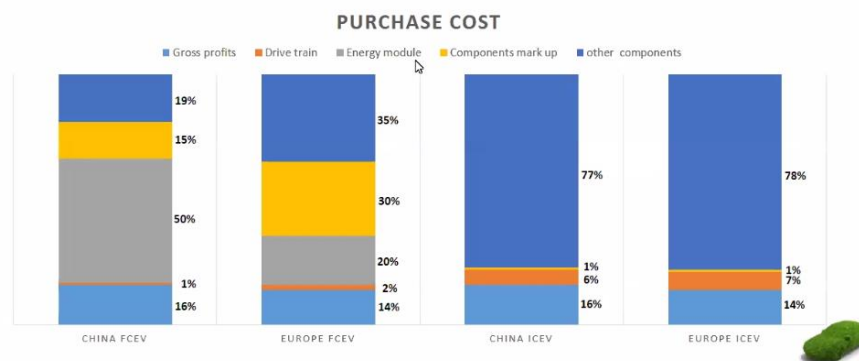
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## 10. Total Cost of ownership hydrogen bus

### PURCHASE COST




| Vehicle Type | Gross profits | Drive train | Energy module | Components mark up | other components |
|--------------|---------------|-------------|---------------|--------------------|------------------|
| CHINA FCEV   | 19%           | 1%          | 50%           | 15%                | 16%              |
| EUROPE FCEV  | 35%           | 2%          | 20%           | 30%                | 14%              |
| CHINA ICEV   | 77%           | 1%          | 6%            | 16%                | 0%               |
| EUROPE ICEV  | 78%           | 1%          | 7%            | 14%                | 0%               |

Source: 27



Join Audio Start Video Security Participants Polls Share Screen Chat Breakout Rooms Reactions Settings More Leave

Type here to search 7°C Rain showers 5:12 PM 12/20/2021



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zoom.us/jc/97092458395/start

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**Requirements: Batteries in Electrical Vehicles**

- Energy density: > 750 Wh/L & > 350 Wh/kg for cells (currently: <)
- Cost: < \$100/kWh for cells (currently: ~\$200/kWh per pack)
- Fast Charge and Power: 80 % state of charge ( $\Delta$ SOC) in 15 min (currently: hours)
- Life: 15 years
- Power capability: differs for vehicle type (compromise cost/energy density)
- Performance: Minimum impact by environment
- Safety: No fire/flame/rupture/explosion

Reference: JieDeng et al., [Volume 4, Issue 3](#) (2020), Pages 511-515

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**Diffusion overvoltage**

- If the reaction steps are fast, the reaction can still be slow due to high diffusion times to the electrodes.
- Even with well-mixed (stirred) electrolytes: stationary boundary layer of a thickness of 10-100  $\mu$ m does not move Diffusion barrier
- For deposition of cations at an electrode the following applies:  

$$-dw/dt = D a dc/dx = D a (c-c_0)/\delta$$
 (diffusion equation)
- D: diffusion coefficient of the cations, a: area, c: Concentration of solution,  $c_0$ : Concentration of electrode surface, w: Amount of cation deposited, t: Time, d : Thickness of the boundary layer
- Current flow to the cathode:  $I_\delta = - n F dw/dt = n F D a \frac{c-c_0}{\delta}$  n: Charge number
- Potential difference before and after boundary layer
- Concentration or diffusion overvoltage:  $\eta_D = RT/(nF) \ln (c_0/c)$

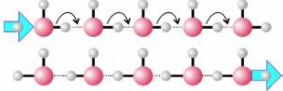
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**Ion mobility**

- $\mu$  is high for an ion that is:
  - highly charged
  - in a solution of low viscosity
  - of small radius  $r$
  - $r$  = hydrodynamic radius (including water ligands)
- Grotthuss conduction mechanism for  $H^+$




