Multi-Disciplinary Solutions for Sustainable Computing in the Digital Era

https://ecocloud.epfl.ch

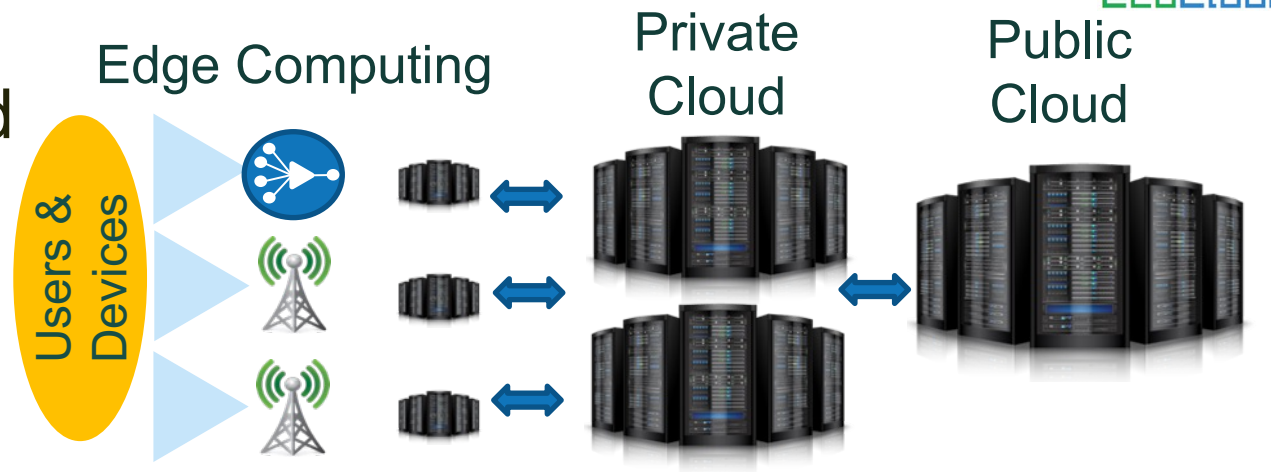
Prof. David Atienza,
Scientific Director of EcoCloud and Head of ESL-STI

Computing Is Ever More Indispensable…

- Cloud and data centers (DCs) are key in supply-chain of IT services
  - Boom on machine learning-based services: e-business, science, etc.

Multi-Layer Cloud Systems: Energy Keeps Growing!

- Today, multi-scale computing beyond “classical cloud” (Public and private DCs, and edge computing together)



- World’s sustainability with IT?
  - Cloud growing: more services and data centers, but they are **not sustainability-driven**
  - Cloud cannot keep up with new trends without **improving its efficiency**

ChatGPT uses 17,000 times the amount of electricity than the average US household.

[Business Insider, 2024]

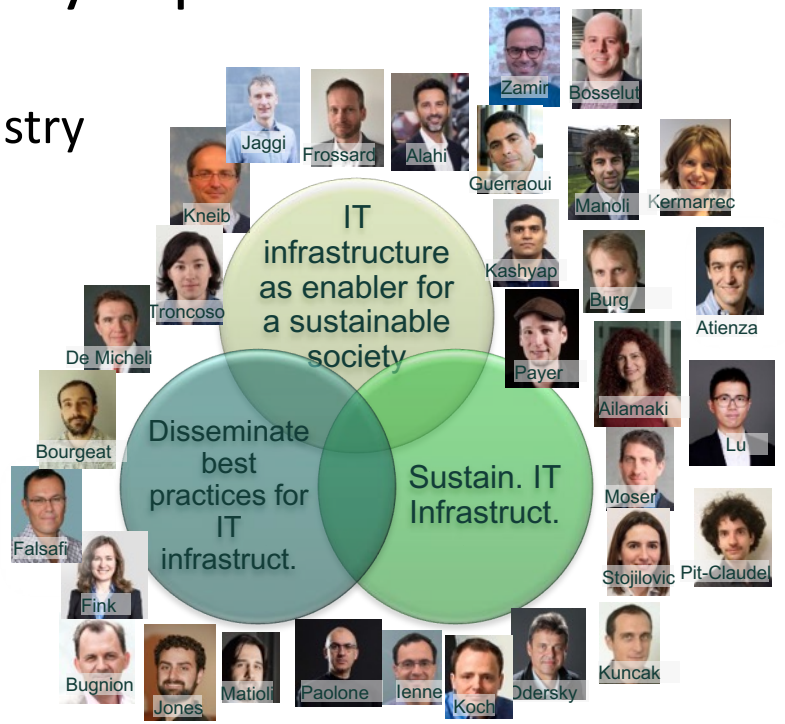
AI will run out of electricity and transformers in 2025. They're running out of transformers to run transformers.

