Systems and Information for Smart Cities

AMCIS 2014
Savannah, GA
August 8, 2014

Ken Geisler
Vice President, Strategy
Smart Grid Division North America
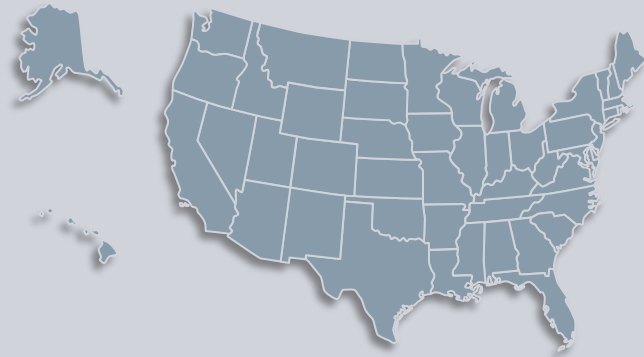**Siemens Infrastructure & Cities Sector**

Siemens is a Globally Integrated Technology Company

SIEMENS

Global

- Operating in 190 countries
- $100 billion sales in fiscal 2013
- 362,000 employees
- $5.7 billion in R&D expenditures
- 29,800 R&D employees
- 290 manufacturing sites

U.S.

- Siemens' largest country market
- $24.3 billion sales in fiscal 2013
- 53,000 employees
- $1.4 billion in R&D expenditures
- 6,300 R&D employees
- 130 manufacturing sites
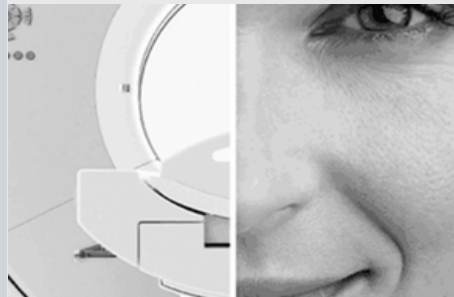
SIEMENS

Siemens Business Sectors

Energy	Healthcare	Industry	Infrastructure & Cities
Divisions	**Divisions**	**Divisions**	**Divisions**
▪ Fossil Power Generation	▪ Imaging & Therapy Systems	▪ Industry Automation	▪ Rail Systems
▪ Wind Power	▪ Clinical Products	▪ Drive Technologies	▪ Mobility and Logistics
▪ Solar & Hydro	▪ Diagnostics	▪ Customer Services	▪ Low and Medium Voltage
▪ Oil & Gas	▪ Customer Solutions		▪ Smart Grid
▪ Energy Service			▪ Building Technologies
▪ Power Transmission			

Siemens Infrastructure and Cities Sector

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Infrastructure & Cities
Dr. R. Busch

Rail Systems	Mobility and Logistics	Low and Medium Voltage	Smart Grid	Building Technologies
High Speed and Commuter Rail	Rail Automation	Low Voltage	Energy Automation	Building Automation
Metro, Coaches and Light Rail	Complete Transportation and e-Vehicle Infrastructure	Medium Voltage		Fire Safety and Security
Locomotives and Components	Infrastructure Logistics		Rail Electrification	Control Products and Systems
Customer Services and Transportation Solutions			Services	

Siemens Smart Grid Division -
OT/IT systems for grid operators, utilities, cities and consumers

Modernization For Operational Efficiencies

- Improve reliability and efficiency of T&D grids
- Maximize the use of existing equipment
- Optimize production and transmission
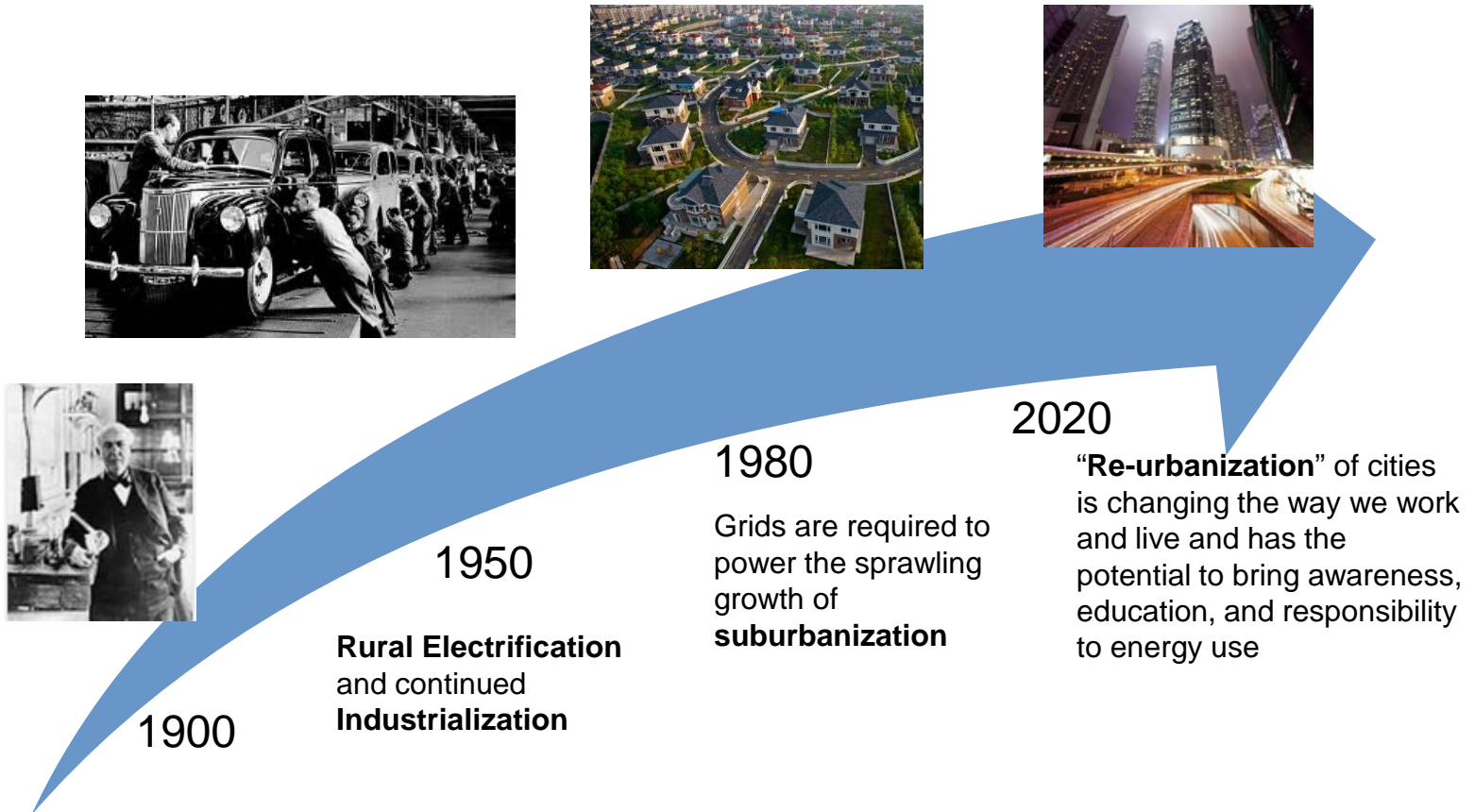- Enable electricity markets

Cleaner Power

- Connect wind farms and solar panels to the grid
- Improve electric railroad transportation
- Enable large scale infrastructure for electric cars

Responsible Consumption

- Use meter information to analyze consumer behavior
- Use meter information to analyze grid behavior
- Innovate in distributed resource management

Cities and the Energy Grid - Evolution

2020

"**Re-urbanization**" of cities is changing the way we work and live and has the potential to bring awareness, education, and responsibility to energy use

1980

Grids are required to power the sprawling growth of **suburbanization**

1950

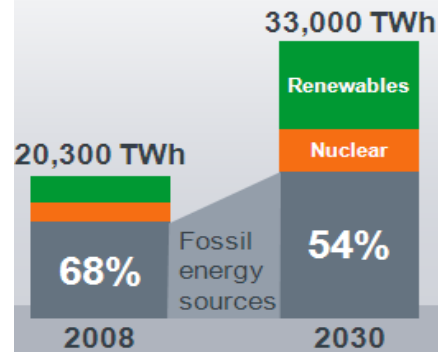**Rural Electrification** and continued **Industrialization**

1900

Thomas Edison develops the **first electric systems**

Why do energy grids need to change?

Increasing Energy Demand

By 2030, power consumption will grow to roughly 33,000 TWh - a 63 percent leap!

