NOKIA

Enabling new utility business models with communications

Martin Hauske

We create the technology to connect the world

Our businesses

Networks business
Providing end-to-end networking technologies, including ultra-broadband, IP and optical, cloud, the Internet of Things, software, analytics and services, we amplify business performance for our key customers.

Nokia Technologies
Licensing valuable Nokia intellectual property, including patents, technologies and the Nokia brand.

Our customer focus

Enterprise
We build mission-critical networks for webscale, transportation, energy and public sector, as well as for technical large enterprises in financial, retail, health, automotive and manufacturing industries.

Communications service providers
We build and operate agile, intelligent, secure and reliable networks for the world's largest fixed, mobile, converged and cable operators.

We enable businesses to provide excellent customer experiences by introducing new services, operating hyper-efficiently and providing autonomous customer care.

Consumers
Through our licensing activities, we provide a premium and distinctively human technology brand, well loved by consumers and an evolving portfolio of audio, imaging and visual technologies to transform the consumer experience.

Our innovation engine

Nokia Bell Labs
Providing award winning research and development in support of a network vision 5-10 years into the future, we have been solving complex ICT challenges for over 90 years.

Nokia in numbers

1865
Year Nokia was founded

Espoo
Corporate headquarters in Finland

~103 000
Employees

~130
Countries of operation

€23.1 bn
Net sales*

9
Nobel Prizes

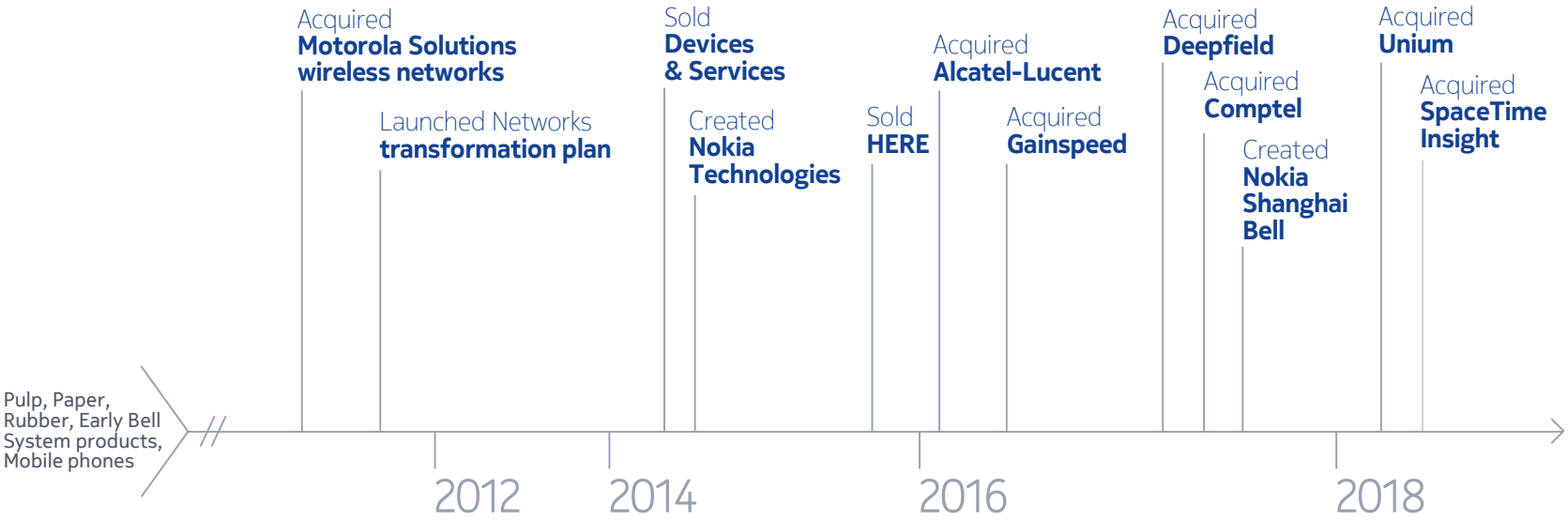
€4.9 bn
Annual R&D spend

2018 WORLD'S MOST ETHICAL COMPANIES® WWW.ETHISPHERE.COM

More information on Nokia is available on our corporate website Nokia.com. Performance information in financial reports is accessible within our website's investors section (nokia.com/investors). * As of December 2017.

NOKIA

Disciplined execution for successful integration and transformation



We are capitalizing on the megatrends with our ‘rebalancing for growth’ strategy

1 Lead	2 Expand	3 Build	4 Create
in high-performance end-to-end networks with communications service providers	network sales to select vertical markets	a strong standalone software business	new business and licensing opportunities in the consumer ecosystem

NOKIA

Unrivalled track record of innovation

1300+	9	3	2	2	1
Patent applications (in 2017)	Nobel Prizes	Turing Prizes	Grammys	Emmys	Oscar

NOKIA

2018 Nobel Prize in Physics
Awarded to Nokia Bell Labs researcher, Arthur Ashkin

"Arthur was on a quest to improve human communications by understanding the limits of optical communications, and in the process, he created a technique that helped understand human life itself. Another classic Nokia Bell Labs tale, and one I anticipate will be repeated for decades to come, with the set of pioneering innovations we are currently working on that will define the 5G era and beyond."