Musk, 2024]

Trend: DCs use 2% of global energy, they can reach 10% by 2030

EcoCloud: The EPFL Research Center for Sustainable Cloud

- EcoCloud networks the EPFL community on sustainability topics
  - IT cross-layer optimization from edge devices to cloud computing
  - Promoting large multi-disciplinary projects including EPFL labs and industry
  - 35 faculty affiliated from 4 schools (IC, STI, ENAC and SB)



- Three main research interests:
  - Transform IT infrastructure into an enabler for a sustainable society
  - Ensure the sustainability of the IT infrastructure
  - Disseminate best practices for IT infrastructure
- With a strong link with local and global industry
  - Industrial Affiliates Program to set up research projects with industry

Challenges in our Path to Sustainable Computing

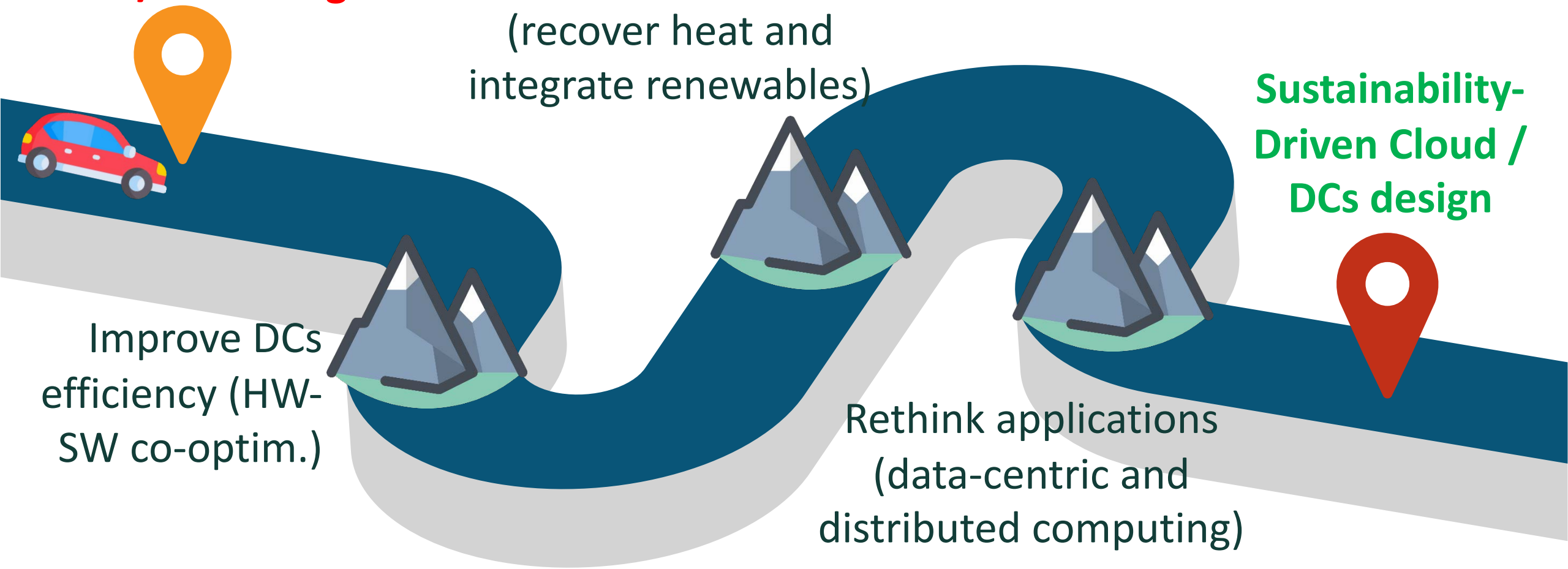
Performance driven Cloud / DCs design

Improve DCs efficiency (HW-SW co-optim.)

Rethink DC design (recover heat and integrate renewables)

Rethink applications (data-centric and distributed computing)