33,000 TWh
Renewables
Nuclear
20,300 TWh
Fossil energy sources
68% 54%
2008 2030

Security Concerns & Regulation

7 Million people without power during 2012 Hurricane Sandy and billions in damage

Renewable Energy Adoption

In 2011, renewable sources of energy accounted for about 9.3% of total U.S. energy consumption and 12.7% of electricity generation
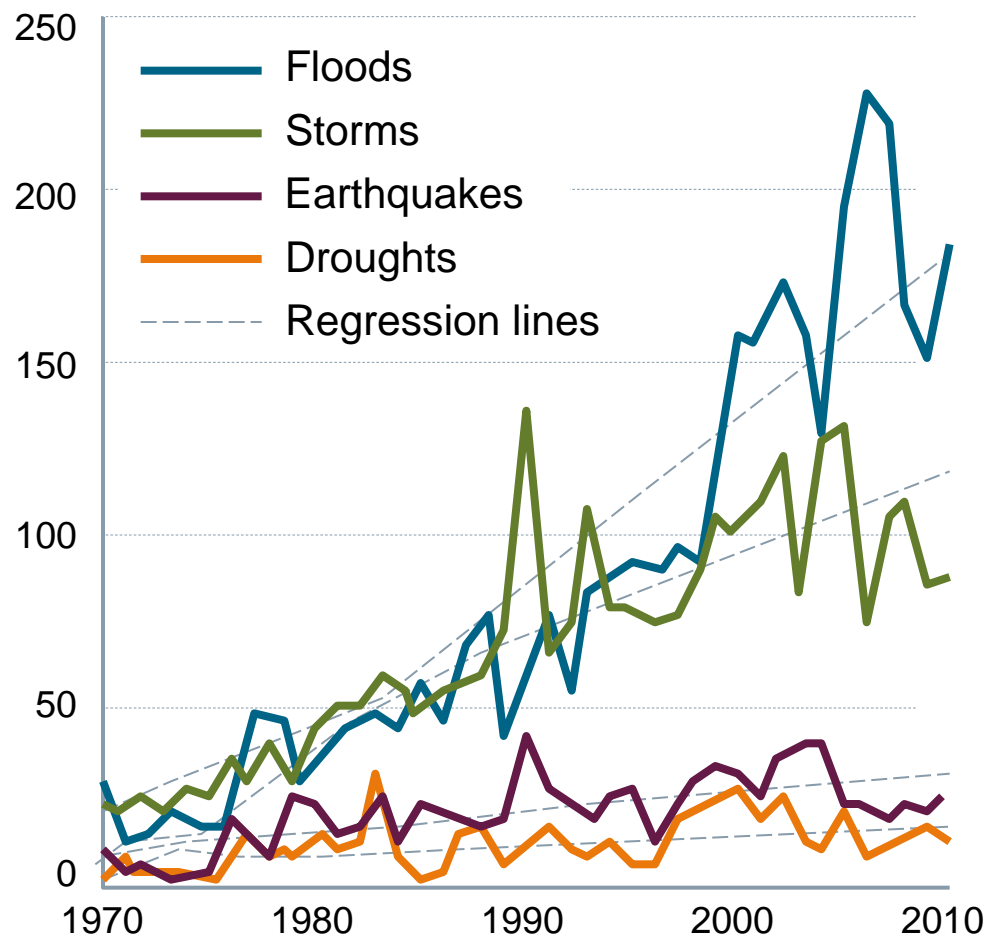
Aging Infrastructure & Electrical Loss

Today, in the U.S. power grid: 70% of transformers and 60% of switchgear are over 25 years old

Source:US Energy Information Administration, Institute for Energy Research
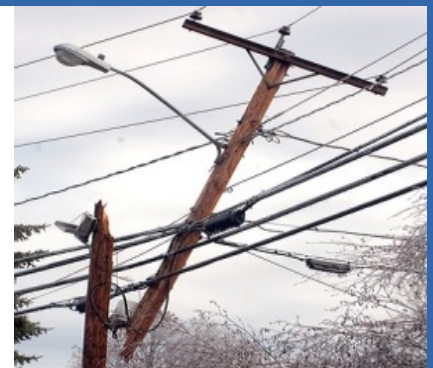
Weather patterns are becoming more extreme, mostly due to climate change…. resilient grids!

Figure 1: Number of recorded disasters
Source: EMDAT-CRED, Brussels

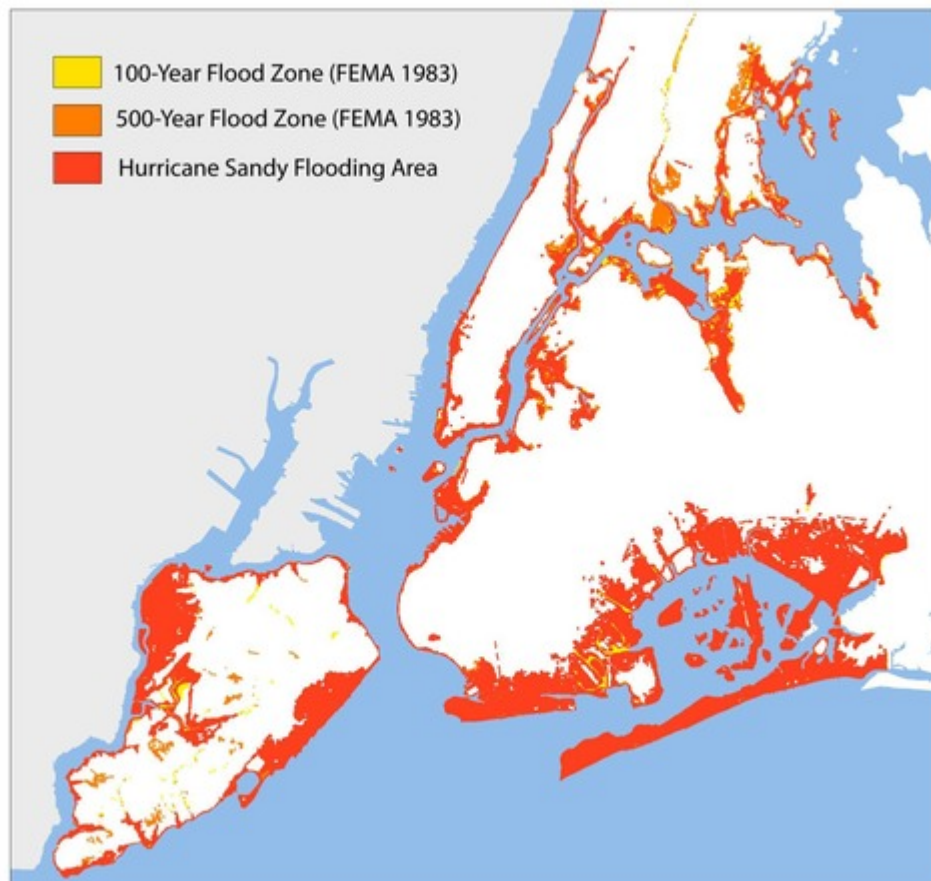Chart legend: Floods, Storms, Earthquakes, Droughts, Regression lines

- Climate change leads to higher temperatures, rising sea levels and more rainfall
- Increasing number of extreme weather events
- Increasing urbanization and settlement patterns lead to higher damages
- 2012: US$ 160 bn damage worldwide (67% in USA)

Why Resilience?   USA, New York City 2012

- 100-Year Flood Zone (FEMA 1983)
- 500-Year Flood Zone (FEMA 1983)
- Hurricane Sandy Flooding Area

- Hurricane Sandy was second costliest in US history

- More than 8 million people without power

- US$ 50 bn in damage

- NYSE down for two days – prior 2 day stretch was in 1888

- 2/3 of storm surge damage exceeded 500 year FEMA* demarcation

*Federal Emergency Management Administration: 2/3 of storm surge damage exceeded 500 year FEMA demarcation in New York City

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Why Resilience?
Disasters hit developed & developing nations

- **Hurricane Sandy, 2012:** $50bn in damages, 2nd costliest in US history

- **USA Droughts, 2011 & 2012:** $28bn in damages

- **Japan Tsunami, 2011:** $210bn damages, geopolitical consequences

- **UK Winter Snow Storms, 2010/2011:** Cost the UK economy $1.5bn per day, total $20bn

- **Haiti Earthquake, 2010:** 220,000 deaths, >300,000 injuries, 1.5m people homeless

- **Europe Heat Wave, 2003:** 66,720 deaths across Italy, France, Spain, Germany, Portugal

