ENERGY PARTNERSHIP
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Prospection in Energy Digitalization in Chile

CENTRO DE ENERGÍA
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Executive Summary

The digital revolution is happening in all sectors. Although some applications of digital technologies are more evident to users than other (i.e., smart phone apps), energy is one of the areas that has benefitted the most by this revolution. The energy sector has seen an expansion in possibilities, transitioning from an industry of traditional services to a highly complex multi-actor system. Today, we hear about renewable energies, smart grids, prosumers, and many other terms that could not have been imagined without those technological advancements. However, this sector has the big challenge of moving towards a consumer-centric (or end-user-centric) paradigm, taking advantage of the opportunities given by digitalization.

In this way, the energy sector presents an interesting opportunity to create value by combining digital technology, people and business strategy and reducing carbon emissions trough the way we produce and consume electricity, safeguarding the planet for future generations. We hope that digitalization will become a fundamental factor for the energy transition and an enabler of industrial trends related to decarbonization and decentralization.

A state-of-the-art review of the digital revolution was performed, as well as an analysis of gaps and opportunities for digitalization applications, with a focus on energy and the associated sectors. The review included scientific publications as well as policy from ten key countries that were selected for their merits in an international digitalization ranking: Germany, Finland, Japan, China, USA, UK, Sweden, France, South Korea and Singapore. From this review, a total of 30 key uses/applications were identified, along with eight classes that group related applications. Several enabling technologies were also identified, divided in six categories.

From the analysis, smart grid technologies and uses are prevalent. Enabling technologies on the Internet of Things category are those most often found in digitalization uses. Big Data, Machine Learning and Artificial Intelligence technologies are usually found in the customer domain uses, which are key when taking into consideration that an end-user-centric vision is usually associated with the digital transformation, according to the literature.

In addition, the analysis helped identifying digital uses and applications that support or incentivize the development of the measures included in the updated Nationally Determined Contributions (NDC) proposal and the carbon neutrality target by 2050. In general, most of the identified digital uses and applications are not included explicitly in the NDC: Eight applications and uses were found to contribute directly to mitigation actions proposed in the NDC, while four applications, although not associated with a specific measure, contribute indirectly to the carbon neutrality target.

The analysis of gaps and opportunities was performed both for the key countries as well as for Chile. This included the goals that the key countries have set for themselves, what gaps they are (or were) associated with, the barriers that digital uses and applications have had to face, and the main opportunities associated with digital uses and applications. The main barriers for the identified applications are summarized below:

- **Economic:** Most of the digitalization uses face economic barriers, such as the lack of economic incentives to implement an application or to deploy a technology. Also, the high investment cost of several technologies appears frequently as a barrier.
- **Regulatory:** Several applications require a modification or update of the current regulation. This is notorious on the Smart Grid, DER Management and Customer domain classes of applications, and in a lesser degree in the Mobility class of applications.
- **Infrastructure:** Barriers found on the technical level, related to the deployment of enabling technologies or the required infrastructure for an application to succeed were also found. Because of the variety of barriers included under Infrastructure, these were found across all classes.
- **Security:** Privacy, data sovereignty and information security were also barriers recognized across all classes of uses.
- **Human Capital:** Several applications, particularly those that involve and benefit customers or end users, were recognized as having barriers on the lack of training and the need of new skills, knowledge and digital education.

The opportunities for digital applications in Chile can be summarized as follows:

- **Smart grids:** These technologies present a great opportunity for both urban and rural zones, with solution that improve access to energy services and their quality.
- **DER management:** The growing penetration of renewable energies at the national level, empowered by the country's goals, brings opportunities for new uses associated with distributed resources. The modernization of the distribution systems regulation opens new possibilities for uses such as demand response and distributed storage
- **Customer domain:** Uses of this class can impact directly the customer's service experience and engagement with the energy sector as they can offer customer-tailored energy products with a wide range of incentives and features.
- **Process management:** The incorporation of these uses entails an improvement in the efficiency of the processes through the deployment of equipment and technology, as well as an increase in the satisfaction levels of employees and the creation of new job profiles.
- **Mobility:** Digitalization favors the reduction of emissions by making the transfer of goods and people more efficient, for example, reducing the number of simultaneous vehicles in the streets and the transit time of each vehicle, or fostering the adoption of electric vehicles in the extent to which it can generate added value to the owners (vehicle-to-grid services, smart charging networks, etc.).
- **Data management:** Data management technologies present an important opportunity to take advantage of the abundant renewable energy resources of Chile, as well as to better understand demand (elasticity, patterns, etc.) for electricity, transport and heating.
- **Smart city:** Digital applications in this class bring social benefits associated with an increase in social well-being, improved road safety, reduced travel times, better services, reduced visual and olfactory pollution, increased quality of life, among others, contributing to the reduction of GHG emissions, through the efficient management of energy and water, the reduction of fuel consumption and the improvement of production processes.
- **Other uses:** Specific opportunities were recognized for each use under this class, where contribution to emission reduction was transversally recognized. Teleworking, in particular, has gained more visibility during the 2020 pandemic.

Considering the international experiences, the following recommendations for public policies are considered in order to reduce barriers and promote the implementation of uses and digital applications:

- Promote articulation between the different institutions related to the digitization of the different sectors at the national level, considering a national policy approach.
- Promote and disseminate the existence of identified digital applications to the public and private sectors.
- Include the impact of the digitization of the energy sector in long-term energy policy and in climate change mitigation policies.
- Increase the public investments in digital infrastructure, build a large-sale ICT infrastructure that supports public utilities and other services such as road infrastructure.
- The adoption of a common data architecture, tools, and standards to reduce bugs and raise the quality, reliability, and security of devices and services, and that facilitates economies of scale and data sharing across different institutions.
- Reduce the digital gap among the different territories of the country.
- Increase investment in human resources and education related to digital application and enabling technologies.
- The implementation and reinforcement of Government's Personal Data Protection Laws and Policies for public and private sectors.
- Develop pilot programs to promote the use of different digital applications, involving the public sector, private sector, and academia.
- Encourage investment by private parties in projects associated with the digitization of the energy sector (greater offer of shared mobility, aggregators for VPPs, smart lighting services, etc.)

The full list of applications and enabling technologies are presented below, along with a summary sheet for each digital application class.

Digitalization uses and applications:

Class	Uses & applications
Smart grid	Smart substation
	Feeder automation
	Microgrids
DER management	Demand Side Management (DSM) / Demand Response (DR)
	Energy storage
	Virtual Power Plant (VPP)
	Distributed energy (electricity/DG & gas)
Customer domain	Prosumer & P2P trades
	Retailing, billing & customer orientation
Process management	Process optimization & automation (gas, oil & coal)
	Emission monitoring
Mobility	Transportation for personal use
	Public transport
	Transport cargo
	Shared mobility

Class	Uses & applications
Data management	Predictive maintenance
	Forecasting and predictive analytics
Smart city	Smart lighting
	Smart traffic
	Smart home & building
	Smart industry
	Smart farm
	Smart parking
	Smart waste management
	Smart fleet management
Other	Market management & operation
	Ancillary services
	Energy management
	Operation (monitoring/control/reporting)
	Teleworking

Enabling technologies:

Category	Enabling Technology
Smart home & Smart building	Load monitor
	In home display
	Smart thermostat
	Smart light
	Smart plug/switch
	Smart appliance
	Hub
Smart grid	Smart meters
	AMR/AMI
	V2G
	EV/PHEV
	IED (relays, SCADA, RTU, etc.)
	PMU
	WAMS

Category	Enabling Technology
IoT & IoE	Smart Sensors
	Sensor and actuator networks
	LAN/HAN/NAN/WAN
	Cloud
	5G
Big data, machine learning & AI Ledger	Machine learning
	Data mining
	Nature inspire intelligence
	Artificial Neural Networks (ANN)
	Multi-agent systems
	Clustering
	Natural language processing (NLP)
	Digital twin
	Autonomous Vehicle
	Blockchain
Physical action	Actuators
	3D printers

Smart Grid

Smart grid is a cyber-physical system which includes communication system with the power flow structure, to gain intelligence and automated control. The communication support schemes and real-time measurement techniques of smart grid enhance resiliency and forecasting as well as offer protection against internal and external threats.