Sustainability-Driven Cloud / DCs design



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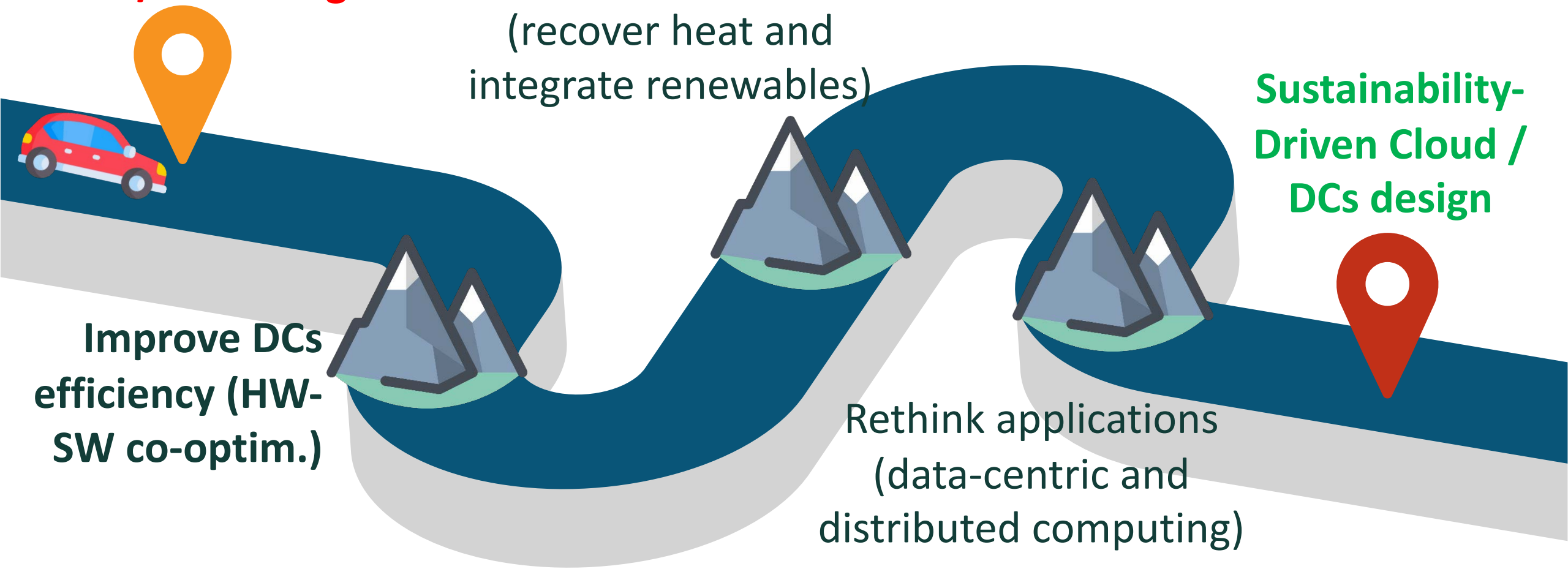
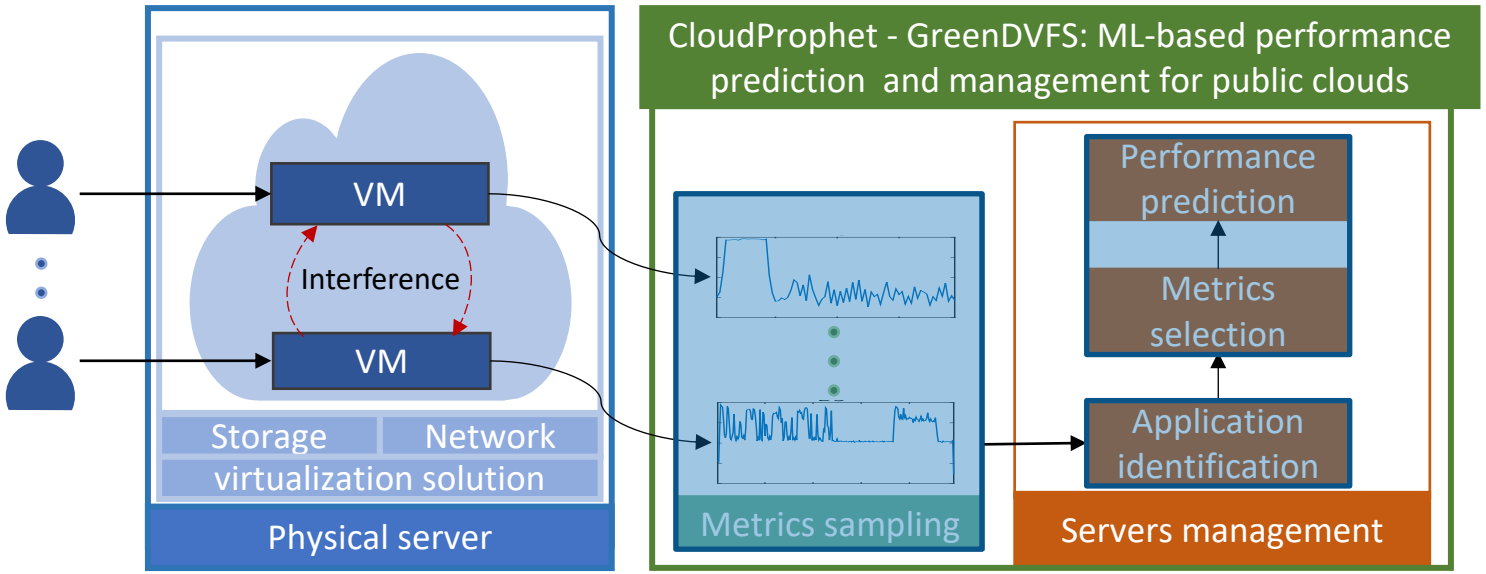


Improve DCs efficiency (HW-SW co-optim.)

Rethink applications (data-centric and distributed computing)

Improve DCs Efficiency: HW/SW Co-Optimization



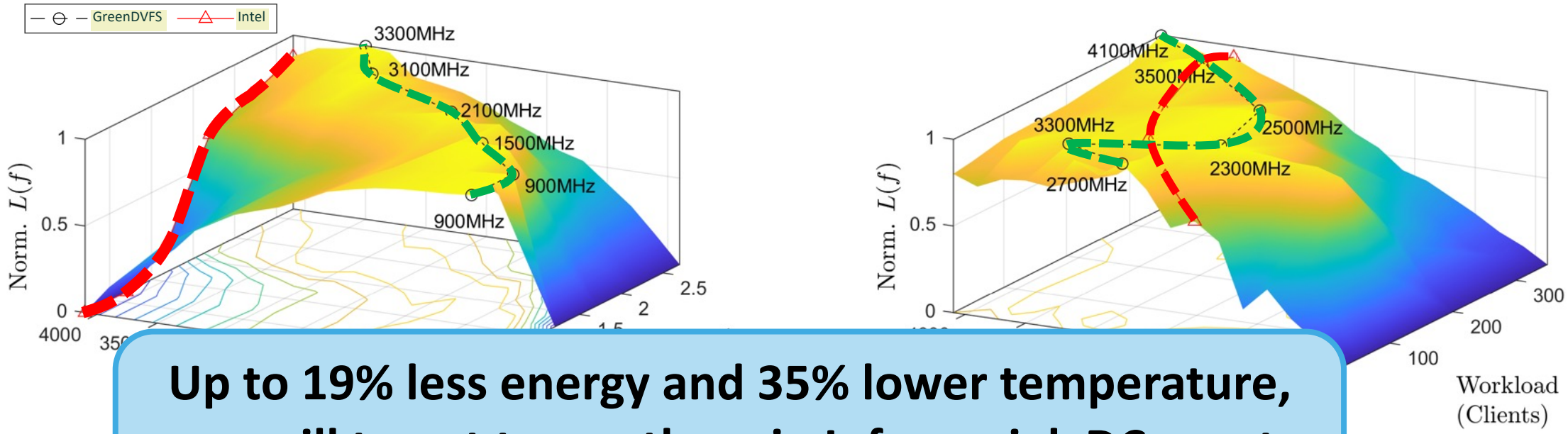
CloudProphet,
[Huang et al., TSUSC 2024]