Decentralization of energy grid generation and design

From centralized, unidirectional grid …
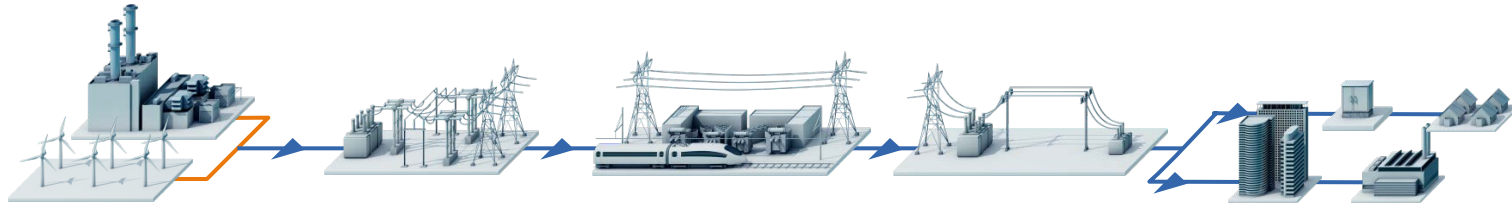
… to distributed energy and bidirectional energy balancing

Offshore Wind Parks

Hydrogen Storage

Diesel Generator

Biogas CHP

Private Solar

Pumped Storage Power Plant

Small Industrial Gas Turbine

Storage Solutions

Storage Solutions

Electrical Vehicles

Smart Street Lighting

Large Scale PV Plant

—— Unidirectional Power Flow   —⚡— Bidirectional Power Flow
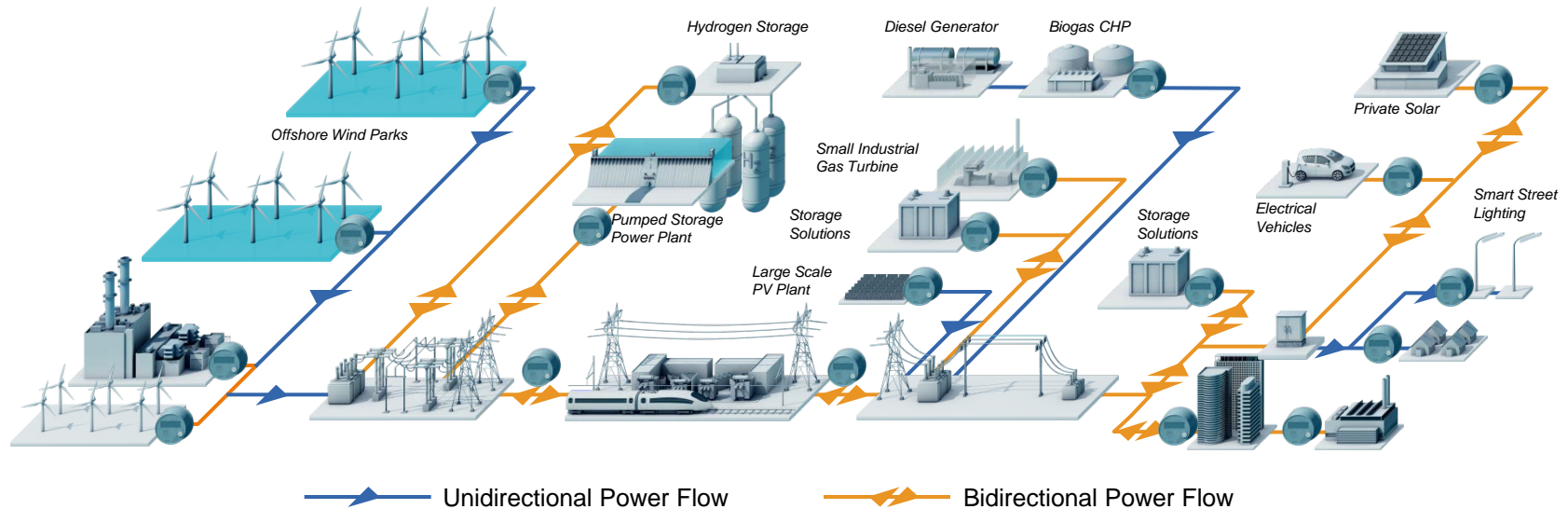
The State of the Utility Market

Key Challenges identified by sampling of 527 IOU/Muni/Coops

Key Value Propositions

Challenge	Percentage
Old Infrastructure	48%
Current Regulatory Model	32%
Aging Workforce	31%
Distributed Generation	30%
Flat Demand Growth	28%
Smart Grid Deployment	23%
Grid Reliability	21%
Coal Plant Retirements	17%
Renewable Portfolio Standards	17%
Energy Efficiency Mandates	16%
Emission Standards	12%
Cybersecurity	11%
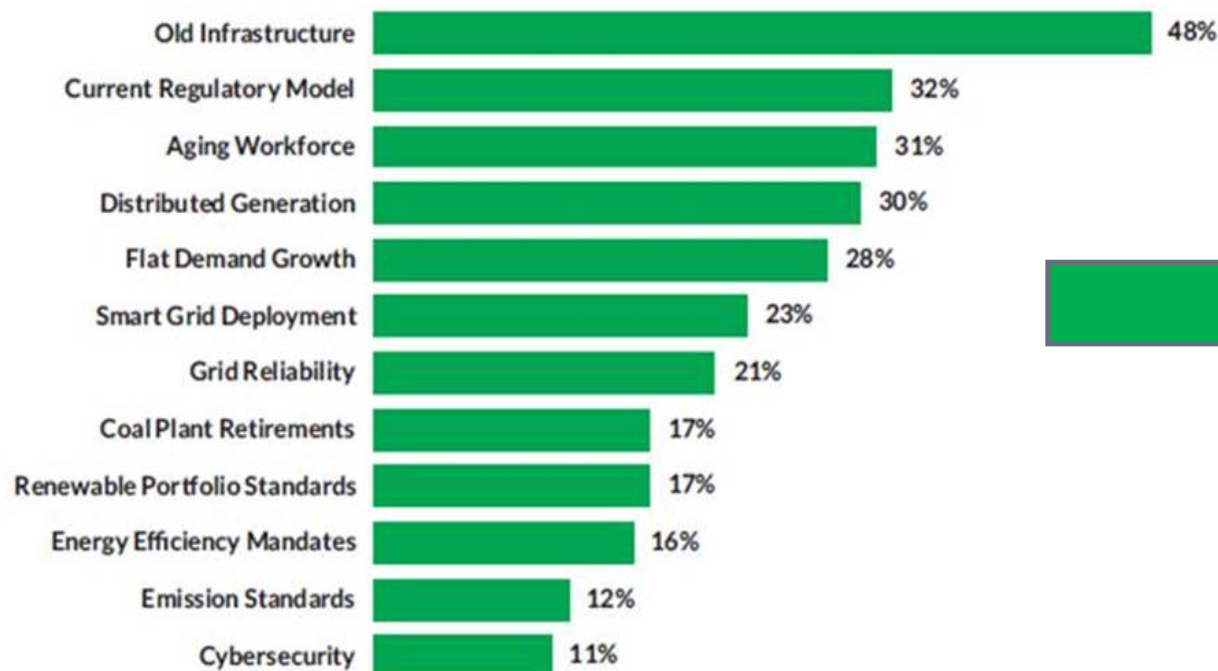
Resilience

Sustainability

Efficiency

Reliability

Source: Utility Dive, The State of the Electric Utility, February 2014

Integrated Resilient Grid Solutions

Integrated Distributed Resources

Market Systems Interface
MMS

Energy Balancing & Demand Response
DERM/DRM

Industrial	Commercial	Residential
Wind	Solar	Batteries

Building, Home, Distributed Energy Management Systems
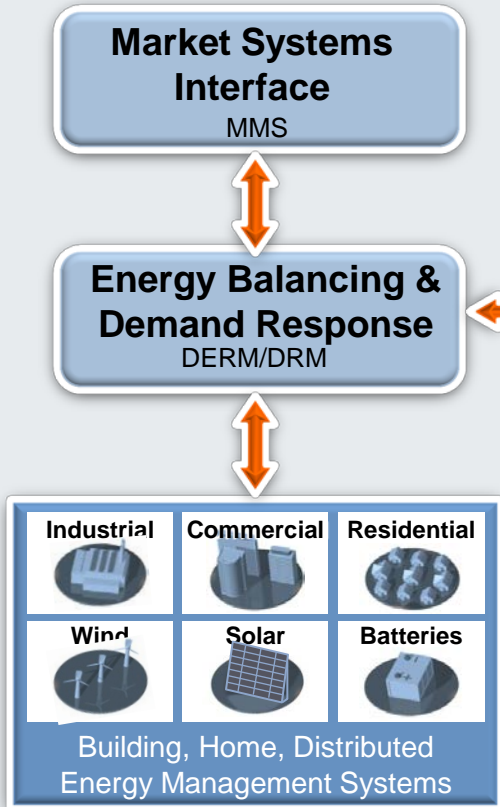
Balancing of Resource Capacity for Reliability and Economics