Smart grid application potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Smart substation		X		X			Electricity
Feeder automation				X			Electricity
Microgrids	X	X	X	X		X	Electricity

Smart grid enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA ...	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire ...	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Smart substation								x	x			x	x	x			x														
Feeder automation									x			x	x	x			x														
Microgrids								x	x	x	x	x	x		x	x	x	x													

Goals, gaps, barriers and opportunities for Smart Grid applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Smart substation	Modernization of the grid, monitoring and control to support flexible, secure grid.	Communication requirements in terms of transmission speed and security of information; Economic incentives.	Reduction in maintenance and operation costs; Increased safety; Reduced response time.
Feeder automation	Modernization of the grid, improved performance, integration of data analytics.	Investment (current digitalization level is low); Customer´s resistance to share information; Economic incentives, recognition of value-added services.	Faster response for reduced failure time; Synergy with DER.
Microgrids	Development of commercial microgrids, coexistence with centralized systems (current developments mostly at remote locations or labs).	Technical barriers (bidirectional power flow, stability, protection, coordination with centralized grids, safety); Lack of flexible regulation that permits bidirectional power flow, local energy trade; Lack of incentives to flexible resources.	Reliable and resilient grids; Incorporation of other digital applications (DER, customer domain); Synergy with DER; Association with SDG 7; Solution for rural areas.

Current goals for Chile:

- *Energía 2050*: 100% smart metering by 2050, intelligent communication and control to enable high renewables penetration, limits for outage durations (<1 hour per year by 2050).

Current initiatives in Chile:

- *Casa Solar* program (potential synergy with microgrids as complementary to the program).
- *Ruta de la luz* initiative (potential synergy with microgrids as rural electrification option).
- Energy policy update process by Ministry of Energy.
- *Anexo Técnico de Exigencias Mínimas de Diseño de Instalaciones de Transmisión* (specifications on smart substation topics).
- Coordinador Eléctrico Nacional is currently working on R&D (Fondef) project to incorporate PMU data in monitoring.

Public policy recommendations:

- Define sovereignty of the data explicitly in the regulation.
- Modernize technical normative: adopt common data architecture, tools and standards.

- Encourage investment by private parties in projects associated with digitization: recognize value-added services.

DER Management

DER Management alludes to the way in which the energy resources distributed in the electrical network are managed, seeking that said management efficiently take advantage of the availability of resources according to the conditions in which the system is found.

DER Management application potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
DSM/DR	X	X	X	X		X	Electricity
Energy storage	X	X	X	X		X	Electricity
VPP		X	X	X			Electricity
Distributed energy		X	X	X		X	Electricity

DER Management enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA …	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire …	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
DSM/DR			x		x	x		x	x					x			x	x													
Energy storage											x					x	x			x											
VPP																x	x	x		x											
Distributed energy																		x													x

Goals, gaps, barriers and opportunities for DER Management applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
DSM/DR	DR programs: tariffs and price schemes, flexible power goals (e.g. 200 MW in UK).	Lack of regulation that enables and incentivizes participation; Enabling technologies (e.g., smart meters); Maturity of smart appliances; Connectivity and access to information; Data security.	DSM/DR as a source of flexibility (e.g. controllability of the demand); Enabling technologies (Big data, AI) to improve operation; new customer services (e.g. smart pricing).
Energy storage	Overcome limits (e.g. 50 MW in UK) and reach specific targets (e.g. 200 MW by 2025 in Singapore), but usually associated with the goal of maximizing renewables penetration.	High investment cost in some technologies (e.g batteries); Regulation and participation on the market not fully defined; Potential conflict with displaced generators with long-term contracts (short term).	Storage as a source of flexibility (e.g. providing ramp capacity); Increased reliability and resilience.
VPP	*No specific targets were found*	Lack of regulation for VPP participation; Enabling technologies; Connectivity and computational cost.	Synergy with other digitalization uses (Microgrids, DG, DSM, storage, etc.), particularly as aggregators.
Distributed energy	Adoption goals either in terms of penetration (e.g. 15% in South Korea) or installed capacity (e.g. 15 GW dist. gas & 60 GW solar in China)	Regulatory barriers; Need to upgrade the electrical system in view of a bidirectional flow.	Lower cost associated with technological advances; potential contribution to emission reduction.

