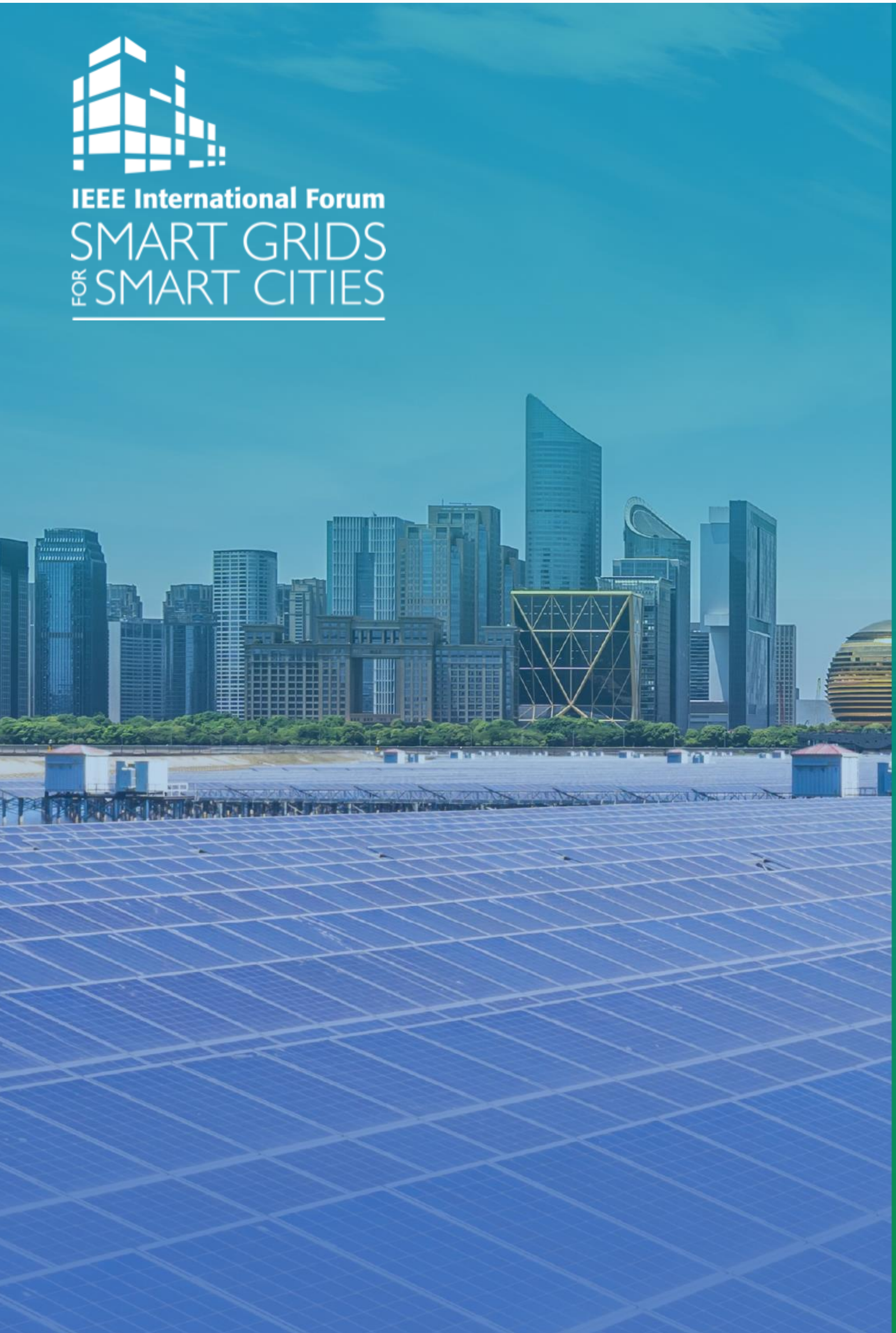

Sustainable urban mobility and energy infrastructure for the future

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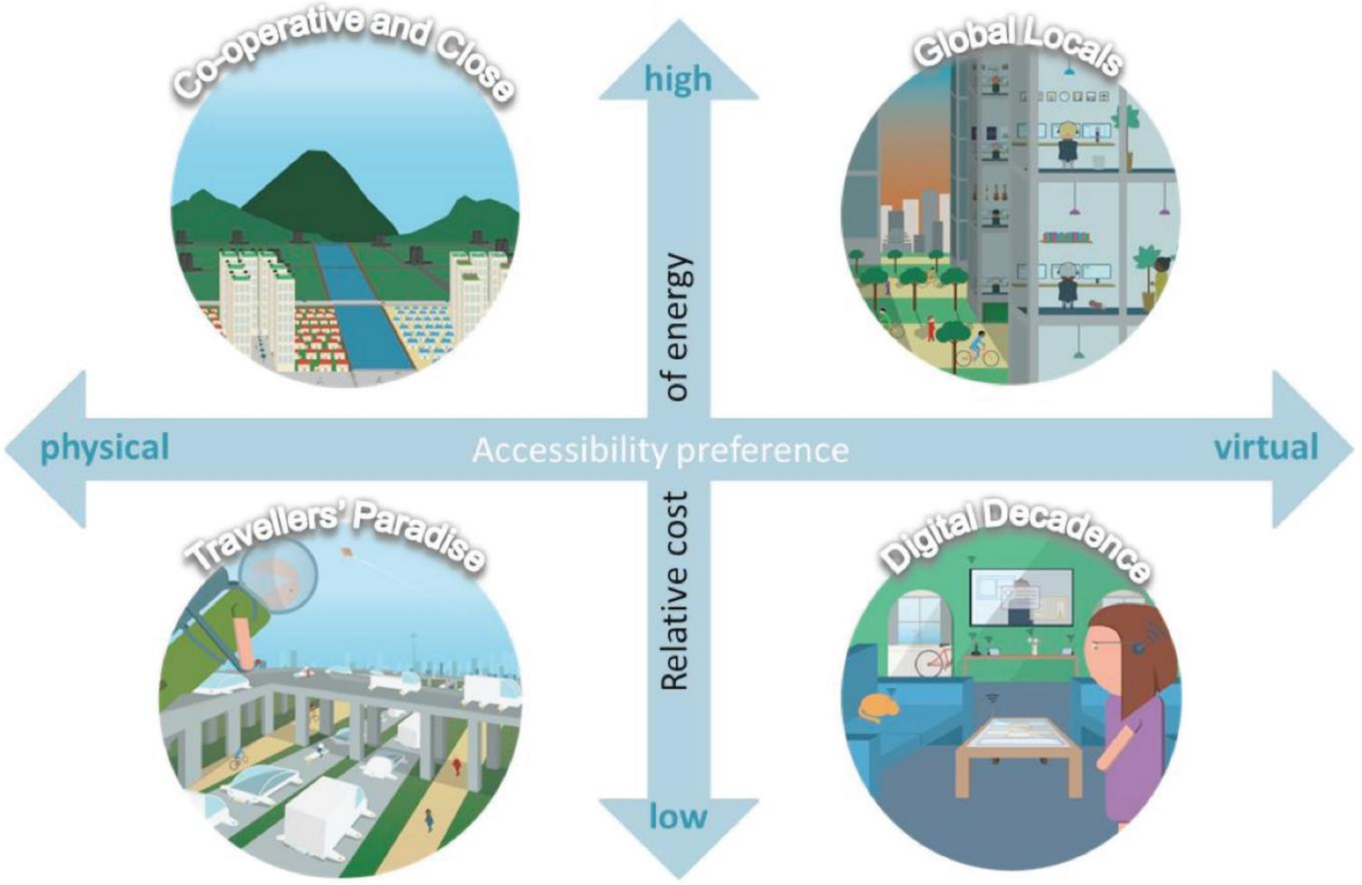
Urban mobility (future) challenges

- Economic growth and better life
  - impacts (urbanization) and constrains (space)
- ICT-based (C-)ITS
  - future TM of (cooperative) automated vehicles
  - urban transport for people and goods (all modes)
  - data, information, resilient systems
- Energy network
  - demand vs. supply
  - limited sources, reliability and redundancy (renewable energy)
  - electrification ≠ green or clean (energy source and supply chain)

Three stories about the future

- Innovating
  - reinventing a city as a young urban innovator, with advanced technologies
- Rebalancing
  - more equal but aging society with lower economic growth
- Accelerating
  - an ever-growing expanding city but struggles to deliver high quality of life for all