Grid Modernization

Planning and Asset Optimization
PAO

Control Center
EMS/DMS/OMS

Substation Automation

Recloser	Switch	Capacitor Bank	DER

Controllable Equipment
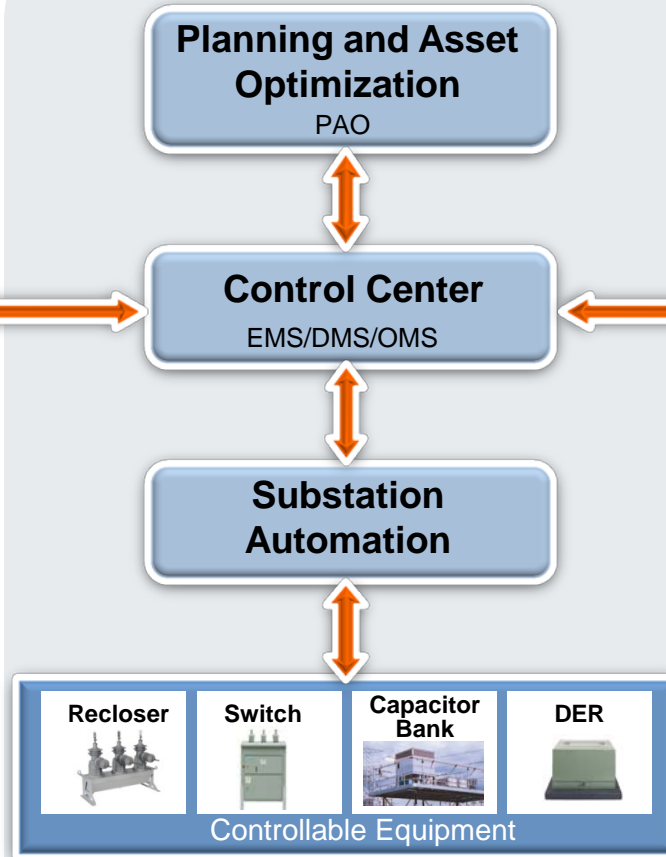
Grid Reliability and Resilience

Informed Consumption

Customer Care Management
CRMS

Consumer Information Management
MDMS/AMI

Industrial	Commercial	Residential

Intelligent Field Devices (i.e. Meters)
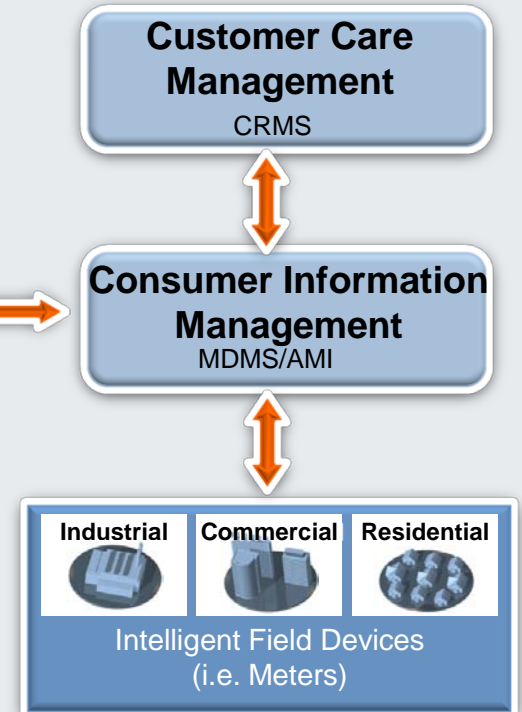
Bi-Directional Management of Customer Energy Information

Decentralized Energy-District designs enhance resilience…

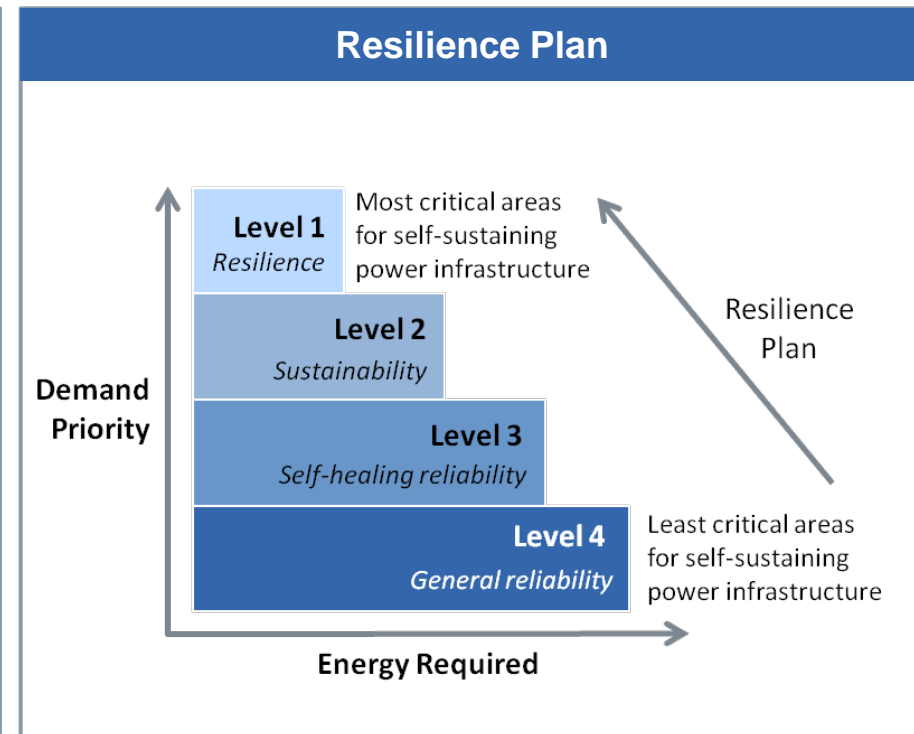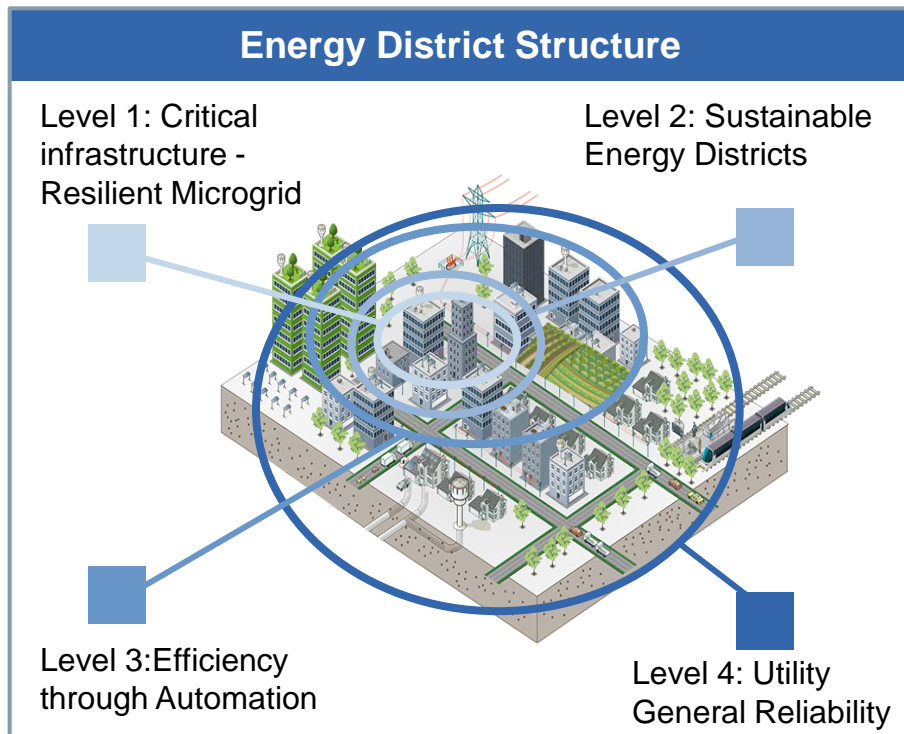- Apply resilience planning as a guiding principle for future infrastructure investments ("Inside-out" distributed design)

- Resilience built on Reliability, Efficiency and Sustainability

- Develop a strategy for prioritizing necessary upgrades, investing in new generation assets and allowing the electrical delivery grid to fail in predictable layers of demand priority

Energy District Structure

Level 1: Critical infrastructure - Resilient Microgrid

Level 2: Sustainable Energy Districts

Level 3: Efficiency through Automation

Level 4: Utility General Reliability

Resilience Plan

Demand Priority

Level 1 *Resilience* — Most critical areas for self-sustaining power infrastructure

Level 2 *Sustainability*

Level 3 *Self-healing reliability*

Level 4 *General reliability* — Least critical areas for self-sustaining power infrastructure

Resilience Plan

Energy Required

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Defining Layers of Infrastructure Criticality

1 Resilience

- Renewable energy sources and other distributed generation enable complete independence from the grid under selected or extreme conditions. Area demand response is able to manage capacity and variation.

