The overview of Digital Technologies

- Green initiatives through digitalization can be divided into: Green by Digital and Green of Digital.

Green by Digital

Digitization of the Energy industry

- Data and analytics in power plants and electricity networks
- Optimized oil & gas production processes

Digitization of energy consumption

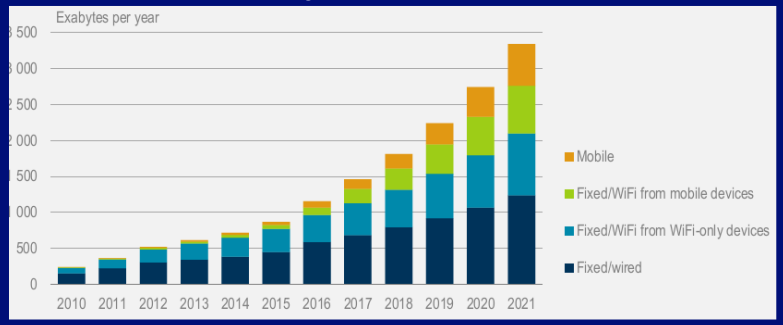
- Smarter and more connected vehicles and infrastructure
- Shared mobility / Automated driving technologies
- Smart thermostat / lighting
- Digitalization of industrial plant

Digitization of consumer and industrial services

- E-commerce
- E-materialization
- Telework

Green of Digital

Global IP traffic by access mode



Energy use by information and communications technologies

Data center	2014 194 TWh 2020 200 TWh
Network	2015 185 TWh 2021 160-320 TWh
Connected device	# of 2016 2020 Smart phone 3.8->6 bil IoT device 6 -> 20 bil

Source: IEA (2017) "Digitalization & Energy", Horner et al (2016) "Known unknowns: indirect energy effects of information and communication technology"

Technology trends (1/2)

- Key areas of demand are assumed as the areas for digitization.

	Green by Digital			Green of Digital		
	Mobility 2.9 Btoe	Building 2.9 Btoe	Industry 2.8 Btoe	Data center 17 Mtoe	Network 14-28 Mtoe	Connected Device
Challenges	•Safety •Efficiency •Decarbonization	•User comfort •Improving energy service	•Safety •Productivity •Less downtime •Lower costs •Reduced energy •Product quality	•Shifting to hyperscale •Energy cost/ environmental impact /reputation	•More data with Less energy /capacity Utilization •Mobile Networks (5G,6G,LPWA)	•Connectivity of devices (consumer devices, appliances and infrastructure)
	・Cyber security ・Privacy ・Economic disruption					
Technology trends	•Connected •Autonomous •Shared •Electric (CASE)	•Responsiveness /predictively (sensors) •Demand response •Maintenance	•Connectivity •Digital twin •3D printing •Robotics	•Energy efficiency •Demand response	•Capacity utilization •LPWA	•Low-power electronics •Energy harvesting
				•Energy efficiency of electric components (SiC, GaN, Ga2O3, opto-electronics)		

Source: IEA (2017) "Digitalization & Energy", "Energy Balance 2020"

Note: number of "toe" are final energy consumption

Technology trends (2/2)

- Green by Digital in Electricity System overlaps with Energy System Integration.

Green by Digital

Electricity System

17 Btoe

	Data and analytics	Interconnected systems
Challenges	•Efficient O&M •Improving efficiency •Reduction of unplanned outage •Extended asset lifetimes	•Integration of variable renewables •Demand response •Roles of EV •Distributed generation, mini-grids, "prosumers"
Technology trends	•Asset management / predictive maintenance •Digital twin	•Local flexibility •V2G •Blockchain

Source: IEA (2017) "Digitalization & Energy", "Energy Balance 2020"
Note: number of "toe" are fossil fuel consumption for electricity system