**Table 9.2 Ionic mobilities in water at 298 K,  $u/(10^{-8} m^2 s^{-1} V^{-1})$**

| Cations  |       | Anions                        |       |
|--|-------|-------------------------------|-------|
| H  | 36.23 | OH <sup>-</sup>               | 20.64 |
| Li   | 4.01  | F <sup>-</sup>                | 5.74  |
| Na <sup>+</sup>  | 5.19  | Cl <sup>-</sup>               | 7.92  |
| K <sup>+</sup>   | 7.62  | Br <sup>-</sup>               | 8.09  |
| Rb <sup>+</sup>  | 8.06  | I <sup>-</sup>                | 7.96  |
| Cs <sup>+</sup>  | 8.00  | CO <sub>3</sub> <sup>2-</sup> | 7.18  |
| Mg <sup>2+</sup>   | 5.50  | NO <sub>3</sub> <sup>-</sup>  | 7.41  |
| Ca <sup>2+</sup>   | 6.17  | SO <sub>4</sub> <sup>2-</sup> | 8.29  |
| Sr <sup>2+</sup>   | 6.16  |                               |       |
| NH <sub>4</sub> <sup>+</sup>                                   | 7.62  |                               |       |
| [N(CH <sub>3</sub> ) <sub>4</sub> ] <sup>+</sup>               | 4.65  |                               |       |
| [N(C <sub>2</sub> H <sub>5</sub> ) <sub>4</sub> ] <sup>+</sup> | 3.38  |                               |       |

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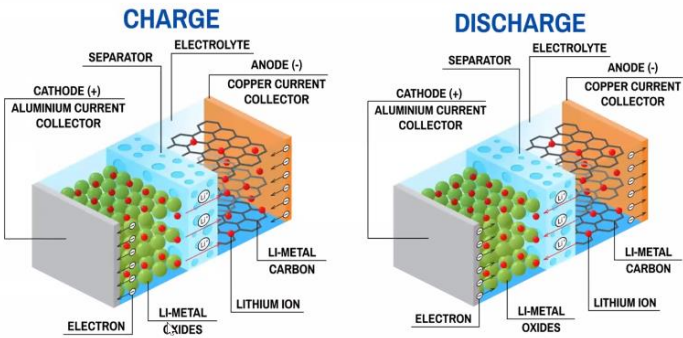
ERASMUS+ PROGRAMME Project Number: 618509-EPP-1-2020-1-JO-EPPKA2-CBHE-JP

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zoom.us/jc/97092458395/start

REC You are viewing Sabine Brunklaus's screen View Options

## Principle of the lithium-ion battery



Intercalation of lithium-ions (yellow spheres) into the anode and cathode matrices upon charge and discharge