Example: generating outcome/vision scenarios

Source: TfL, 2019

Future needs & user groups corresponding

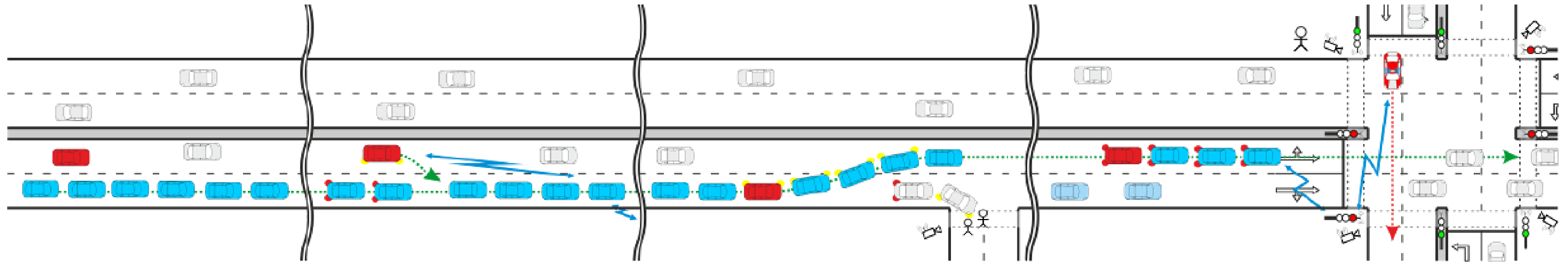
Future needs						
More attractive public spaces	●	●	●	●		●
Seamless mobility integration	●	●	●	●	●	●
Regulations for new transport modes		●		●	●	●
Safe streets for all	●	●	●	●		●
Cyber security for mobility	●	●	●			●
Personalised mobility	●		●			●
Adapted parking policy to future mobility				●	●	●
Alternative fuels provision			●	●	●	●
Increased capacity for public administration						●
Embracing new operating/business models and new modes of governance			●		●	●
Environmental quality	●	●	●	●	●	●
Vision and validate						●