Marcus Weldon
Corporate Chief Technology Officer and President of Nokia Bell Labs

NOKIA

Nokia Energy Offerings

Utilities Value Chain

Digital Oil Field

Digital Mining

Cybersecurity

Our track record of continued investment & innovation in the Utility sector

14
Years of Industrial MPLS Experience

100%
In-house development

200+
Utility customers

+12
Industry Awards

+1000
Teleprotection Circuits in service

24Bn
NOKIA

NERC/CIP
COMPLIANT END-TO-END CYBERSECURITY

COMPLETE GRID COMMS SOLUTIONS & SERVICES

NOKIA Bell Labs

SDN
Market leader

P-LTE

IoT
Market leader

NOKIA

Nokia Power Utilities References

AMERICAS

- Aliant Energy, USA
- Allegheny Energy, USA
- AltaLink, Canada
- Amazonas Energia, Brazil
- BC Hydro, Canada
- Bristol Virginia Utilities, USA
- BTES, USA
- CFE, Mexico
- Chelan County Public Utility, USA
- CHESF, Brazil
- Dalton Utilities, USA
- Dayton Power and Light, USA
- EDELCA, Venezuela
- EPB, Chattanooga, USA
- First Energy, USA
- FPL Fibernet, USA
- Furnas, Brazil
- Grand River Dam Authority, USA
- Lafayette Utilities, USA
- MINET, USA
- Morristown Utility Commission, USA
- NPP, USA
- OG&E, USA
- Oncor, USA
- Paducah Power System, USA
- PDVSA, Venezuela
- PECO, USA
- PEPCO Holdings, USA
- We Energies, USA

EMEA

- ADWEA, Abu Dhabi
- AES Sonel, Cameroon
- AEW, Switzerland
- Alstom Power, Spain
- Areva, France
- BEWAG, Germany
- BKW FMB Energie, CH
- C Power NV, Belgium
- C4 ENERGI AV, Sweden
- CNR, France
- Creos, Luxemburg
- DATATEL, Russia
- DELTA, Netherlands
- DGA, France
- EDF, France
- EETC, Egypt
- ELIA, Belgium
- ENDESA, Spain
- Energy Ouest Suisse, CH
- EPAL, Portugal
- Eskom, South Africa
- Gas Natural Fenosa, Spain
- Hafslund, Netherlands
- IBERDROLA, Spain
- Israel Electric Corp, Israel
- Joököping Energi, Sweden
- KELAG, Austria
- NEK EAD, Bulgaria
- NRGi Fibernet, Denmark
- QUANTUM ICT, Belgium
- RTE, France
- Saudi Electric Company, Saudi Arabia
- Sazburg Stadtwerke, Austria
- SSE, United Kingdom
- Stadtwerke Schwedt, Germany
- STATTNETT, Netherlands
- Swissgrid, Switzerland
- SYDFYNS INTRANET, Denmark
- TEIAS, Turkey
- Teletrans, Romania
- TELVENT, Spain
- Tennet, Netherlands
- Transco, UAE
- TWL, Germany
- Unified Energy System, Russia
- USEPS, Slovakia
- Vattenfall, Germany

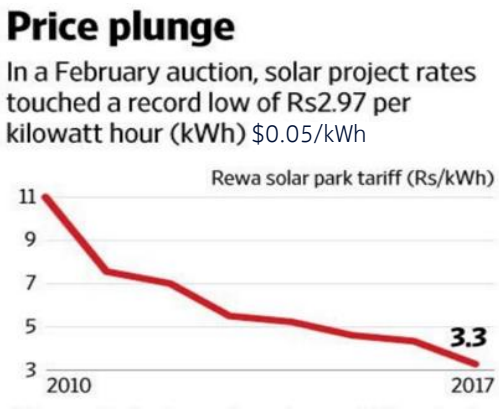
APAC

- Ausgrid, Australia
- CSG, China
- Electranet, Australia
- Energex, Australia
- Ergon Energy, Australia
- HEC, Hong Kong
- KEPCO, Korea
- MEA, Thailand
- PEA, Thailand
- PGCIL, India
- PLN, Indonesia
- SGCC, China
- TATA Power, India
- TEPCO, Japan
- TNB, Malaysia
- TPC, Taiwan
- TPDDL, India
- Transgrid, Australia
- Transpower, New Zealand

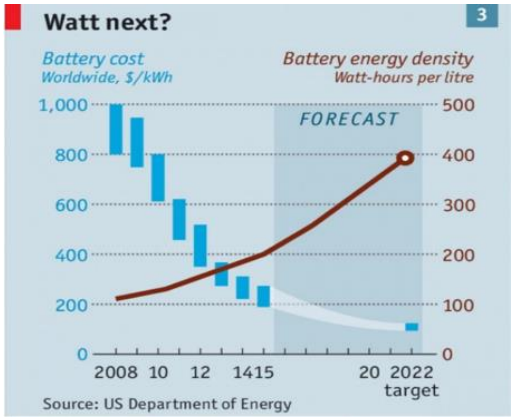
30 years experience providing mission critical communications to 200+ utilities