- Infrastructure of Hospitals, Water, Transportation, Military Bases, Public Safety…

2 Sustainability

- Distributed renewable and traditional energy sources enable significant energy demand to be met while approaching grid independence. Eco-districts where off-set is green. Area demand response to manage capacity.
- Airports, rail systems, marine ports, university campuses, etc.

3 Efficiency

- System designed with redundant feed paths and switchable connection points

- Developed automation, monitoring, and control of feeder equipment

- Control Center applications for Distribution Management and efficiency
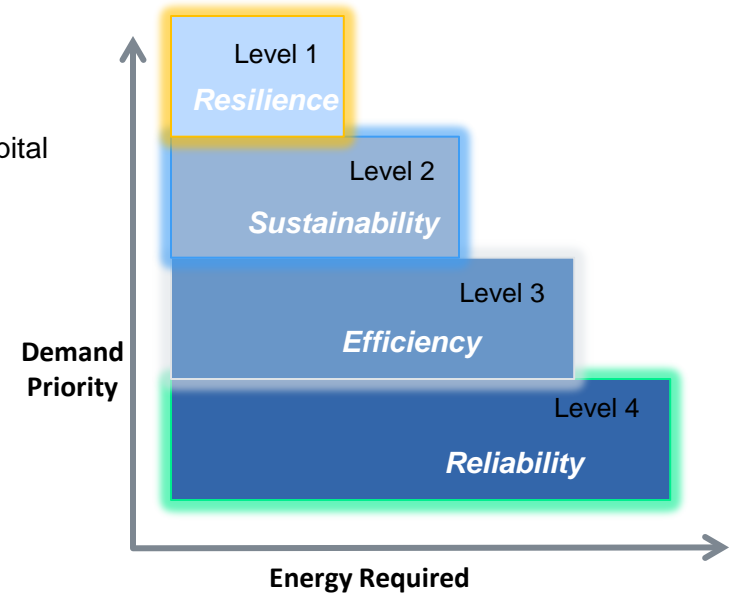
4 Reliability

- Utility reliability measures address outage duration and frequency averages

- Maintenance and expansion is driven by the current rate structure

- System design supports an "average" level of reliability for all customers

City infrastructure with sustainable and resilient energy districts
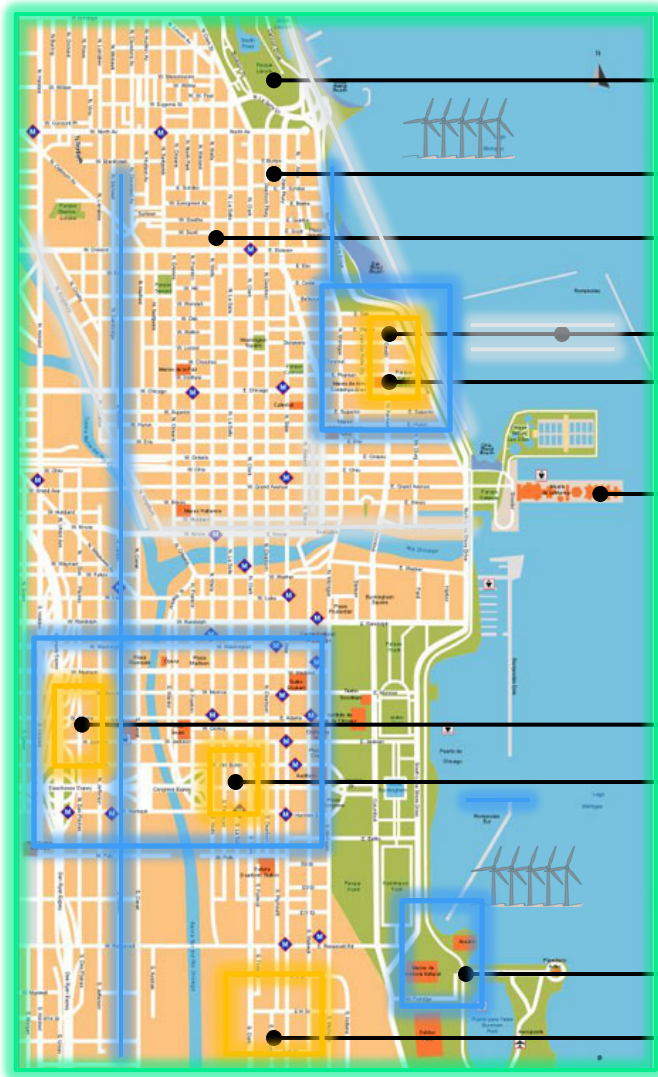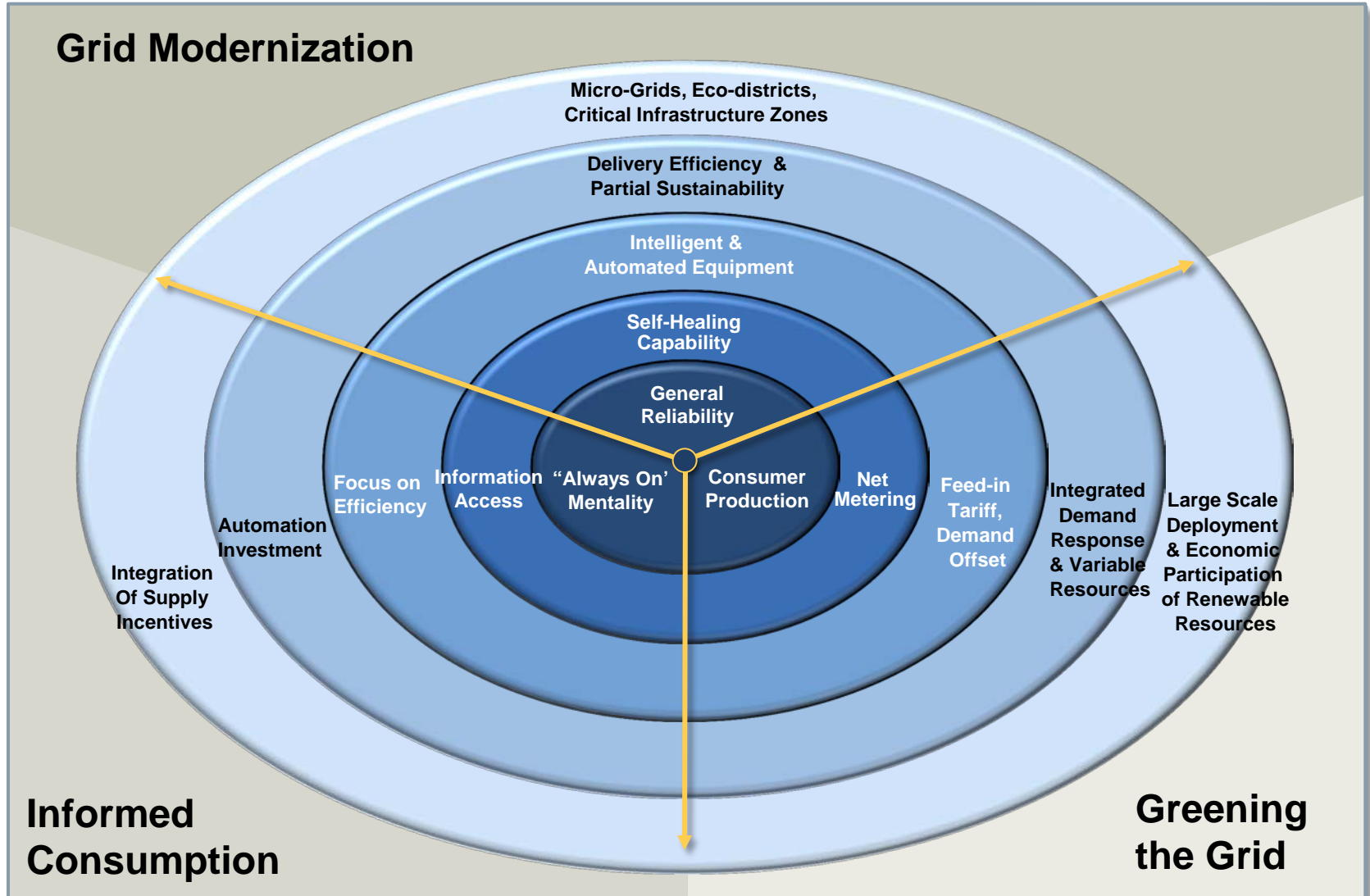
- Lincoln Park Zoo
- Red Line (Elevated Train)
- Residential Area
- Water Tower & Water Intake
- Northwestern University Hospital
- Navy Pier – Tourist District
- Union Station (Train Transit)
- City Hall
- Soldier Field (da Bears)
- Midway Airport