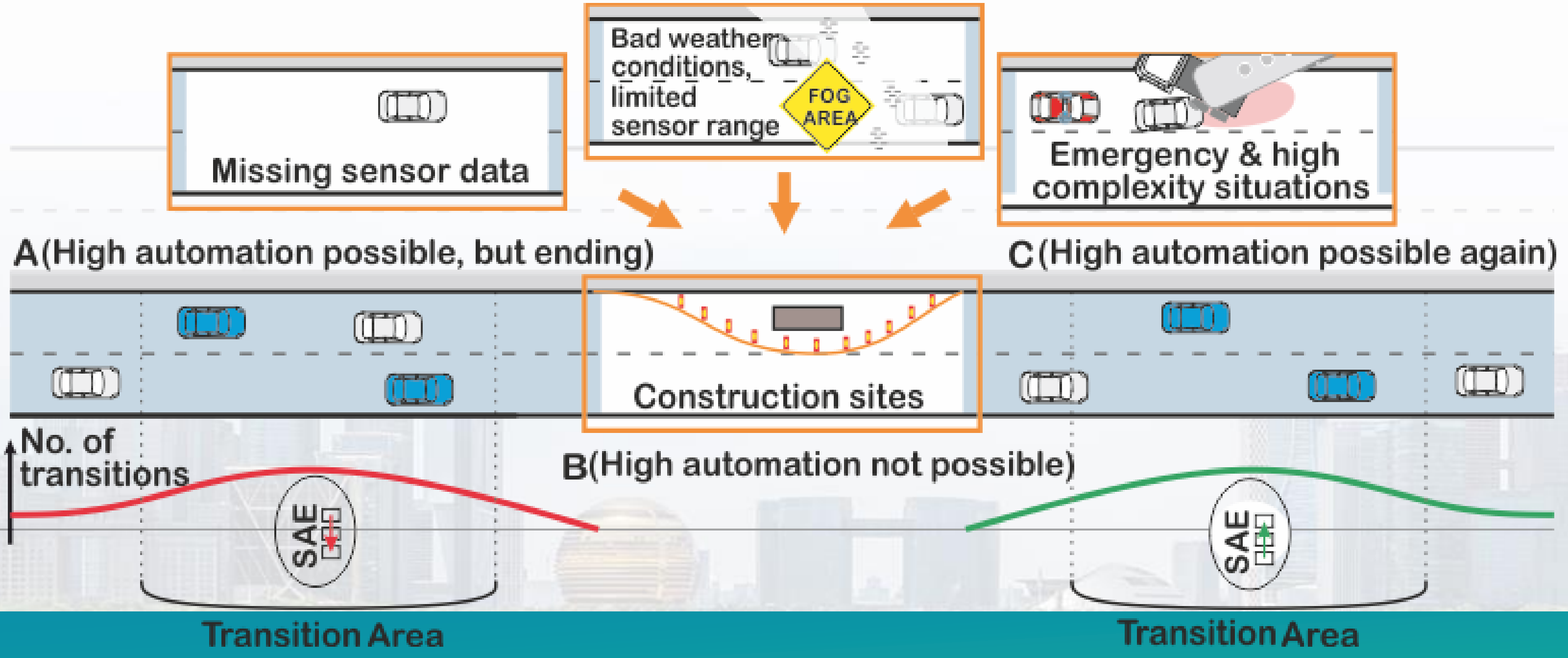
ITS and core technologies

- Base technologies
  - positioning, sensor, control, and communication (e.g. autonomous/cooperative systems, location referencing, digital map)
- Technology requirements
  - robustness, reliability
- Other aspects, e.g.
  - information/warning/control mode, choice of driver interface (HMI), legal, (data) privacy, and security

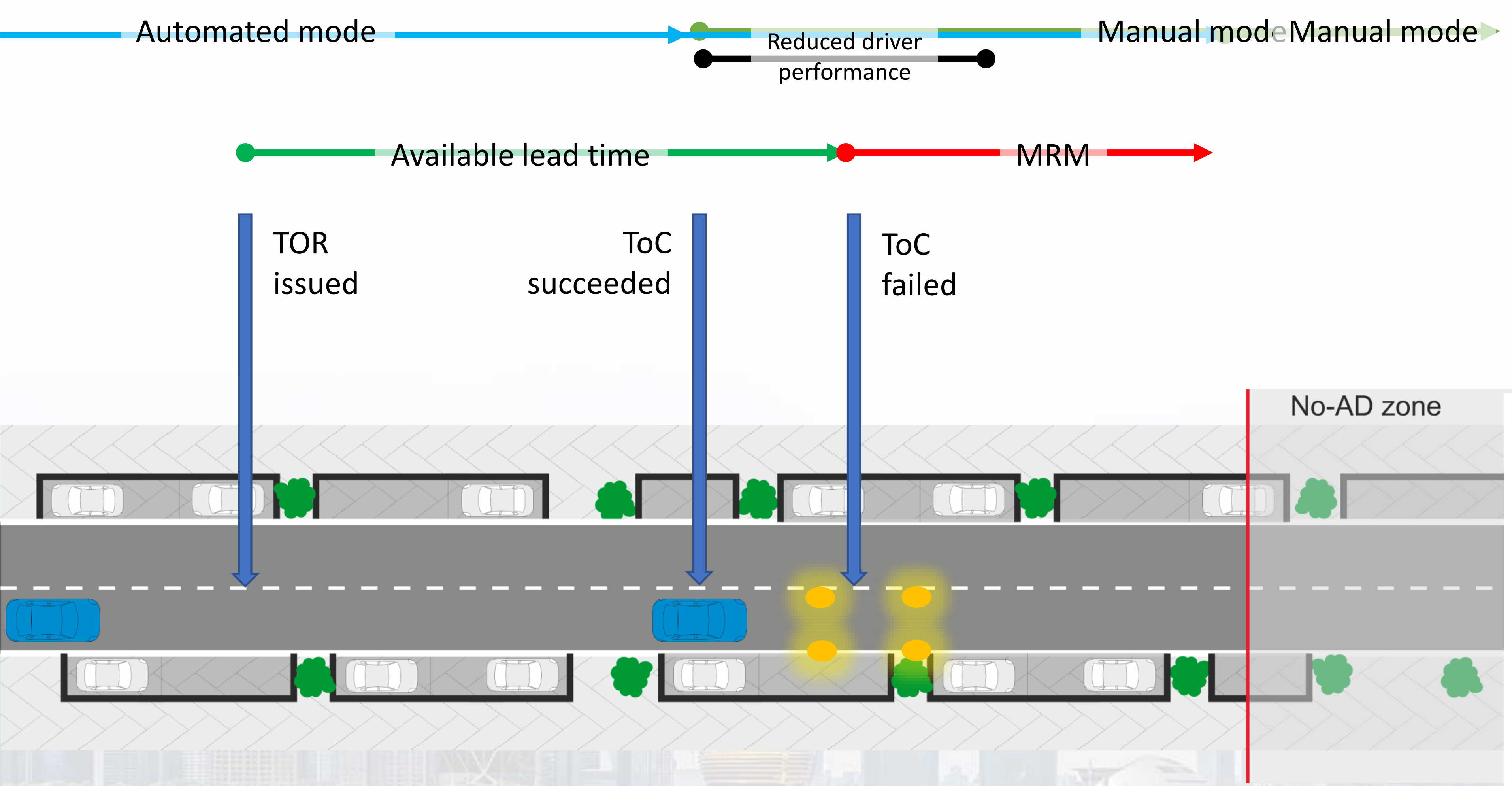
	SAE Level	Name	Steering, acceleration, deceleration	Monitoring driving environment	Fallback performance of dynamic driving task	System capability (driving modes)
Human monitors environment	0	**No automation** the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems				
Human monitors environment	1	**Driver assistance** the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.				Some driving modes
Human monitors environment	2	**Partial automation** the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task				Some driving modes
Car monitors environment	3	**Conditional automation** the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene				Some driving modes
Car monitors environment	4	**High automation** the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene				Some driving modes
Car monitors environment	5	**Full automation** the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver				All driving modes