Current goals for Chile:

- *Energía 2050*: 70% renewable penetration by 2050, storage and demand as flexibility resource.
- *Ruta Energética 2018-2022*: 4-fold increase in renewable DG.
- New distribution systems law: new agents (Demand aggregator, Energy retailer, Information Manager).

Current initiatives in Chile:

- Updates to the Net billing law: Up to 300 kW of DG.

Public policy recommendations:

- Establish economic incentives for the participation of flexible resources in energy markets (energy, capacity, and ancillary services) that effectively reflect the value of their flexibility.

Customer domain

This class contains the uses whose focus is on the end user and how this participates in the system, considering aspects such as billing or the existence of the prosumer as a relevant agent for the energy system.

Customer domain application potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Prosumer & P2P trades		X	X	X			Electricity and fossil fuels
Retailing, billing & customer orientation	X			X	X	X	Electricity and fossil fuels

Customer domain enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA ...	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire ...	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Prosumer & P2P trades								x									x												x		
Retailing, billing & customer orientation																				x	x	x			x	x					

Goals, gaps, barriers and opportunities for Customer domain applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Prosumer & P2P trades	Participation of a large number of consumers, especially small ones; There is a confidence or trust gap.	Data security must be ensured, ownership defined, and access to information guaranteed.	Creation of new services and markets; Highly compatible with the application of other uses (e.g. DG, DSM).
Retailing, billing & customer orientation	Open the retail energy market (e.g. gas, electricity) to full competition where users are free to choose suppliers.	Regulatory framework (must be tailored to the reality of each country); security and sovereignty of the information; lack of competition.	Improvement of user experience and engagement in this and other uses (e.g. EV, DSM).

Current goals for Chile:

- *Energía 2050*: prosumers recognized in policy, but no goals are set.
- New distribution systems law: electric portability (Energy retailer agent).

Current initiatives in Chile:

- phiNet (Phineal) is promoting energy traceability through blockchain technology (GTIME), current pilot at Transelec.

Public policy recommendations:

- Promote the entry of prosumers to the electricity market, incorporating economic incentives (taxes, tariffs) or the promotion of others that complement (e.g. energy storage).
- Promote the implementation of smart meters to facilitate the introduction of this type of schemes and to improve the quality of customer service.
- Promote competition and efficiency in energy trading.

Process Management

This class is associated with uses whose objective is to improve processes associated with energy generation and / or consumption and also for internal processes.

Process Management application potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Process optimization & automation (gas, oil & coal)	X	X	X	X			Electricity and fossil fuels
Emission monitoring		X		X			Fossil fuels

Process Management enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA ...	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Process optimization & automation															x		x	x		x	x		x	x			x	x		x	x
Emission monitoring															x		x	x		x			x		x						

Goals, gaps, barriers and opportunities for Process Management applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Process optimization & automation (gas, oil & coal)	Increase satisfaction levels of employees; cut electricity usage; save fuel (e.g. airlines, vehicle fleets).	High investment cost; IT readiness; need for new skills; resistance from employees (potential job elimination), lack of trust, dependence on non-humans.	Improvement in process efficiency, economic benefits; creation of new jobs; Closely related to Smart Industry.
Emission monitoring	Zero emissions goals (e.g. COP 25 CO_2 goals); people's behavior and business ethics gap.	High cost of modernizing monitoring systems; lack of economic incentives.	Climate change mitigation actions.

Current goals for Chile:

- Carbon neutrality by 2050 (updated NDC).
- *Plan de Descarbonización de la Matriz Eléctrica* (decommissioning of coal power plants without carbon storage or sequestration).