GreenDVFS,
[Huang et al., CCGrid'24

- Multi-disciplinary: Computer Science (CS) and Electrical Engineering (EE)
  1. Monitoring workloads (black box) **– Instrument DCs**
  2. CloudProphet: Application identification and performance prediction **– Use of ML: CNN (CloudProphet)**
  3. Performance-aware energy management **– Use of AI/ML: LSTM (GreenDVFS)**

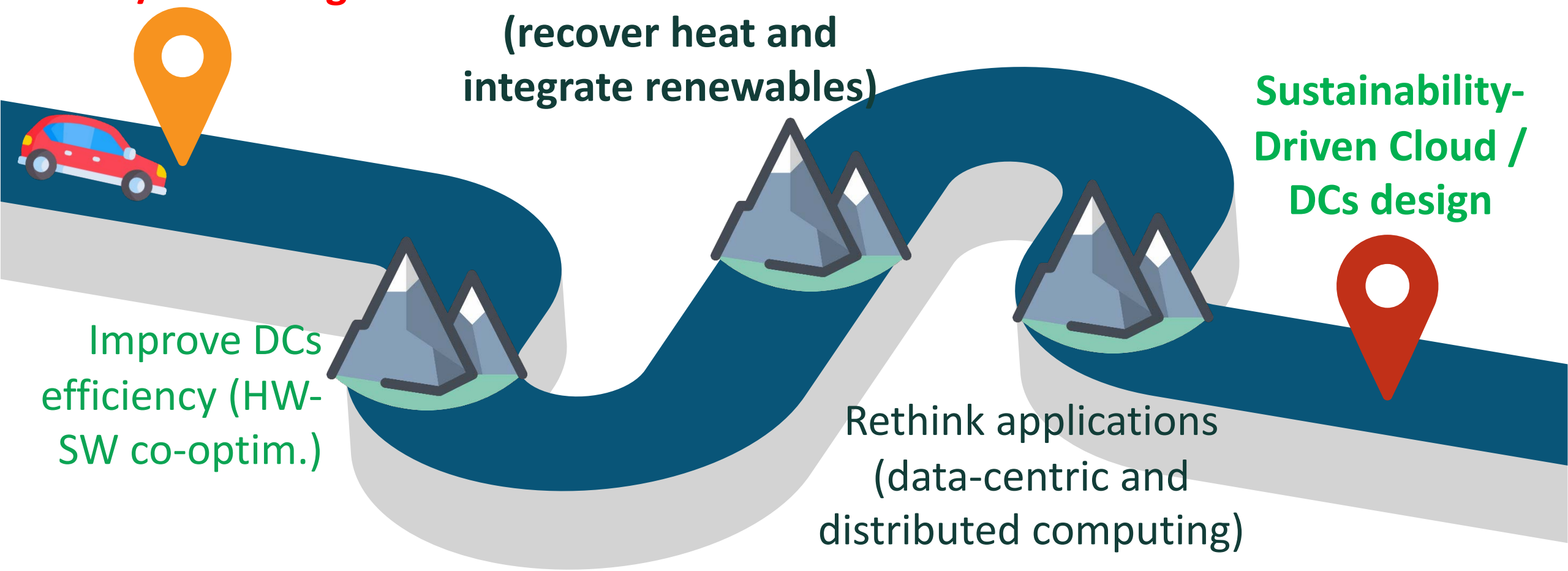
Better Workload-Frequency Scaling Optimizer for Energy: Take it easy when going uphill!

- *GreenDVFS - L(f)*: optimizes performance, power, and temperature
  - Designed per server family, fast to tune to different applications



Up to 19% less energy and 35% lower temperature, we will target to use them in Infomaniak DCs next (and hopefully in the EPFL DCs soon!)

Challenges in our Path to Sustainable Computing



Rethink DC Design: New Experimental Facility on Campus to Explore Sustainable Cloud Computing