Future TM with automated vehicles





ToC, TOR & MRM

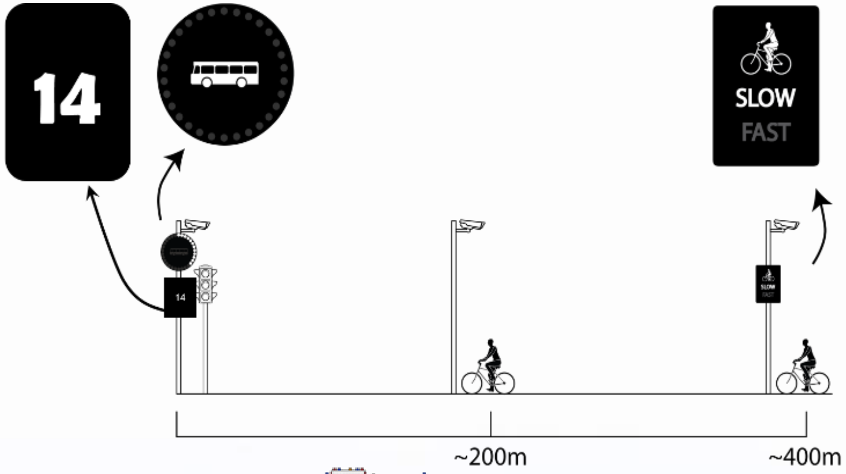


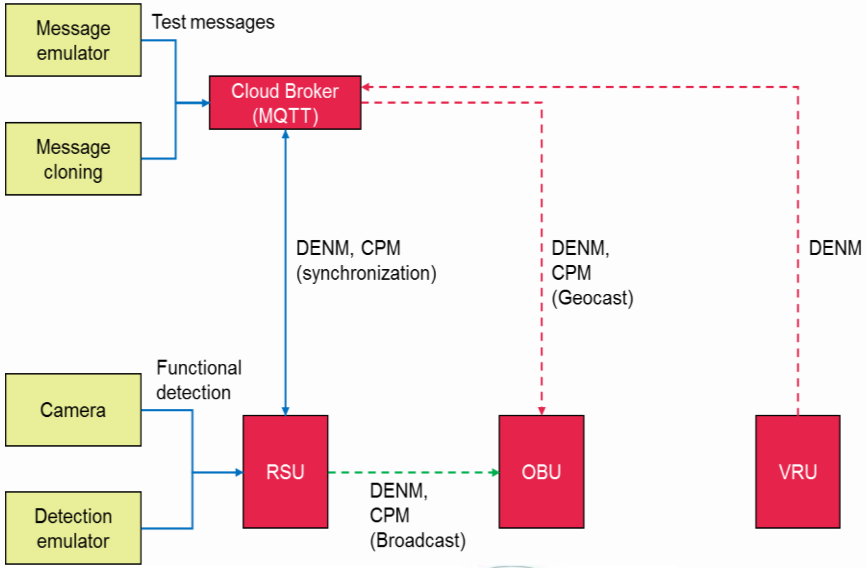
- ToC:
  Transition of Control
- TOR:
  Take Over Request
- MRM:
  Minimum Risk Manoeuvre