Current initiatives in Chile:

- *Estrategia de Inteligencia Artificial para Chile*, from the Senate's Commission on Future Challenges, Science, Technology & Innovation.

Public policy recommendations:

- Promote digitalization (in particular, optimization and automation) on Small and Medium companies through economic instruments.

Mobility

This class includes those mobility applications that have incorporated digital technologies in some of their processes. Incorporation of mobility is important as transportation and electromobility are closely associated with energy.

Mobility applications potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Transportation for personal use	X		X				Fossil fuels and electricity
Public transport	X						Fossil fuels and electricity
Transport cargo	X						Fossil fuels and electricity
Shared mobility	X						Fossil fuels and electricity

Mobility applications enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA …	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire …	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Transportation for personal use										x	x																	x			
Public transport										x	x																	x			
Transport cargo											x																	x			
Shared mobility										x	x									x						x	x	X			

Goals, gaps, barriers and opportunities for Mobility applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Transportation for personal use	Several infrastructure goals (e.g. charging stations) associated with the expected adoption of EVs.	Low market penetration of connectivity devices for vehicles; Lack of consensus on the technology to be massively adopted by vehicle manufacturers: Competition between IEEE 802.11 and 4G / 5G; Lack of regulation; High investment cost for EV; Prohibition for car conversion to electric	Overall customer satisfaction; Contribution to the mitigation of GHG emissions against climate change.
Public transport	Link with artificial intelligence strategies and their application in public transport (e.g. development of autonomous driving technology in South Korea).	High investment in infrastructure; Lack of incentives to prefer public transport over private.	Contribution to the mitigation of GHG emissions against climate change.
Transport cargo	Associated to zero emission policies (e.g. Sweden, UK)	Lack of ICT skills in freight companies.	Reduced operating cost through optimized logistics and automation.
Shared mobility	Require certain connectivity of vehicles and users. Interconnection between cities and introduction of large fleets of shared cars (Berlin is the city with the most car sharing).	Cybersecurity (exposed user location). The ownership of the information and access to the information must be defined.	Contributes to the mitigation of GHG emissions against climate change. Allows less crowding of public transport, desirable in situations of crisis (COVID-19).

Current goals for Chile:

- National Electromobility Strategy: 40% of private vehicles and 100% of public transportation by 2050.

Public policy recommendations:

- Flexible regulatory framework, which allows the implementation of shared mobility and the implementation of associated enabling technologies (autonomous vehicle, V2G, EV, among others).
- Legal definitions that establish rights, duties and responsibilities between the parties (users and providers of mobility services).

Data Management

This class groups uses oriented to data analysis using Smart Meters and / or AMIs. These uses allow to have a more reliable network for the information and forecasts that they deliver.

Data Management application potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Predictive maintenance	X	X	X	X		X	Electricity and fossil fuels
Forecasting and predictive analytics	X	X	X	X	X	X	Electricity and fossil fuels

Data Management enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA ...	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire ...	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Predictive maintenance								x	x			x		x						x							x				
Forecasting and predictions																				x	x		x		x						

Goals, gaps, barriers and opportunities for Data Management applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Predictive maintenance	Need for greater penetration of technologies for maintenance and acquisition in real time, which entails an investment.	The existence of infrastructure that allows the acquisition of data is essential. High investment in complex systems. It requires significant use of computational resources.	Significant cost reduction. Increased safety of equipment operation by optimally managing maintenance.
Forecasting and predictive analytics	Massive implementation of this use; adoption of data acquisition technologies.	It needs incentives from relevant agents to adopt this use (eg utilities). The use of technologies with high costs means that this use has a relevant investment.	The high potential of renewable energies in Chile promotes the implementation of this use, considering that it allows for better adapted and planned responses. Complements the implementation of other uses.

Current goals for Chile:

- No public policies specifically related to this class.