Energy world is changing
Indicators of change

Renewable energy prices falling sharply



Surge in battery storage and microgrids



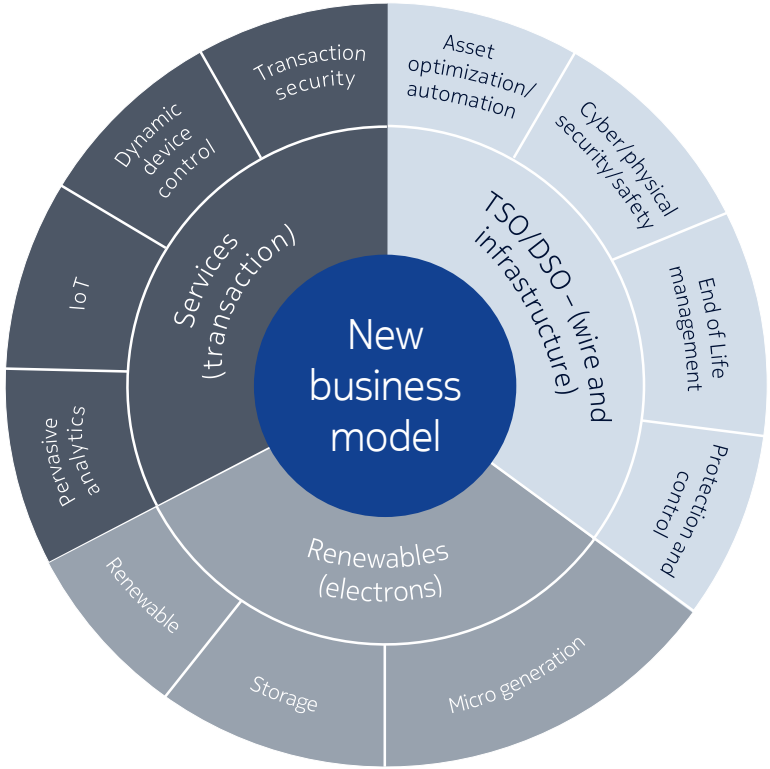
Demand disruptions impacting utility revenue models

- Energy conservation and demand management
- Building energy efficiency
- Distributed energy generation/ off grids/micro grids
- Energy substitution (e.g., EVs, district heating)

- Origin Energy (Australia) adds 530 mw of renewable sets new benchmark for renewable ppa pricing – $60/mWh ($0.06/kWh)
- India recent bids as low as inr 1.58 ($0.022/kWh) for solar

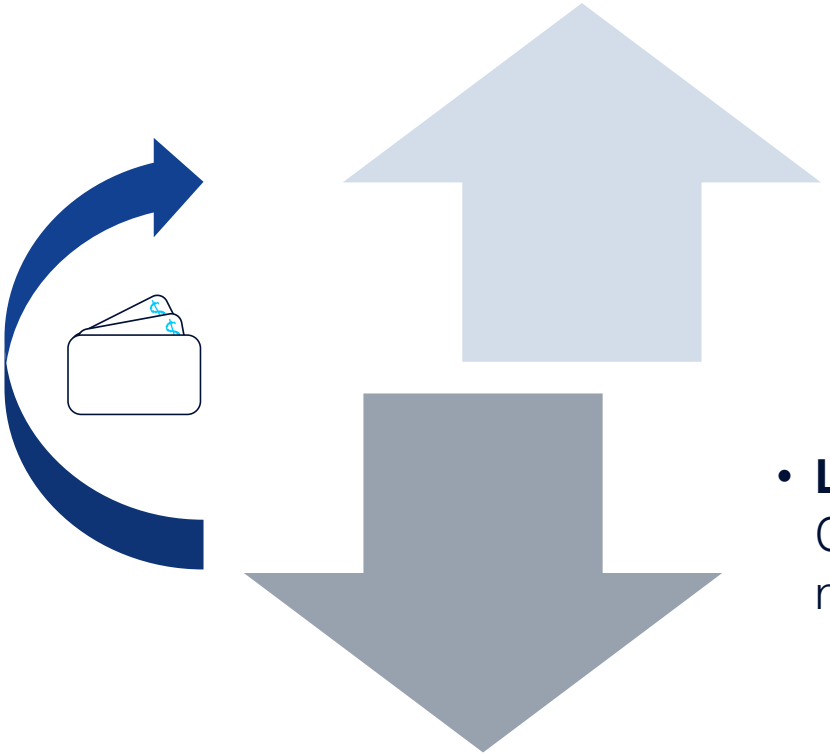
NOKIA

New business model



Key reactions to industry changes

Grow revenues and build new capabilities paid for through cost savings



- **Grow revenues** with new services
- **Build capabilities** to manage distributed generation

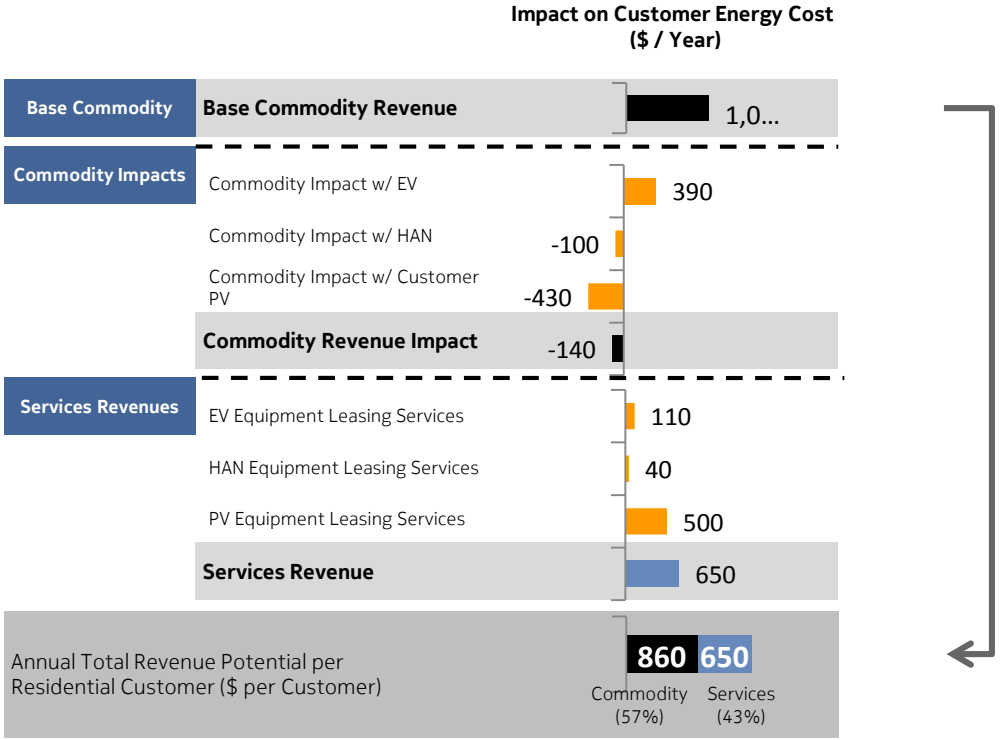
- **Lower costs** by consolidating IT, OT, and external communication networks and IoT capabilities