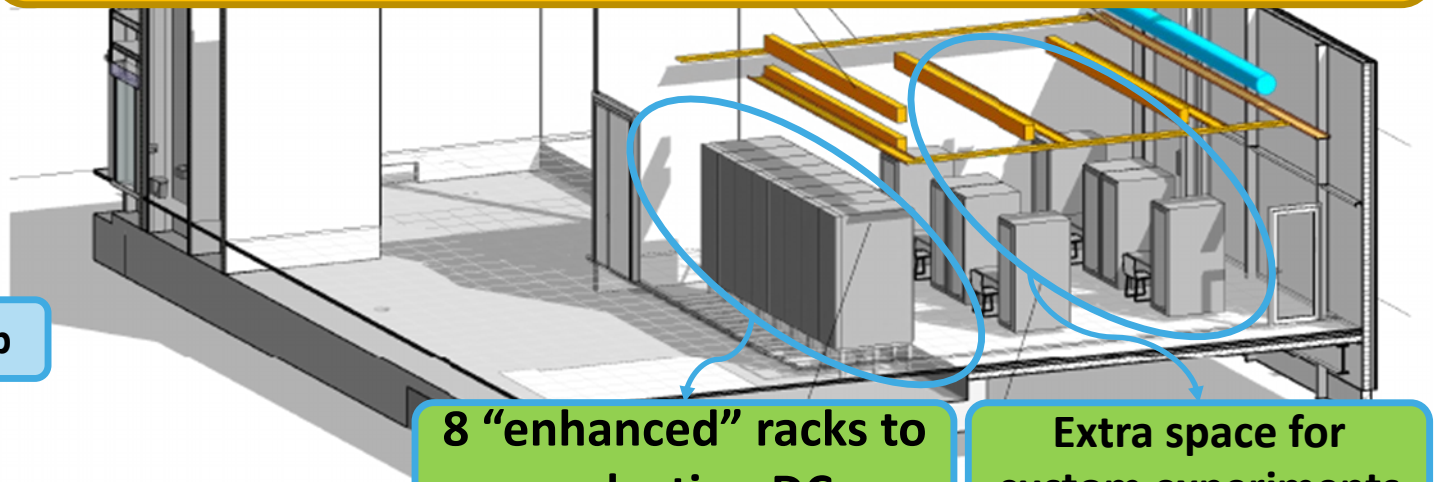
- Included in EPFL central heating plant and DC
  - Financial support of AVP-CP/VPA, VPI, and donations of the industrial affiliates of EcoCloud

- Support multi-disciplinary research: CS, EE, ME, Environmental Engineering, Material Science, Basic Science, etc. working together
  - UrbanTwin: An urban digital twin for climate action for Lausanne **(12 labs)**
  - Heating Bits: DCs integrating heating and cooling supply of local districts **(6 labs)**
  - SEAMS: Sustainable & energy-aware methods for Square Kilom. Array **(5 labs, 3 centers)**

EcoCloud-EPFL Sustainability Experimental facility CCT

- ~150 m² of space for experiments on sustainable computing
  - Recycled racks/donations
- Experimental support: two spaces
  - 50KW per rack/2.5m rack
  - Monitoring: energy, temp., etc.
  - Cooling: air or water coo

Please contact EcoCloud if you have interest on testing ideas on sustainable computing!



8 "enhanced" racks to production DCs

Extra space for custom experiments

Controlled setup

Racks with air/water passive cooling

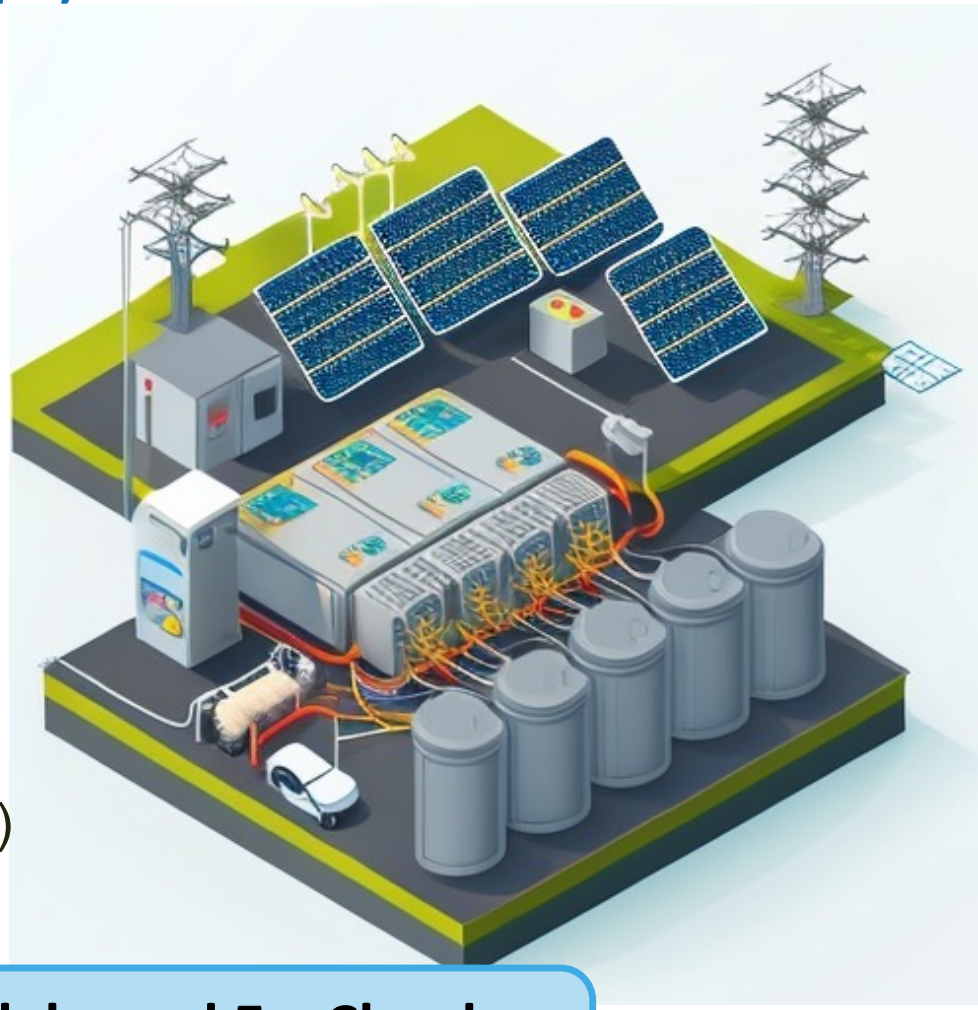
Underground water exchangers

Full supervision integrated with EPFL systems

Heating Bits: Renewable-Supplied DCs Integrating Heating and Cooling Supply of EPFL