Demand Priority

| Level 1 *Resilience* |
| Level 2 *Sustainability* |
| Level 3 *Efficiency* |
| Level 4 *Reliability* |

Energy Required

Creating a Plan for Resilient Energy Transformation

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Grid Modernization

Micro-Grids, Eco-districts, Critical Infrastructure Zones

Delivery Efficiency & Partial Sustainability

Intelligent & Automated Equipment

Self-Healing Capability

General Reliability

Focus on Efficiency · Information Access · "Always On" Mentality · Consumer Production · Net Metering · Feed-in Tariff, Demand Offset · Integrated Demand Response & Variable Resources · Large Scale Deployment & Economic Participation of Renewable Resources

Automation Investment

Integration Of Supply Incentives

Informed Consumption

Greening the Grid

City Transformation

Energy

Transportation

Residential Homes

Air Quality

Commercial Buildings

Water/ Wastewater Treatment

Public Services: Hospitals, Police, Fire

Government

Landfills

Micro-Grids, Eco-districts, Critical Infrastructure Zones

Integrated Traffic system & Utility Network Management

Active "real-time" Energy Management

Energy Reliability & Partial Sustainability

Advanced Consumer Relationship through Information

"Prosumer" Energy feedback to Utilities

Renewable Integration

Infrastructure Investment

Renewable Adoption

Cap and Trade Carbon Market Participation

Self-Healing Capability

Energy Efficiency Appliances

Collaboration with City Planning & Utilities

Cleaner Fuel Consumption

Financial Incentives

Community Management of Emissions

Greenhouse Gas Reduction Goals

Financial Incentives

Energy Efficiency Investment

Integrated Demand Response & Variable Resources

Goals & Standards

Service Goals

Integrated Water & Utility Network Management

Water Recycling Planning

Energy Education

City Goals

Infrastructure Investment

Infrastructure Investment

Energy Budgets

Community Education

Collaboration with City Planning & Utilities

Resilience for 24-hr service

Energy Efficiency Investment

Net-Zero Consumption

Recycling Programs

Awareness of Environmental Impact

Enabling Resilient Cities

siemens.com/answers

Focus on Energy, Transport, Water, Safety

Information & Telecommunication Networks

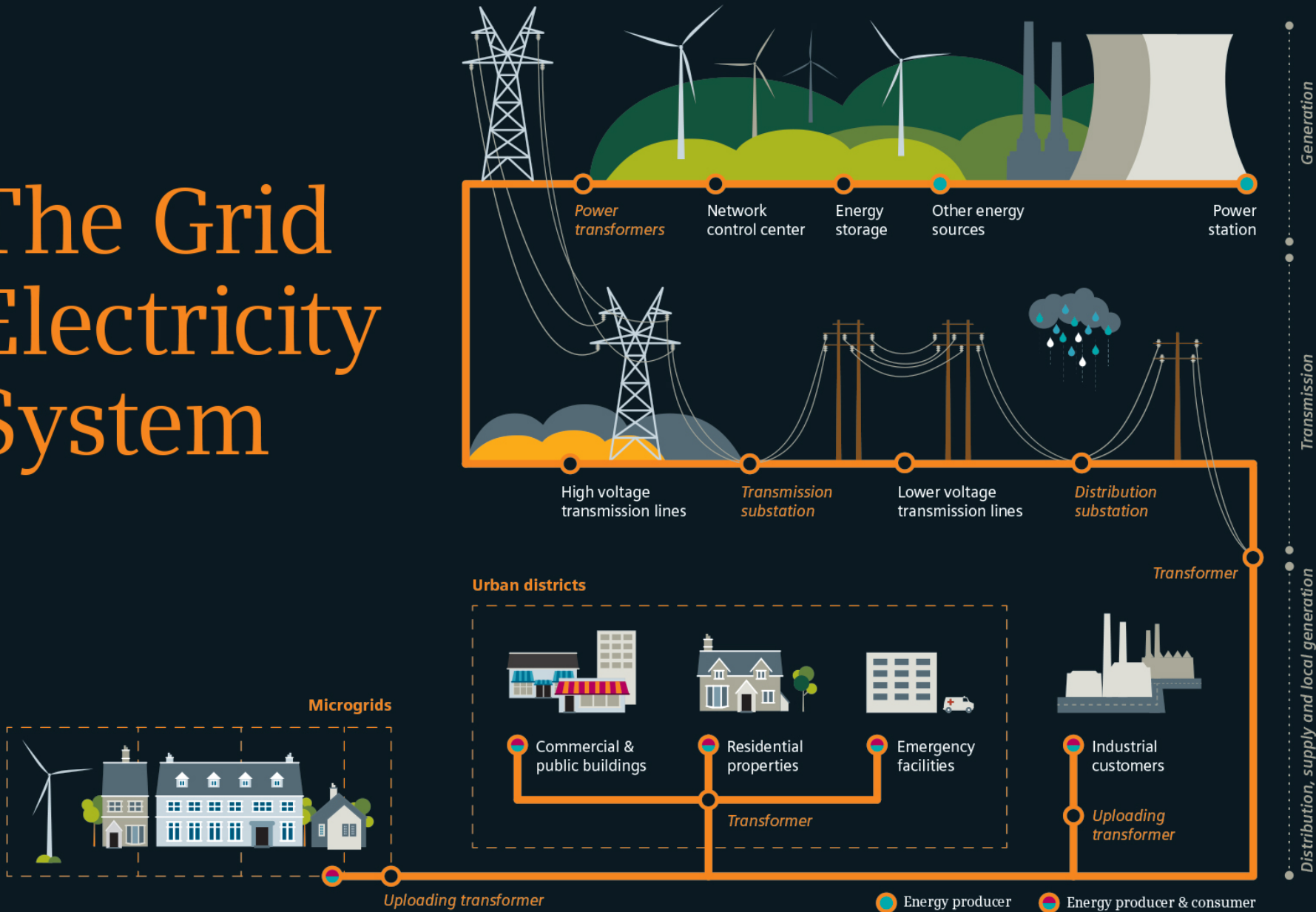| **Transport**	**Energy**	**Water**	**Buildings**
Passengers Emergency services Logistics, incl. food, waste, materials.	*Generation Transmission Distribution*	*Potable supply & distribution Waste water*	*Residential Commercial Public / Institutional*

Security & Physical Protection

The Grid Electricity System

Generation

Power transformers

Network control center

Energy storage

Other energy sources

Power station

Transmission

High voltage transmission lines

Transmission substation

Lower voltage transmission lines

Distribution substation

Transformer

Distribution, supply and local generation

Urban districts

Commercial & public buildings

Residential properties

Emergency facilities

Industrial customers

Transformer

Uploading transformer

Microgrids

Uploading transformer

● Energy producer   ● Energy producer & consumer

Grid Automation (Efficiency)
Hawaiian Electric Company, East Oahu, USA

- Automation of 46kV sub-transmission system

- To address overload & reliability issues in East Oahu

- New transformers installed to shift load from north to south corridor

- Automated high-load distribution circuits to feed sections of East Oahu

- Creates intelligent hierarchical control system

- Substations & devices become intelligent agents supervised by the control center, providing robust contingency situations, maintenance switching, fault isolation & restoration

University of Genoa, Savona Italy (Sustainability)