Scenario analysis: New products and services can increase a utility's share of wallet, despite declining commodity revenues

Potential Value of Bundling Smart Technologies – EV, HAN[1] and Solar PV

Example

- New revenue stream from retail business
- Services revenues compensate for the negative commodity revenue impact



[1] Home Area Networks
Source: Accenture analysis

Enhance Transmission Grid - Creos, Luxembourg

Lower Cost

"The new communications system will form the basis of our smart grid and ensure the network is always available to meet demand."

9,000 km T&D grid

Challenges

- Bring new intelligence to its power transmission network
- Enhance reliability and efficiency
- Engineers remain connected while at substations

Solutions

- Consolidates vital services supporting remote monitoring, fault isolation and system safety and reliability onto a single IP/MPLS network
- IP/MPLS network meets differential protection and teleprotection requirements – tested less than 5 milliseconds latency across 104 km network of 11 routers with less than 200 microseconds jitter
- Advanced network monitoring and control tools

Benefits

- Enhance operational performance
- Save costs associated with managing multiple networks

Improved Asset Management – Oklahoma Gas & Electric, USA

OG&E
Power at the speed of life.

Lower Cost

EEI Edison electric institute
The association of shareholder-owned electric companies

2013 Edison award

"OG&E Electric Services: Our regulated electric utility serves 30,000 square miles in Oklahoma and western Arkansas"

Challenges

- Reduce peak demand
- Defer need to build generation plants
- Improve operational efficiency
- Strict timeline
- Complex project
- Limited resources

Solutions

- E2E IP/MPLS network
- P2P microwave backbone
- 3.65 GHz P2MP layer
- Full WiMAX and P2P microwave integration
- Tower/shelters/generators
- Advanced tools for monitoring and control

Benefits

- Reduction in customer demand by additional 2 percent/yr for next three years
- Savings of at least $22M over next year
- Demand response savings of 280 MW by 2017
- Defer fossil fuel generating investment to 2020

NOKIA

Improved Data Center and SD WAN – Leading Australian Utility

Lower Cost

Grow Revenue

"We need to offer new services, connect to customers outside our existing network for deregulated services"

Challenges

- Offer New Services
- DC first, SD-WAN second

Base Scope

- VMware integration
- WBX L3 VTEP
- AWS cloud bursting
- Inter corp. branch traffic steering simplification through overlay techniques
- 2 DC integration via WBX and overlay
- AWS integration
- Underlay segments to overlay traffic steering with service chaining

Benefits

- Faster provisioning of IT services
- Provisioning of new energy services in deregulated business

NOKIA

New Services, New capabilities -San Diego Gas & Electric, USA

Sempra Energy

Grow Revenue

"Every month a large number of customers are introducing Solar and we need to find a way to support that"

Challenges

- Reduction in demand
- Managing large amount of solar
- Supporting government and communities push for green power
- EV charging
- Innovative business model

Solutions

- Increase monitoring and control capability
- Increase number of endpoints to 200,000 end points (vs 3.6m customers)
- Looking at Private LTE

Benefits

- Improved integration of renewables
- Gain new revenue from service business – islands, green communities, etc.
- New business model – DSO
- Platform

NOKIA

Details of San Diego Gas & Electric - Market

Government Policy:

- The state is strongly committed to clean energy, even though the California Senate voted down its Bill 100, a proposed adoption of 100% renewables in California by 2045. In fact, a new report from the California Public Utilities Commission says California's major utilities have already met or will all soon exceed the state's 2020 renewable energy target of 33%, and will likely meet the 2030 target of 50% by 2020.