1. Increase DCs energy efficiency and operate them with the least CO_2 emissions
   - Optimize power supply: converters
   - Renewables and batteries integration
   - Reuse of waste heat in EPFL (heating and warm water)

2. High-temperature liquid micro cooling and electricity generation
   - Maximize servers efficiency with microfluidic cold plate
   - Transform heat back into electricity (Organic Ranking Cycle)



Funded by EPFL's S4S Initiative: involves 6 labs and EcoCloud, details this afternoon (SESSION IV)

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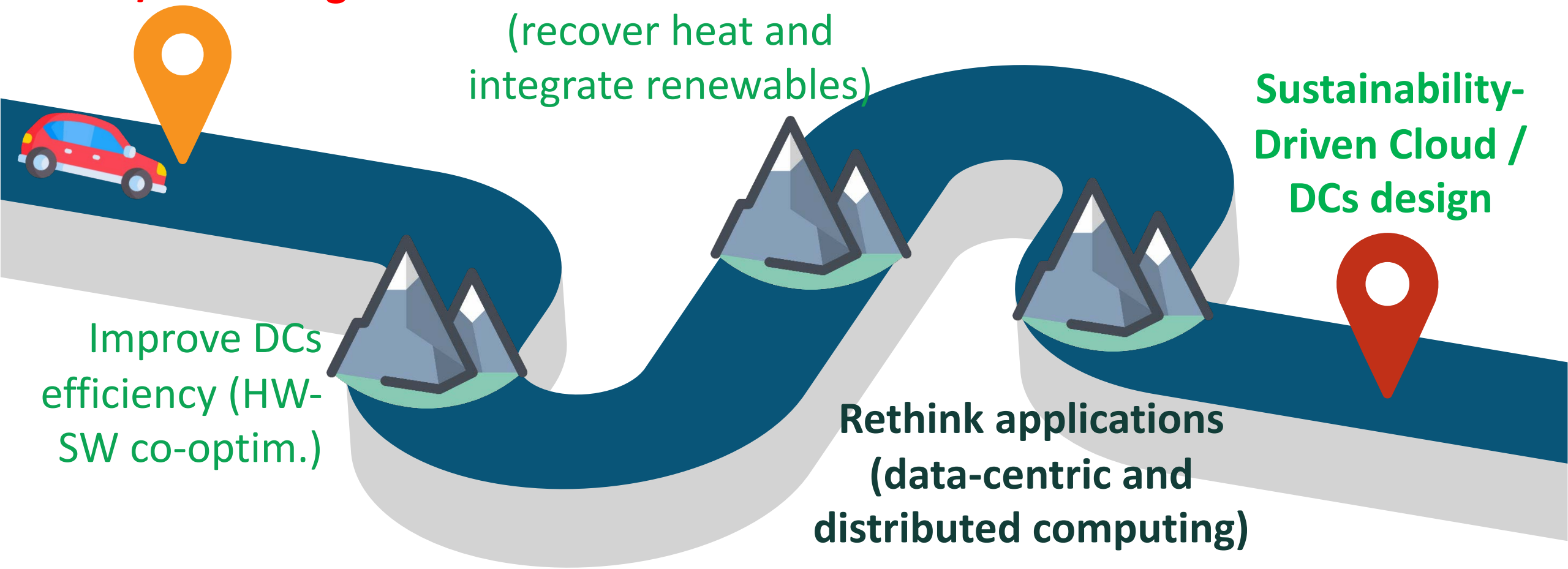
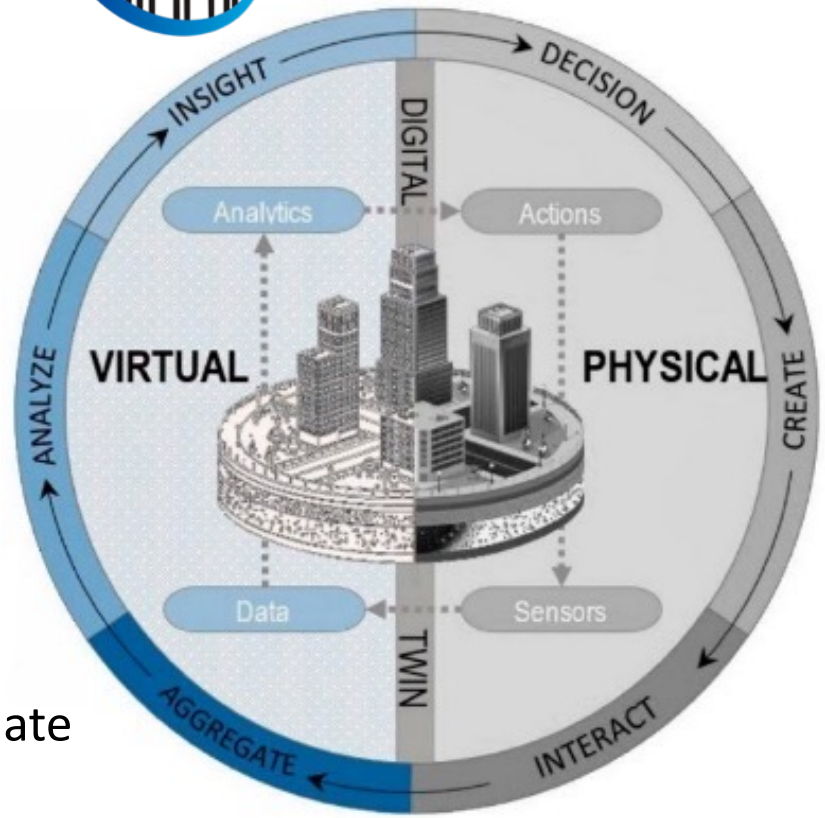