- The Smart Polygeneration Microgrid has been developed for University of Genova, precisely in its campus in Savona.
- The system is a microgrid (with its own grid) connected to the national grid by a MV connection.
- Although the size (in terms of nominal power) is not huge, the system is complex and there are many generation, storage and load units to be managed.
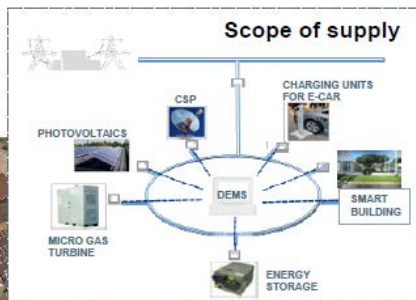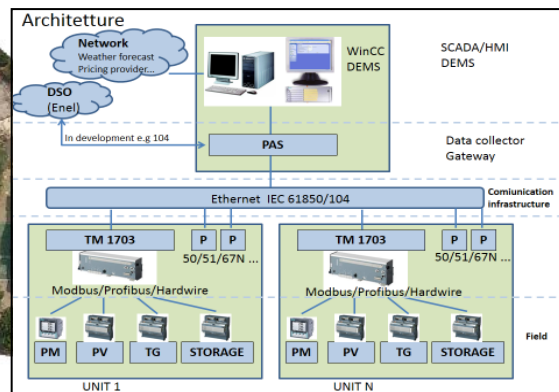

Power Generation:
- 2 cogenerative GTs
- 1 PV plant
- 3 cogenerative CSPs

Loads
- 4 LV electric Boxes
- 3 Thermal Loads
- 3 Charging Units for Electric Vehicles

Storage:
- 1 Electrochemical Energy storage
- 3 thermal storages

Thermal generation
- 2 Boilers
- 1 Electrical Chiller
- 1 Abosrption Chiller
- Cogenerative heat from GTs and CSPs

DEMS is a SW tool which is able to optimize the management of electrical and thermal energy flows in a Smart Grid/ Micro grid
Planning Functionalities:
- Weather, Generation and Load Forecast
- Economically optimized Unit Commitment

Online Functionalities:
- Monitoring of every unit and of the exchange with the grid
- Manual and automatic control of each controllable unit

Possibility to interact with DSO
Possibility to provide primary reserve service

Resilience
Revealed by Hurricane Sandy

Co-Op City, Bronx, NYC

- 14,000 apartments

- 35 high-rise buildings

- 40MW steam turbine generator, plus CHP

- Operates on a micro grid

- Retained power for 60,000 residents

The Transportation Network

Vehicle-to-Infrastructure Communications
Houston, Texas, USA

- Pilot project in Harris County, Texas, in response to Hurricane Ike

- Traffic lights & vehicles communicate in real time

- Data from smart phones in vehicles are aggregated to produce real-time estimates of numbers of vehicles on the road, & their speeds

- Data mapped in a database accessible to drivers via smartphone

- During evacuation, allows drivers to choose route with shortest travel time

- Traffic lights can detect emergency vehicles & turn green to facilitate rapid response

Communications-Based Train Control
Metro lines - São Paulo, New York, Paris, Beijing

- Railway signaling system using telecommunications between train & track equipment for traffic management

- Position of train known more accurately

- Safer & more efficient way to manage railway traffic

- Enables improved time intervals between trains, & therefore increased passenger capacity on the line

- Technology allows 'driverless trains'

- More energy-efficient than traditional signaling equipment, reducing draw on the grid

Transport Coordination Centre
London 2012 Olympics, UK

- Transport Coordination Centre for the London Olympics 2012

- Active sharing of information & coordinated responses to incidents

- Multi-modal transport providers &other key stakeholders

- Supported the 2012 Games additional spectator movement, whilst enabling London & the UK to maintain free flow of people

- Estimated passenger time savings due to TCC intervention on a single event at Bank Station, were quantified at £85,538

Water Management System

Supply
- Storage reservoir
- Groundwater aquifer
- Pumping station or gravity
- Treatment
- Pumping station or gravity
- Service reservoir
- Pumping station or gravity
- Rainwater

Distribution
- Greywater reuse or blackwater reuse
- Residential users
- Commercial users
- Industrial users

Removal
- Sewer network
- Wastewater treatment
- Pumping station or gravity
- Discharge
- Combined sewer overflow risk
- Flood risk
- Collection or discharge

Real-time Levée Monitoring System
Livedijk, Netherlands

- EU Urban Flood project

- Internet-based early warning system issues warnings if there is threat of flood or breaks in dikes

- Sensors buried in dike measure water height/pressure, moisture, temperature

- Data transferred to via internet to connected server

- System evaluates data & issues early warning

- Seasonal & daily weather phenomena are integrated within the evaluation

- Livedijk at Eemshaven is first coastal levée that can be monitored online

Water System Improvement Program (WSIP)
San Francisco, USA

- 6 major earthquakes in California the last 100 years

- San Francisco undertaking a $4.6 billion comprehensive program to upgrade the water system by 2016

- Broad range of projects covering all aspects of the water system – from dams, reservoirs, pipelines, & tunnels to treatment facilities & pump stations

- The aim is to ensure that should a large seismic event occur, the system can remain relatively intact & continue to deliver water to 2.4 million people

- The project includes projects that harden the infrastructure, add redundancy to the system & increase monitoring & automation

Decentralized wastewater treatment manages wastewater flexibly
Shenzhen, China

- The Food Chain Reactor (FCR) solution for urban wastewater management combines conventional treatment methods with biological treatment provided by the roots of 2,000-3,000 plant species, thereby treating water to high quality standards.

- This is a decentralized approach, which manages wastewater on a neighborhood scale using small, odor free facilities

- The decentralized approach helps to avoid the risk of sewer overflows and burst pipes during severe weather

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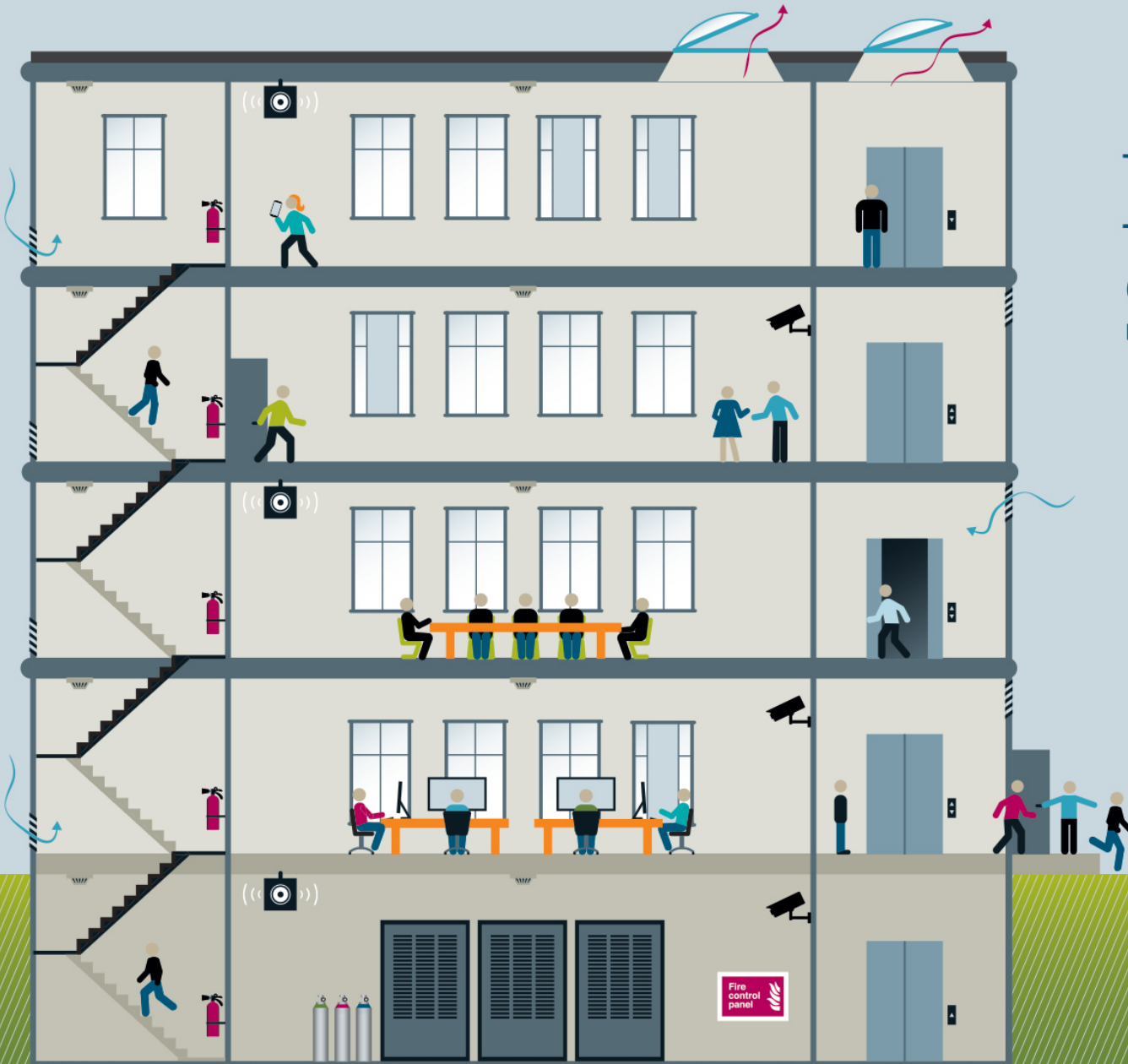
Building Systems