Sempra situation –high residential solar

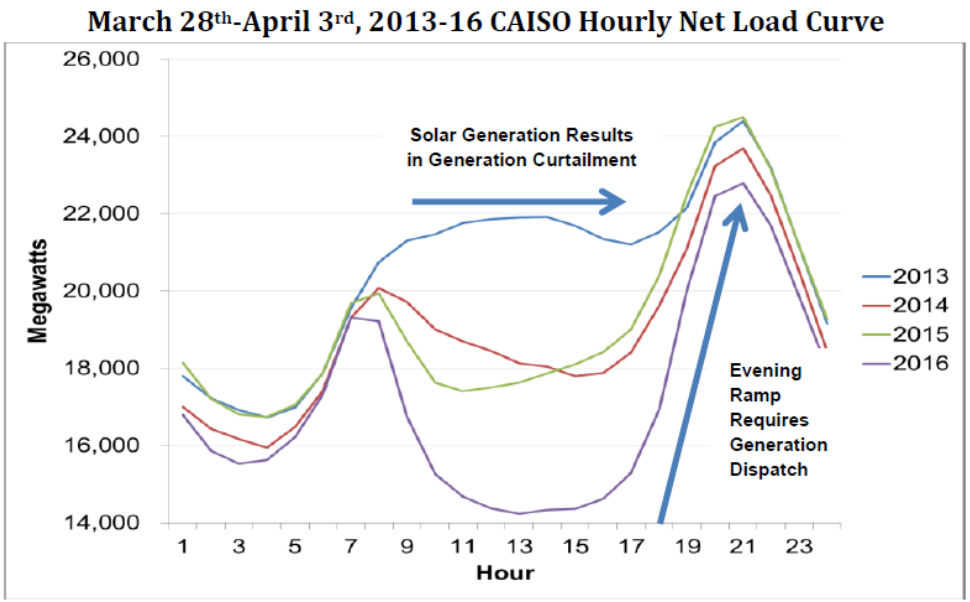
- On average 43% of the electricity used at SDG&E is from renewable sources, which leads the nation. And on top of that, customers have another 800 megawatts or so of rooftop," he says. (vs 4,781 megawatts (MW) system peak)

18

Load

Electric volumes (millions of kilowatt hours)			
Residential	6,577	6,685	7,143
Commercial	6,763	6,700	6,877
Industrial	2,198	2,189	2,161
Street and highway lighting	79	75	83
	15,617	15,649	16,264
Direct access	3,394	3,515	3,652
Total	19,011	19,164	19,916

*from SEMPRA Annual Report 2017



**California Energy Commission – Renewable Energy Overview

Losses

6.58% - down from 7.95% from 2009 - 2014

Estimated Electricity Losses from Delivery in California (2009-14)

Supply and disposition of electricity, 2009 through 2014
California
megawatthours

Category	2014	2013	2012	2011	2010	2009
Supply						
Generation						
Electric utilities	71,037,135	78,407,643	82,486,064	105,360,204	96,939,535	85,123,706
Independent power producers	89,576,573	86,201,998	80,574,100	58,255,052	69,294,065	80,766,990
Combined heat and power, electric	20,207,580	16,905,498	18,163,487	18,656,710	19,582,003	21,008,878
Electric power sector generation subtotal	**180,821,288**	**181,515,139**	**181,223,651**	**182,271,967**	**185,815,603**	**186,899,573**
Combined heat and power, commercial	2,802,160	2,761,572	2,894,426	2,880,277	2,300,044	2,243,754
Combined heat and power, industrial	15,184,174	15,800,604	15,400,490	15,652,598	16,009,968	15,632,805
Industrial and commercial generation subtotal	**17,986,334**	**18,561,976**	**18,294,916**	**18,532,875**	**18,309,992**	**17,876,559**
Total net generation	**198,807,622**	**200,077,115**	**199,518,567**	**200,804,842**	**204,125,596**	**204,776,132**
Total international imports	**12,369,304**	**12,414,827**	**8,572,815**	**6,269,511**	**3,478,583**	**3,047,148**
Total supply	**211,176,926**	**212,491,442**	**208,091,382**	**207,074,353**	**207,599,179**	**207,823,280**
Estimated losses	**13,887,284**	**14,243,546**	**14,288,222**	**16,408,719**	**15,972,943**	**16,524,105**
Percentage losses	**6.58%**	**6.70%**	**6.87%**	**7.92%**	**7.69%**	**7.95%**

Facility direct retail sales are electricity sales from non utility power producers which reported electricity sales to a retail customer.
Net interstate trade = Total supply - (total electric industry retail sales + direct use + total international exports (if applies) + estimated losses).
Net trade index is the sum of total supply / (total disposition - net interstate).
A negative net interstate trade value indicates a net import of electric power.
Notes: Totals may not equal sum of components because of independent rounding. Estimated losses are reported at the utility level, and then allocated to states based on the utility's retail sales by state. Reported losses may include electricity unaccounted for by the utility. Direccommercial or industrial use of

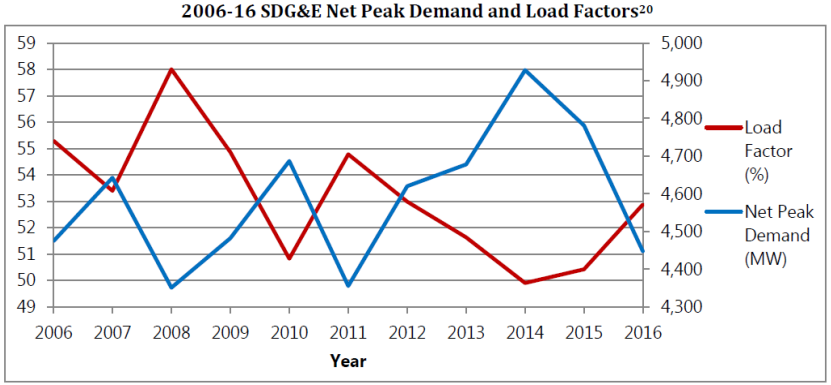
Electricity Losses Reported by California IOUs (2015)[11]