Rethink Applications in a Sustainable World: Urban digital twin for climate action (ETH Joint Initiative Project)

EcoCloud

URBANTWIN

- Goal: Digital twin of a Swiss city (Lausanne and Aigle)
  - Support decision-makers with sustainability goals
  - Forecast issues in the development of urban areas

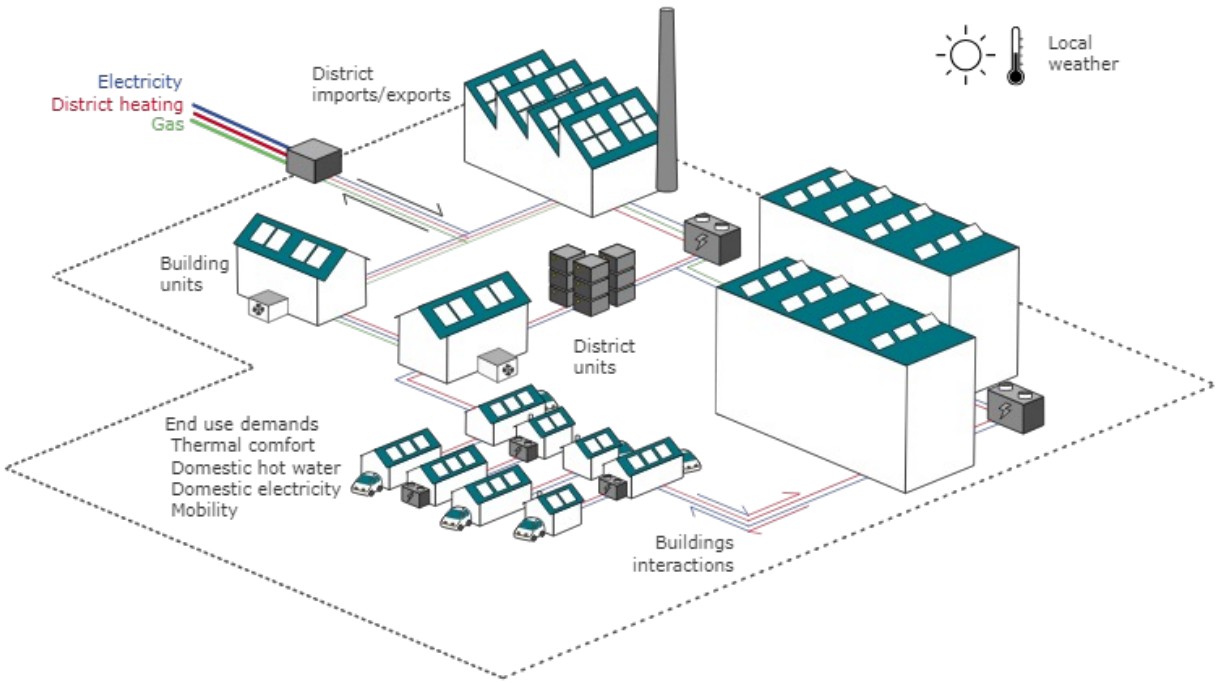


- Challenges
  1. Multi-scale model of critical urban infrastructure
     - City-level targets: energy, water, buildings and mobility
  2. Need for efficient use of multi-level Cloud support
     - Scalable simulation of interlinked infrastructures models and climate

eawag aquatic research | Empa Materials Science and Technology | EPFL | ETH zürich | WSL Swiss Federal Institute for Forest, Snow and Landscape Research WSL

Urban Twin involves 12 EPFL labs (from the 4 schools) and 4 EPFL centers

Challenges: Scaling from a Single Building to a Complete City



- Building characteristics (materials, surfaces)
  - Type of heating/cooling installations
- Points of generation of renewable energy
- Weather models
  - Forecast insolation on buildings, temperature, wind, rain
- Vegetation areas
- Relations between buildings (e.g., local energy transfers)