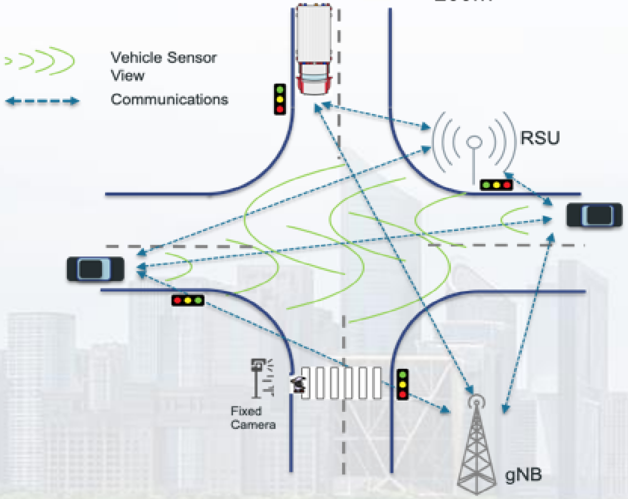
Managing AVs: key findings

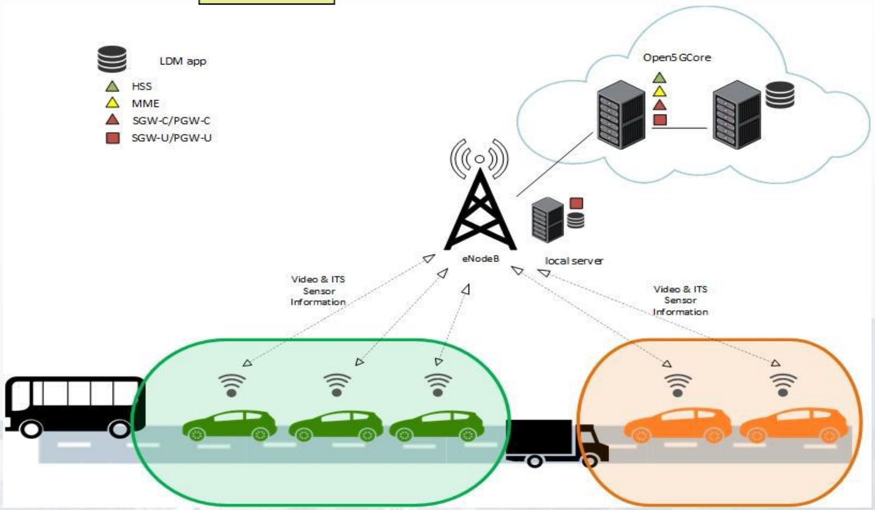
- People have high expectations on the positive impact of AVs
  - > 80% of the respondents believe that CAVs will decrease no. traffic accidents
  - ~ 70% of the respondents expect improvements in traffic congestions
  - most customers would pay a bit extra, up to €5k for a car with automated features
- Proper integration of AVs into a road infrastructure
  - clear positive effects on emissions, travel time, traffic flow harmonisation, safety
- Already lower levels of penetration have positive impacts
  - 20% penetration (effect of speed change advice and green wave optimisation) with reductions of 17.3% delays, 10.9% queue length, 0.4% CO_2
- AVs' impacts depend on policies/BM, e.g. green mobility, car sharing