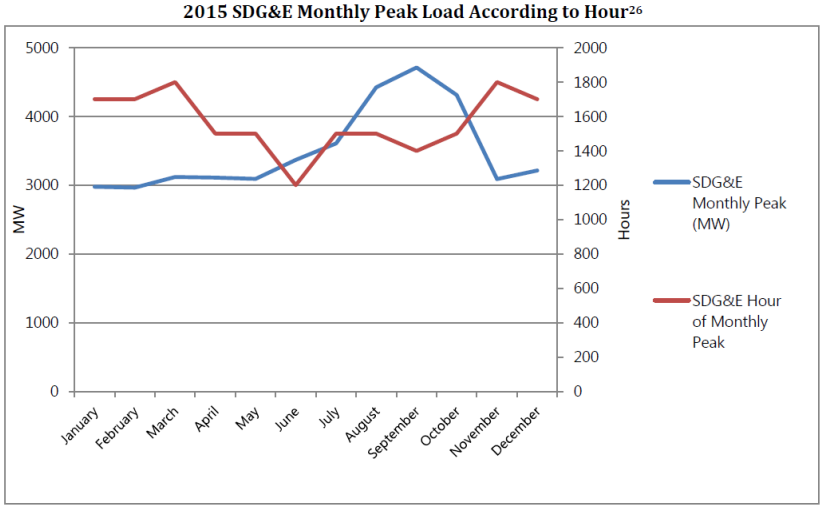
	PG&E	SCE	SDG&E	Total
Sales to Customers (MWh)	86,167,420	74,929,346	16,267,013	177,363,779
Sales for Resale (MWh)	1,813,603	4,031,926	16,865,020	22,710,549
Energy Used By Company (MWh)	NA	134,341	32,899	167,240
Total Sales (MWh)	87,981,023	78,961,272	33,132,033	200,074,328
Total Energy Losses (MWh)	7,615,777	3,360,028	1,544,260	12,520,065
Percent Electricity Loss	**8.66%**	**4.26%**	**4.66%**	**6.26%**

**California Energy Commission – Renewable Energy Overview

Load Factor

Shift to afternoon peak except for June – relatively mild climate





**California Energy Commission – Renewable Energy Overview

San Diego Gas & Electric

Building the cleanest, safest and most reliable energy company in America.

Sempra policy influence – shift to DSO, storage,

- In 2016, the California Public Utility Commission directed Southern California investor-owned electric utilities to fast-track energy storage options to enhance regional energy reliability.
- Shift peak pricing to 4pm – outside solar main time
- Shift to renewables business
- EV - File for V2G approval (Application of San Diego Gas & Electric Company (U 902-E) for Approval of Senate Bill 350 Transportation Electrification Proposals Regarding Medium and Heavy-Duty Electric Vehicles and a Vehicle-to-Grid Pilot)

How to improve reliability in the new world of distributed generation – Californian Utility

Cut Cost

Grow Revenue

"The utility is in the process of upgrading their substation infrastructure in an effort to improve grid reliability. This include a total substation redesign (Relays, RTUs, SCADA and telecommunication (NOKIA) equipment). "

Solution highlights:

- Long term TDM to IP migration but short term need for legacy TDM interfaces in a packet environment.
- IP/MPLS is the technology of choice
- Around 400 Transmission substations involved, 1000 routers, 800 switches.
- Nokia solution selected after multiple rounds of lab and field testing.
- Heavy cyber security requirements, NSP, 7705 and 7210 had to go through special testing - third party security company.
- NSP/CPAM/Service Portal Express with north bound integration with their MoM (SPLUNK)
- Project broken in multiple phases. Currently implementing Phase 1, 250 routers, 200 switches.

Scope includes

- Hardware/Software
- Network Design and Engineering, Installation supervision (unions), Staging
- Two Full time Resident Network Engineer,Project Manager, Nokia's Remote Network Operation Center (NOC) involvement
- Training and Certification classes for products involved , Full Maintenance, Remote Tech Support
- Software Subscription Plan
- Extended Warranty, Advanced Exchange Program

Aquarius Generator
Capabilities

AQUARIUS
ENERGY GENERATION

- Modular unit, small form factor, few moving parts.
- Monitored and managed remotely by software connected to sensors.
- Extensive advanced diagnostics data and remote control capability, enabling real-time analysis of performance, optimisation, identification of potential failures as well as remote resolution.
- Cluster design with load balancing/redundancy capabilities, providing higher SLAs and flexibility to meet various energy load requirements.
- Generator analytical models developed through extensive telemetry data significantly improving predictability of engine performance, failure and optimization of energy consumption.

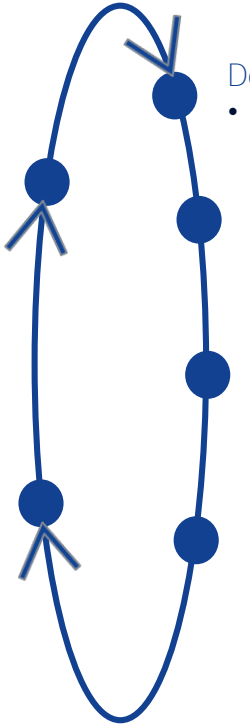
NOKIA

Nokia's – Global NOC
Global Monitoring and Management Service

AQUARIUS
ENERGY GENERATION

Reliable operations
- Self monitoring
- Operations segmented based on work scope
- Predefined templates

Security
- High availability
- Forensic analysis
- Attack resistant
- Centralized user management



Deployment
- Automated bulk software updates (firmware and configuration)

Analyzing
- Advanced visualization
- Map views and real-time dashboards

Configuration
- Consistent device configurations based on auditing and policy enforcements

Trouble shooting
- Alarm correlations
- Fault management
- Trouble ticketing system