Building Mass Notification Systems coordinate human reactions to hazards
Alberta, Canada

- Mass Notification Systems (MNS) deliver targeted messages to advise building occupants during a crisis

- Messages are disseminated through multiple redundant channels, including voice systems, LED signage and local area networks

- The system can contact people en masse inside and outside of the building, and directly via personal devices such as cell phones

- Systems inform occupants about what action they should take, therefore coordinating movement to facilitate safe and efficient response

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3D simulation of human behavior enables advanced evacuation planning

London, UK

- The behavior of building occupants during an emergency can be modeled prior to an event, using advanced 3D simulation software

- The software enables movement through a building or space to be forecast up to ten times faster than real time with relative accuracy, including places where blockages may occur

- This tool improves human preparedness, coordination and response. With a faster than real time reaction, this technology also helps to gain valuable time in a situation where every second counts

Holistic system design secures information flows and communications
Geneva, Switzerland

- The Safe Host SA data center in Geneva, Switzerland, incorporates a range of data center infrastructure services that promote service reliability and data security

- Built-in solutions protect against power supply interruptions, security and fire safety threats and ensure that servers operate at the correct temperature to protect customer data from changes in environmental conditions

- Features of the data center include a central management system, over 800 smoke detectors, fire control panels, nitrogen based extinguishing solutions and video surveillance at all major entrances

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Metropolitan Security

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Integrated Operations Center
Rio de Janeiro, Brazil

- State-of-the-art intelligent operations center

- Real-time data feeds monitor weather, traffic, police, medical services

- Operators anticipate problems & take instant action to reduce their impact

- Coordinates 30 municipal & state departments, plus private utility & transportation companies

- Weather & flood forecasting predicts emergencies 2 days ahead

- Alerts distributed direct to mobile phones

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Metropolitan security reference
Emergency Management Project HELS
(Hamburger Einsatzleitsystem)

SIEMENS

Facts and figures

1400 incidents/h

450K Police missions p.a.

185K Rescue missions p.a.

95K Patient transport p.a.

30K Fire mission

Challenges

4 public authorities (police, fire brigade, rescue services, patient transport ambulance) should collaborate with only one C&CC-system (first time in GER)

Siemens solutions

Incident Mgmt. System (ELS Web)

HiPath 4000 RTC platform

Cross redundancy through distributed DB (two locations)

Preparation for digital radio communication

Existing individual developed systems have to be replaced

Customer benefits

Improved collaboration between public authorities

Renewal of existing C&CC architecture, optimized coordination flows (i.e. effort plans, authority overlaps for bigger efforts) and cost savings (one system only)

Integration of digital radio communication

Additional redundancy through distributed architecture
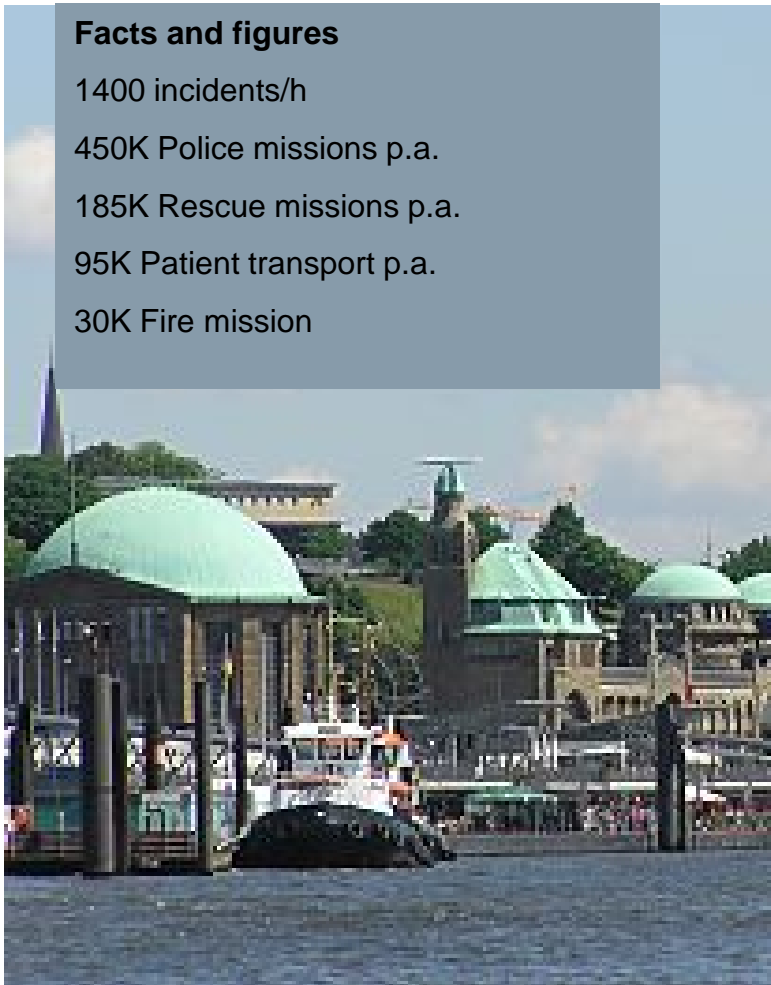
Metropolitan security reference
Emergency Management Italian
Ministry of Defense – Carabinieri Corp

Facts and figures

Rollout in 73 towns (control centers)

500 central and local offices

2.500 radio localized vehicles

8.000 vehicles for patrol services

Challenges

Modern emergency management scenarios require highly integrated, effective, quick response time solutions to manage emergencies

Siemens solutions

Call Flow Management module for collecting and managing emergency / event data

Real Time Tracking module for keeping in touch with field forces

Geographical Information System (GIS) module for retrieving detailed geographic information

Mobile CC112 module for gathering and for the distribution of information on field

Customer benefits

A single framework to manage every emergency management need

An encapsulation of the different components to easily focus the customer requirements

All functionalities integrated in one system to have high "end-user" acceptance

Metropolitan security reference
Emergency Management POLYCOM – Swiss National Security Network

Facts and figures

One nation wide TETRAPOL network

- Based on 26 regional networks
- More than 50 different organizations
- More than 50 control centers,
  750 base stations,
  finally 40,000 terminals

Challenges

Complex network capable of connecting all security organizations in Switzerland for seamless interworking

Protection of communication against eavesdropping

High availability

Siemens solutions

Radio Network Management System (incl. switches e.g.)

Tactical Working Position

Voice Dispatch Systems

Data communication software

Automatic vehicle localization system
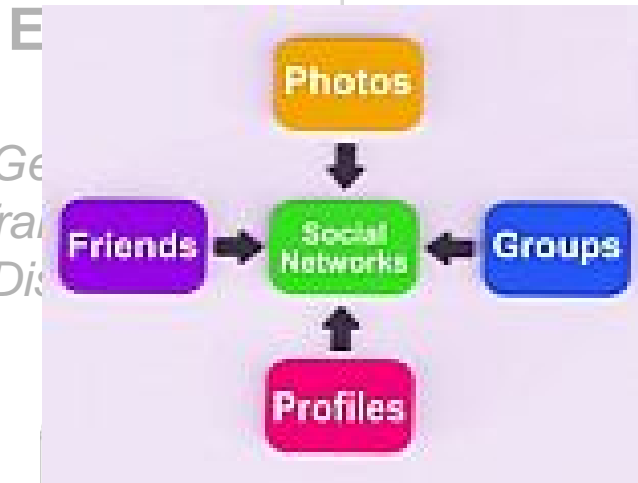
Application integration

Customer benefits

Radio Network Management System (incl. switches e.g.)

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Automatic vehicle localization system

Application integration

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