Public policy recommendations:

- Promote policies to increase the public investments in digital infrastructure, build a large-sale ICT infrastructure.
- Promote articulation between the different institutions related to the digitization of the different sectors at the national level.
- Reduce the digital gap among the different territories of the country.
- Develop pilot programs to promote the use of different digital applications, involving the public, private sector, and academia sector, which may reduce the barriers of entry of different technologies.

Smart City

Smart City is a vision of future urban area where smart ICT technologies will connect every major sector of the city through rich features such as the smart economy, smart mobility, smart environment, smart people, smart living, and smart governance.

Smart City application potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Smart lighting		X	X			X	Electricity
Smart traffic	X	X				X	Electricity and fossil fuels
Smart home & building		X	X				Electricity and fossil fuels
Smart industry		X			X	X	Electricity and fossil fuels
Smart farm		X					Electricity and fossil fuels
Smart parking	X					X	Fossil fuels and electricity
Smart waste management		X	X			X	-
Smart fleet management	X	X				X	Fossil fuels and electricity

Smart City enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA ...	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire ...	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Smart lighting		x		x											x	x	x		x											x	
Smart traffic									x																						
Smart home & building	x	x	x	x	x	x	x	x							x		x	x	x	x											
Smart industry						x									x			x		x	x				x			x			x
Smart farm			x	x	x			x							x		x	x	x	x	x				x					x	
Smart parking								x							x		x	x	x	x											
Smart waste management		x													x		x	x	x	x										x	
Smart fleet management										x	x				x		x	x	x	x								x			

Goals, gaps, barriers and opportunities for Smart City applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Smart lighting	Requires a remote monitoring and control system, capable of providing a quick and adapted response.	It requires a robust cybersecurity system against possible attacks. Its implementation must be supported by the state and socially, the public must be kept aware of its benefits.	Improves road safety in the city. Contributes to the efficient use of energy.
Smart traffic	Adoption of enabling technologies (VANETs, 5G).	Large investment due to the need for telecommunications infrastructure and fleet renewal or adaptation. Requires the analysis of large amounts of data and the integration of different platforms.	Contribution to emissions reduction.
Smart home & building	Develop broad standards in the smart home and building industries.	Sovereignty of information; lack of interoperability; cost of enabling technology.	Increased adoption of smart devices at home.
Smart industry	The transition process requires significant investments in equipment and staff training. SMEs cannot implement this use independently and therefore need government support (for example, the "Industry of the Future" initiative in France supported the modernization of more than 7,400 SMEs between 2016 and 2017).	It carries a high cost of implementation. There may be some resistance from employees.	Improves the efficiency of production processes. Digitization of the information handled by the industry allows obtaining simplified administrative processes.
Smart farm	Adoption of AI and automation in the agricultural industry.	Internet access must be guaranteed in mostly rural areas. Data sovereignty must be established. It is important to consider interoperability between producers.	Contributes against the climate crisis thanks to the efficient use of water. Boost agricultural productivity through new technologies (5G, IoT and Big Data).
Smart parking	Use of real-time information on parking facilities and interaction through mobile device apps.	Requires a real-time information system. Data security must be guaranteed. High investment in equipment and training.	Overall user satisfaction; smarter parking pricing.
Smart waste management	Goals such as zero waste and circular economy (e.g. Denmark); related to Emissions monitoring application.	Citizens must be trained so that the effects are consistent with change in behavior. It must be accompanied by incentives for companies to adopt this use. Investment in infrastructure (mainly sensors and telecommunications systems) and computational cost.	Contribution to emissions reduction. Use of emerging technologies. Increase in people's well-being.
Smart fleet management	Integration of information from different operators, sensors and services based on geolocation is needed. It requires the development of new technologies and specialized software. It needs non-existent infrastructure (VANET and 5G stations).	The ownership of the information and access to it must be established. It requires very fast communication systems and complex prediction algorithms.	It is associated with a reduction in GHG emissions, as well as a reduction in O&M costs. Reduces vehicular traffic congestion and optimizes travel times. Friendly with the incorporation of technologies (e.g. EVs and V2G). .