NOKIA

Aquarius Smart Energy Management System
High Level Requirements

AQUARIUS
ENERGY GENERATION

- Centralized Energy Management System for all Aquarius generator installations.
- Offered as a service to clients with an annual maintenance & support subscription fee on a per generator unit basis.
- Remote, near real-time (24x7x365) Centralized Monitoring and Management as per agreed SLA's :
  - Service Desk
  - Alarm Monitoring
  - Fault Investigation and Management
    - 1st Level (Nokia)
    - 2nd Level escalation (Aquarius)
    - 3rd Level site support (client field support resource)
  - Change Management
  - Generator Data Collection & Storage
  - Generator Device Management (e.g. device discovery, firmware & software updates)
  - Security Management (e.g. Anomaly detection, User management, software signing)
  - Generator Remote Management
    - Northbound Interface to Aquarius software system
    - Configuration (remote settings)
    - Cluster Optimization
    - Predictive / Preventative Maintenance

End-to-End Smart Energy Management System

Evaluate Gen Parameters → Control Gen Features → Monitor Gen Performance

Creating with University of Strathclyde a resource for utilities to accelerate their innovation and reduce risk while transforming to new business models

BHP Project Insights

- BHP Minerals Australia goals:
  - Increase Safety
  - Increase Tonnage
  - Reduce Operational costs
- BHP Current situation:
  - “In pit” Wireless end of life and unreliable
  - Rail corridor becoming a bottleneck
  - Lost production on Truck Autonomy fleet
  - Unable to expand fleet with reliability
- BHP process:
  - Trial with Private LTE 3 years ago
  - RFI, RFT – Nokia successful
  - Moved to implementation phase

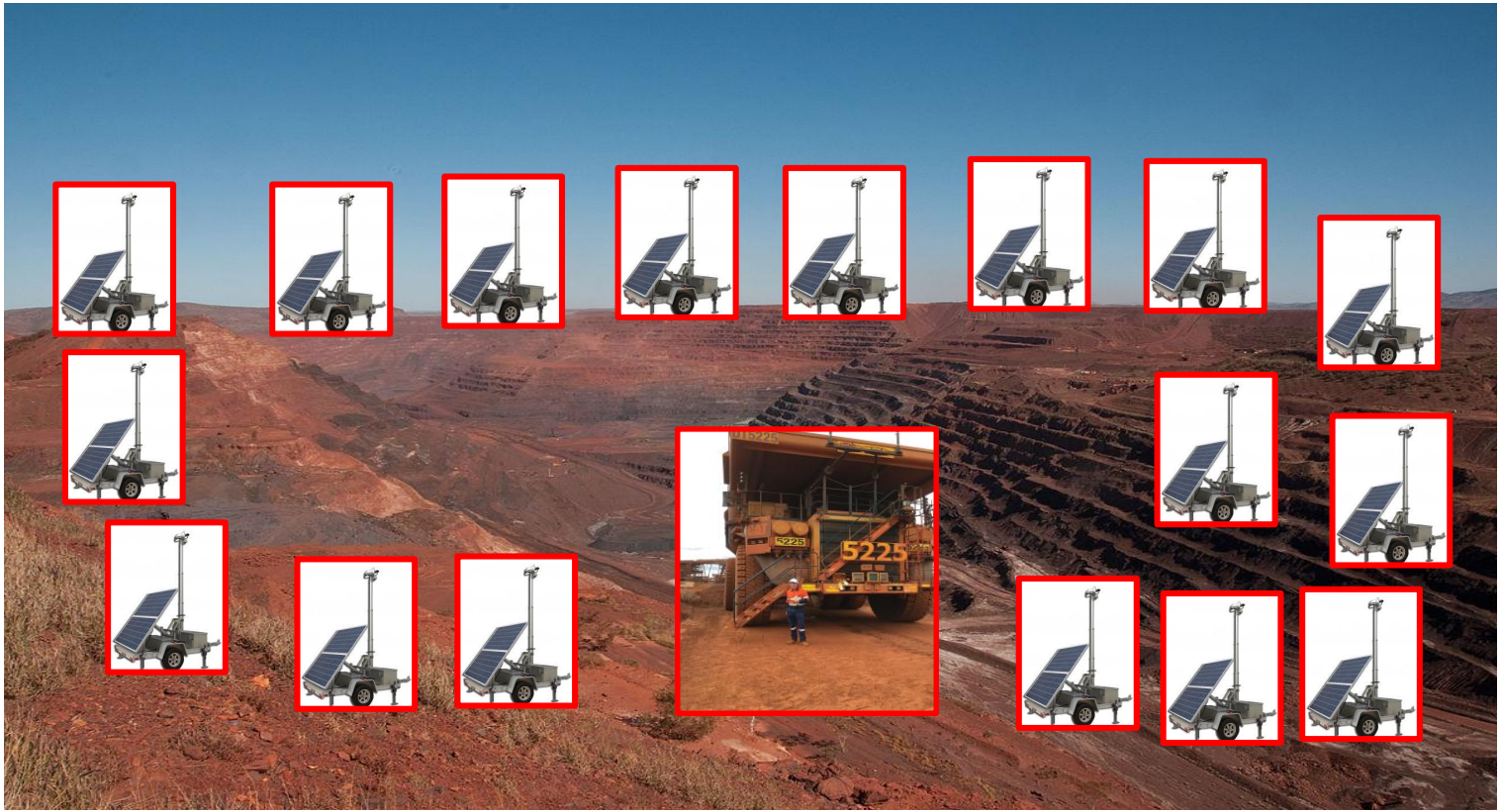
-

- What made the solution successful?
  - Reliable In Pit Coverage with increase bandwidth and Quality of Service
  - Met BHP all goals by increasing Autonomous mine fleet and increases Rail capacity , reduces manpower at site’
  - Management of delivery process
    - Equipment testing prior to delivery
    - Lab Testing
    - Management of technology upgrade and change over
    - Use of experienced resources in mining environment
    - Operational readiness program for BHP Staff
    - Training
    - Managed Services - to decrease risk

BHP as we lay the foundations for fully integrated and highly automated operations by 2025.