Intelligent intersection: vehicles, cyclists and pedestrians









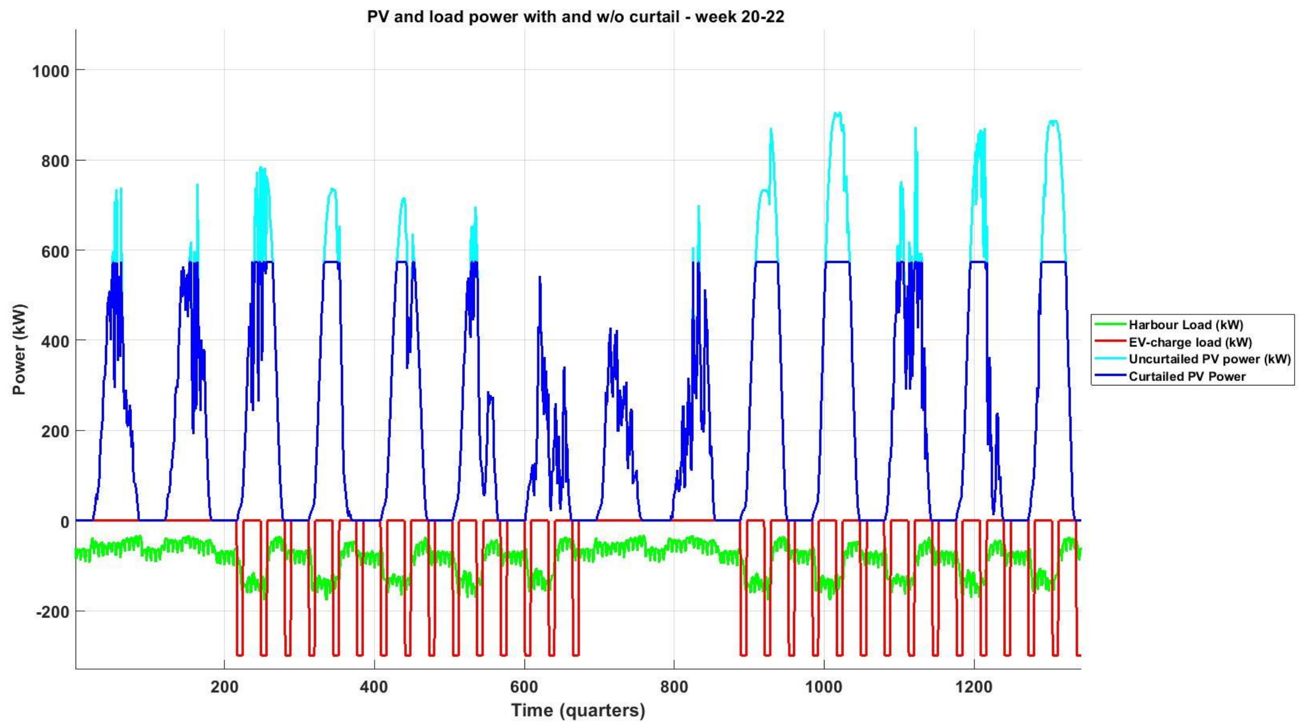
C-ITS services: benefits

- Fatalities reduction
  - road works warning 9%
  - road hazard warning 9%
  - in-vehicle signage 6%
- Injuries reduction
  - signal violation warning 7%
  - in-vehicle signage 6%
  - motorcycle approaching indication 4%
- Travel time reduction
  - green priority 9%
- Average speed increase
  - mode and trip time advice 8%
- Fuel consumption reduction
  - green priority 17%
  - mode and trip time advice 6%
- CO_2 reduction
  - mode & trip time advice 6%
  - green priority: 5%

Energy assessment

- Energy infrastructure for intelligent hubs
- Simulations of electrical grid with load, renewable energy, battery and grid connection