Current initiatives in Chile:

- Digital Agenda 2020: Strategic map of the Smart City Plan, allowed to recognize opportunities and gaps, in addition to the implementation of pilot projects.
- Santiago Smart City: public-private initiative promoted by CORFO and *Fundación País Digital*.

Public policy recommendations:

- Support companies for the development of innovation in software related to the efficient management of the city. Application of pilot projects that show the benefits for society.
- Accompany the implementation of any program or initiative by a campaign that aids in justifying the adoption of these uses.
- Consider citizen education plans for the use of applications that are directly related to daily work.
- Develop comprehensive strategic plans that include the implementation of various uses related to Smart City, in order to take advantage of synergistic opportunities and common solutions to detected gaps or barriers.

Other uses

Other applications potential by sector:

Uses & Applications	Transportation	Industry	Buildings	Electricity generation	Finance	Public Sector	Main type of energy
Market management & operation				X	X		
Ancillary services	X	X	X	X			Electricity
Energy management	X	X	X	X			Fossil fuels and electricity
Operation (monitoring/control/reporting)				X			Electricity
Teleworking	X	X	X	X		X	Fossil fuels and electricity

Other applications enabling technologies:

Technologies	Load monitor	In home display	Smart thermostat	Smart light	Smart plug/switch	Smart appliance	Hub	Smart meters	AMR/AMI	V2G	EV/PHEV	IED (relays, SCADA …	PMU	WAMS	Smart Sensors	Sensor and actuator	LAN/HAN/NAN/WAN	Cloud	5G	Machine learning	Data mining	Nature inspire …	ANN	Multi-agent systems	Clustering	NLP	Digital twin	Autonomous vehicle	Blockchain	Actuators	3D printers
Uses / Applications	Smart home & Smart building							Smart grid							IoT & IoE					Big data, machine learning & AI										Physical action	
Market M&O																			x	x									x		
Ancillary services	x											x	x	x	x	x	x	x	x											x	
Energy mgmt..	x	x						x	x						x		x	x	x	x										x	
Operation								x	x			x	x	x	x	x	x			x			x						x	x	
Teleworking		x															x	x	x								x				x

Goals, gaps, barriers and opportunities for other applications:

Uses & applications	Goals & gaps	Barriers	Opportunities
Market management & operation	Move to decentralized, digitized systems, with new forms of transactions and empowered consumers.	Regulatory obstacles to new agents and ancillary services; Lack of incentives to share electricity data; data security.	New agents and markets that need management.
Ancillary services	Modernization of the grid (associated with Smart Grid class).	Need of a higher computational capacity for the implementation of new technologies (such as forecasting) in the ancillary services market.	Penetration of renewable energies, storage and EVs.
Energy management	Introduction and widespread use of Home Energy Management (associated with Smart Home and Building application).	Investment costs, low returns on capital; Lack or ignorance of economic incentives; Lack of regulation and governmental support; Low level of development of the ESCO model; Lack of in-house technical expertise; Difficulty measuring and verifying energy and cost savings.	Electrification of heat and smart applications (e.g. smart lighting); Development of Smart Home technologies.
Operation (monitoring/ control/reporting)	Reach a digital-enabled operation of energy systems; real-time operations.	Conflicts with privacy due to the use of user information; Distrust towards smart meters.	Reduction of cost and downtime.
Teleworking	Quick adoption (pushed by COVID-19); Improvement in infrastructure for cybersecurity; Telework policies at the corporate level.	Ambiguity between personal space and workspace; Need for connectivity improvements at residential level; Lack of employee training; Costs to enable good performance.	Reduction of expenses and transport times for workers. Encourage flexible hours. It is associated with the reduction of GHG emissions resulting from the non-use of transportation.

Current initiatives in Chile:

- Law 21.229 (Teleworking law) published on April 2020.
- Auction mechanisms in ancillary services.

Public policy recommendations:

- Increase the public investments in digital infrastructure, build a large-sale ICT infrastructure, including massification of 5G and AI technology.
- Promote the adoption of a common data architecture, tools, and standards to reduce bugs and raise the quality, reliability, and security of devices and services, and that facilitates economies of scale and data sharing across different institutions.