REHO image source: https://reho.readthedocs.io/en/main/sections/3_Model.html

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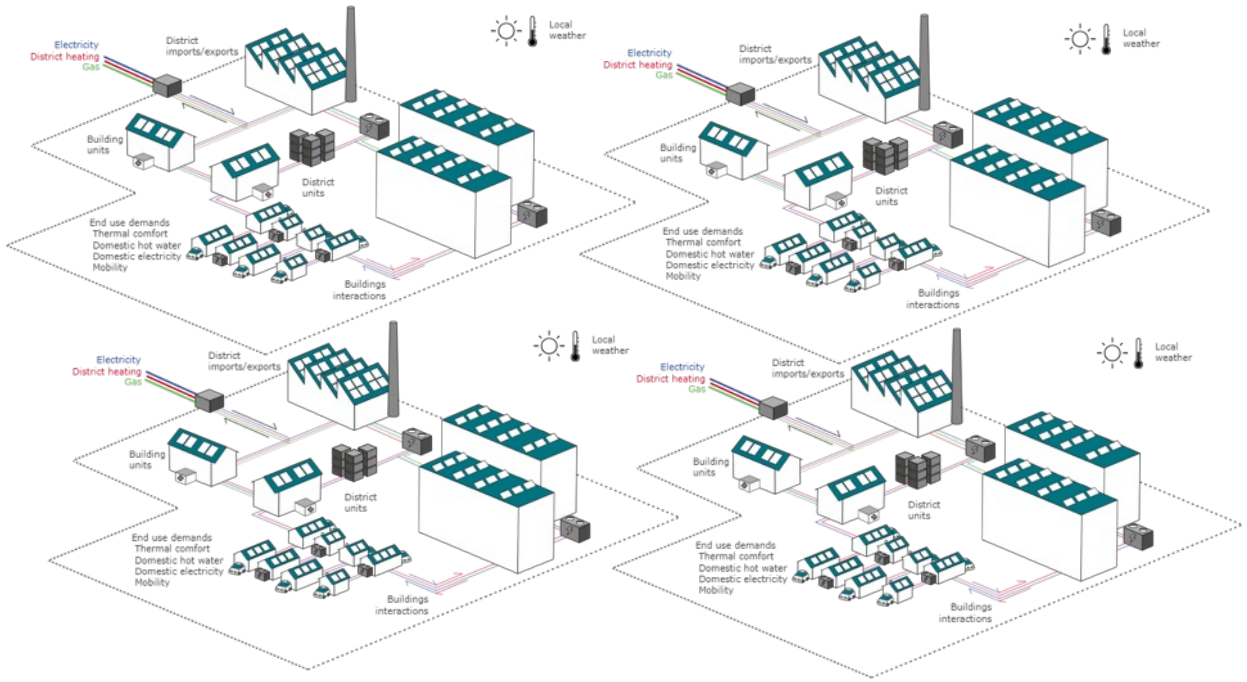

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  - Forecast insolation on buildings, temperature, wind, rain
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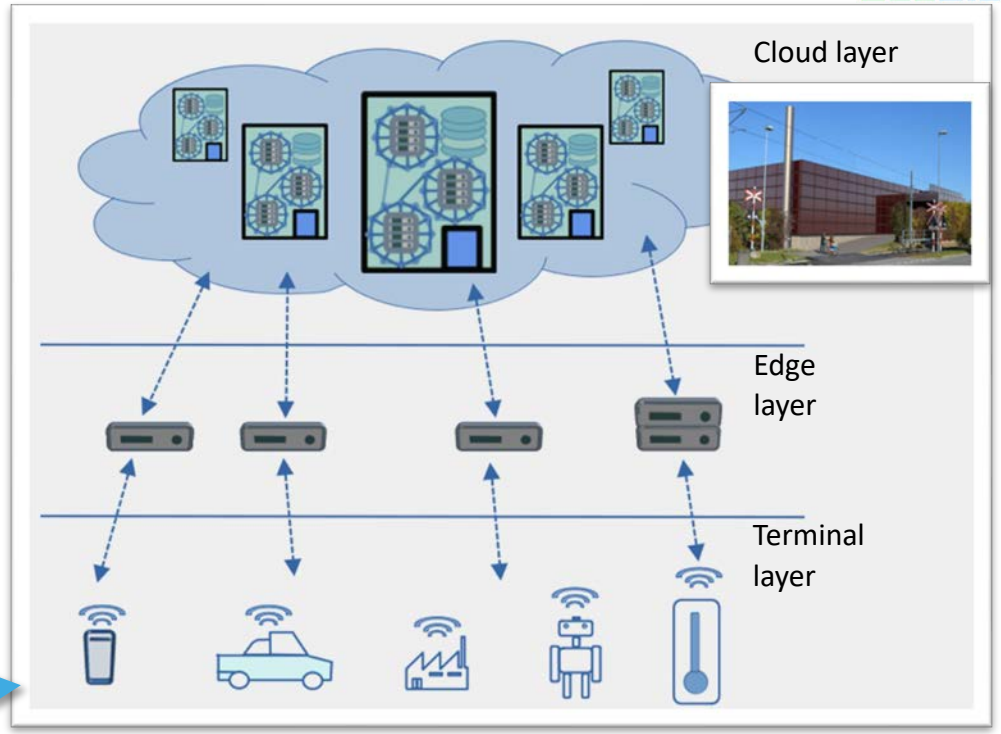
- Relations between buildings (e.g., local energy transfers)
- Relations between neighborhoods

Source: Dr. Xavier Ouvrard, EcoCloud[1]



1. **Multi-scale computing: terminal, edge and Cloud layers (federated learning)**
2. **Develop Digital Twin models that scale up (reasonable energy demands)**

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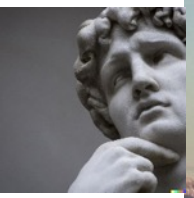

Questions?

Thank you for your attention!

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