  => Controlled by EMS, which is included in simulation



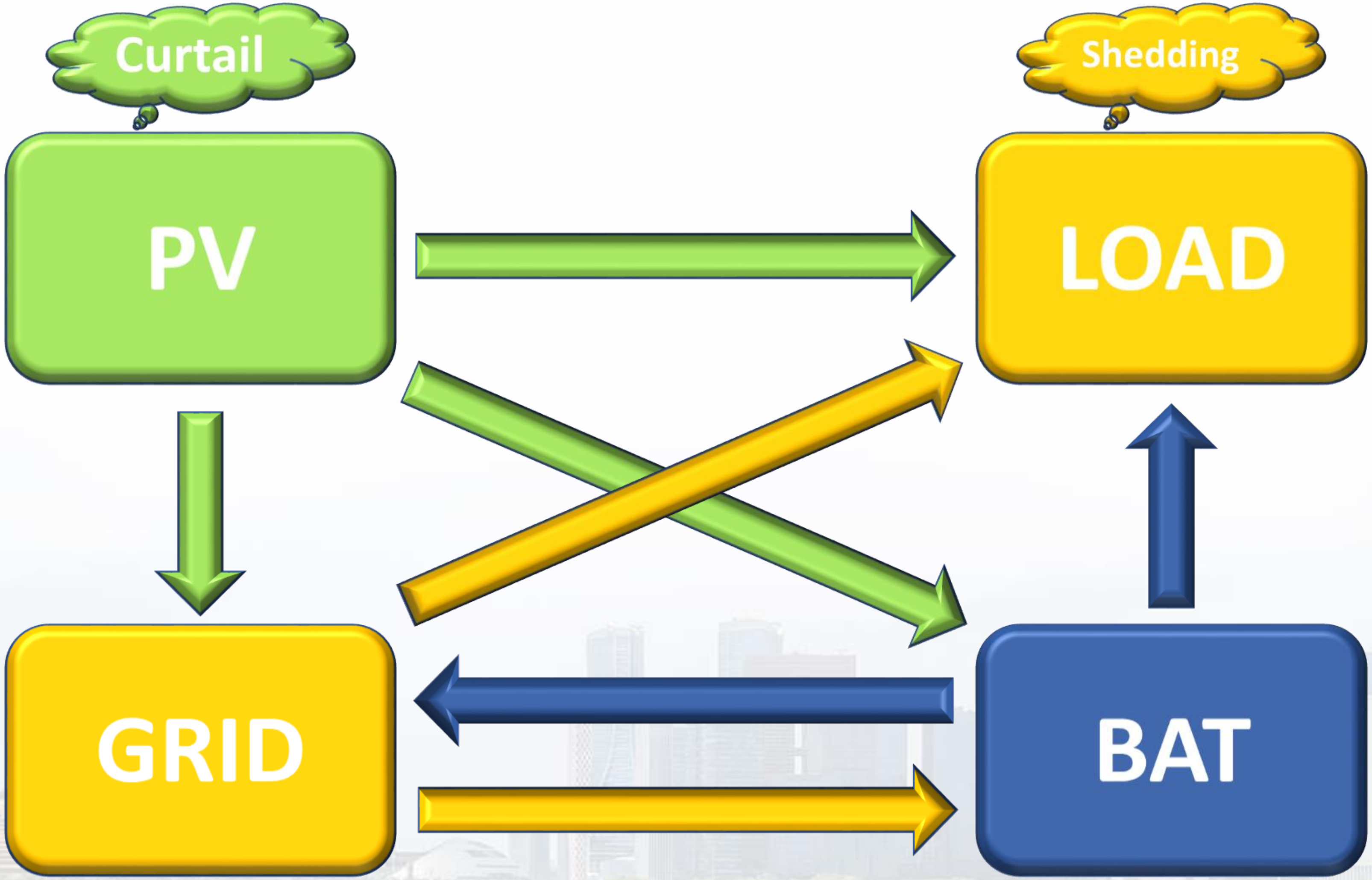
EMS development - powerflows

Powerflows

- PV to Grid / PV to Bat /PV to Load
- Bat to Load/Bat to Grid
- G2L/G2B

Losses

- PV Curtail
- Load Shedding

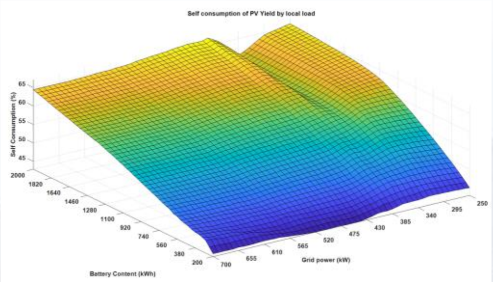


EMS development

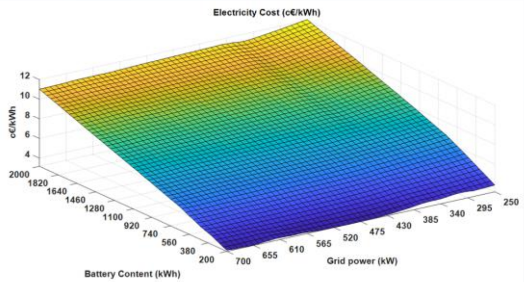
- Energy Management System
  - Simulate realistic behaviour of grid with RES and battery
  - Track & Control
- Method
  - Simulation over entire year
  - Current Load Demand vs PV Production
  - Load-PV prediction next 4h
  - SoC Battery
- Using
  - Measured PV-values
  - Load profile with addition of EV (300 kW*2h – 3*day)
- Results
  - Control battery charge/discharge
  - PV => Bat/Load/Grid – Curtail
  - Load => PV/Bat/Grid - Shedding

Energy assessment results

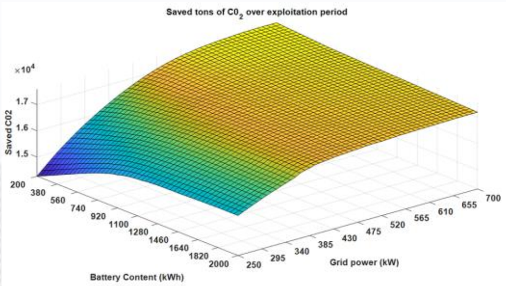
- Energy management (model)
- Costs per kWh is very low with small battery (< 4 c€/kWh)
- Benefits
  huge CO_2 reduction, grid expansion at lower cost, energy saving



Grid power and battery content



Cost calculation



CO_2 reduction

Conclusion

- Holistic view on sustainable transport: improving safety, (traffic/energy) efficiency, air quality, comfort, accessibility, equality, …
- Urban planning, space design, eco-driving, eco-freight transport, eco-TM/control
- Mobility choices for people, synchromodality for goods, cleaner technologies, efficient (use of digital and physical) infrastructure
- (C-)ITS (deployment) for urban mobility, and future TM with AVs
- Energy mgmt. system (simulation study) for hubs

Acknowledgements

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THE PORT OF THE FUTURE

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Thank you for you attention!

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