Sabine Brunklaus

Ahmed Al-Salaymeh Salman Ajib Sabine Brunklaus Ehab AlShmaileh Majed Alsweiti

Bilal Jarrah

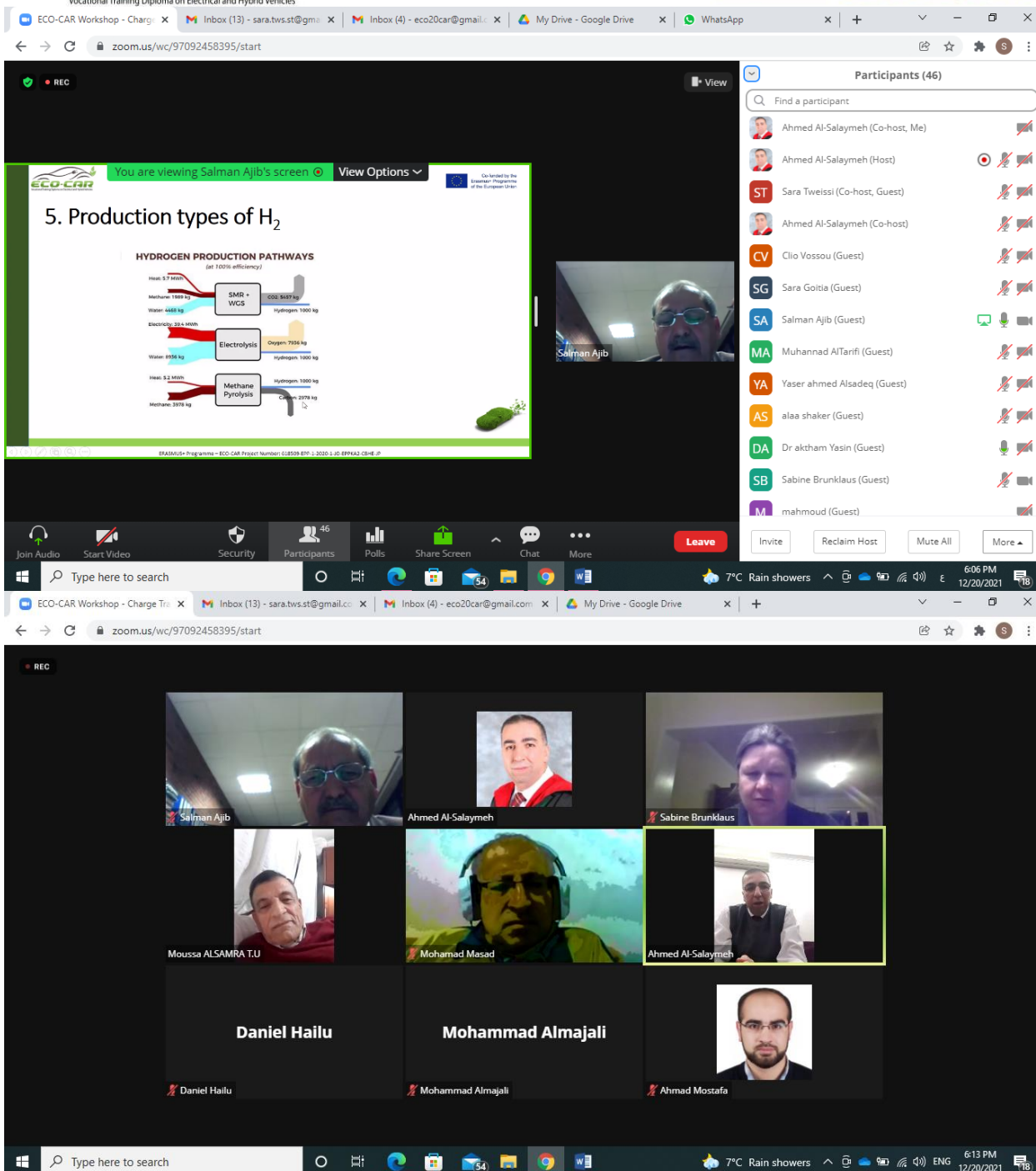
Join Audio Start Video Security Participants Polls Share Screen Chat Breakout Rooms Reactions Settings More Leave

Type here to search 7°C Rain showers 5:43 PM 12/20/2021

zoom.us/jc/97092458395/start

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The screenshot shows a Zoom meeting interface. The main window displays a presentation slide titled "5. Production types of H<sub>2</sub>" with the sub-heading "HYDROGEN PRODUCTION PATHWAYS (at 100% efficiency)". The slide contains three flowcharts:

- SMR + WCS:** Inputs: Heat: 5.7 MWh, Methane: 1859 kg, Water: 4459 kg. Outputs: CO<sub>2</sub>: 5447 kg, Hydrogen: 1000 kg.
- Electrolysis:** Inputs: Electricity: 22.4 MWh, Water: 9136 kg. Outputs: Oxygen: 7556 kg, Hydrogen: 1000 kg.
- Methane Pyrolysis:** Inputs: Heat: 5.2 MWh, Methane: 3976 kg. Outputs: Hydrogen: 1000 kg, Carbon: 2776 kg.

The Zoom interface includes a "Participants (46)" list on the right with names like Ahmed Al-Salaymeh, Sara Tweisli, and Salman Ajib. The bottom of the screen shows the Windows taskbar with the time 6:05 PM on 12/20/2021.

## 6 Video

<https://www.youtube.com/watch?v=pp7yFS-3HVs>

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