The productivity benefits of the autonomous haulage fleet at Jimblebar has helped reduced costs by around 20 per cent. Most importantly, our autonomous trucks and drills shield employees from dangerous situations.

BHP Current state



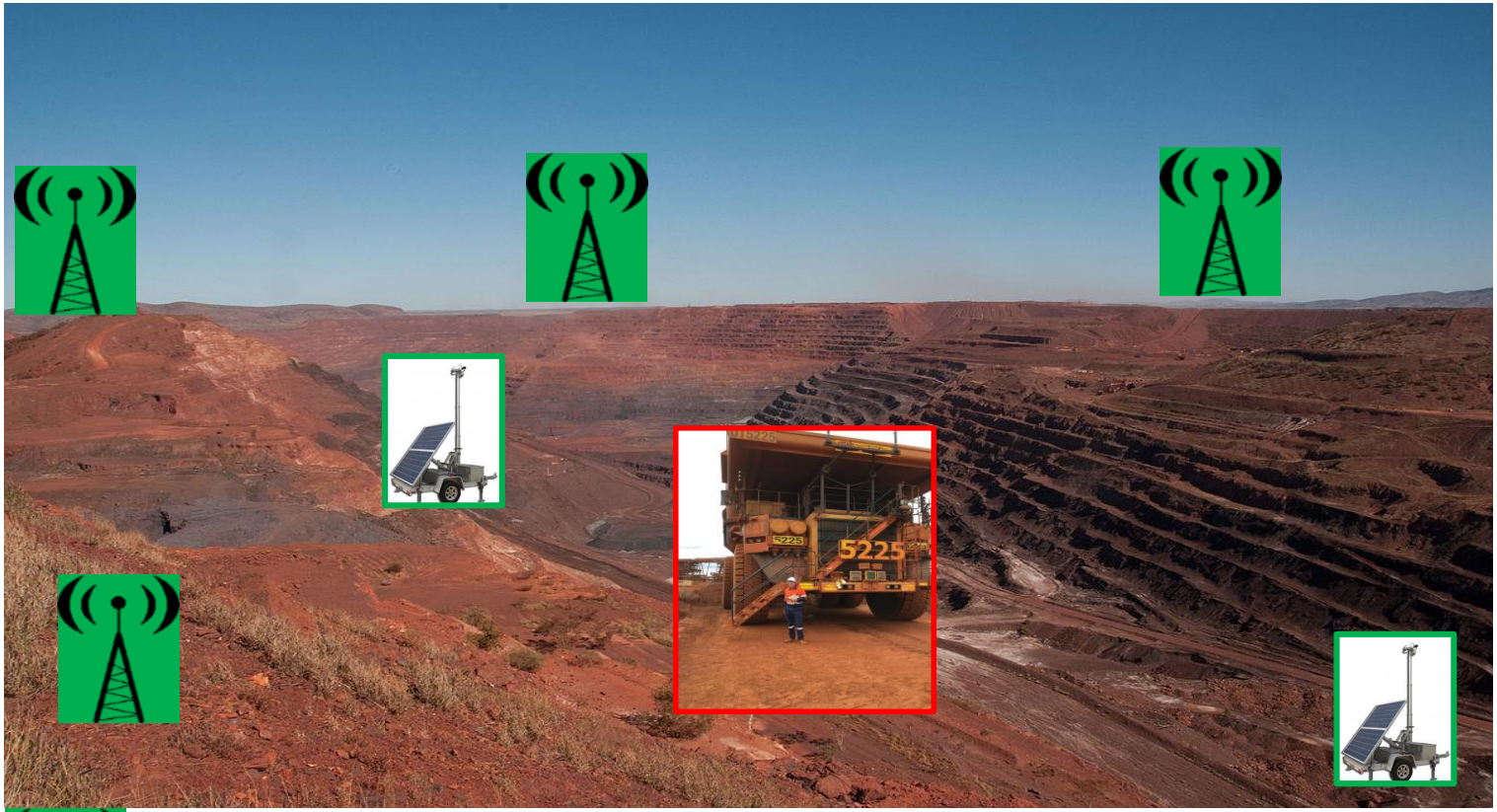
Trailer x 100

- Unreliable
- High maint
- End of life

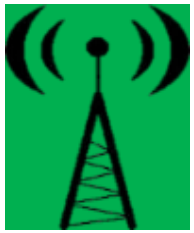
Rail Bottleneck

NOKIA

BHP Future state



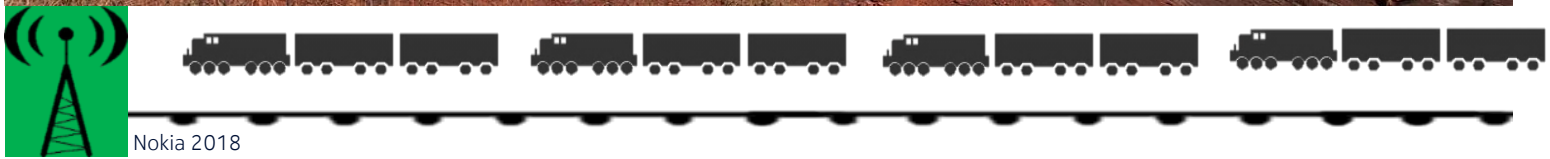
Trailer
x 5



Macro sites x 12

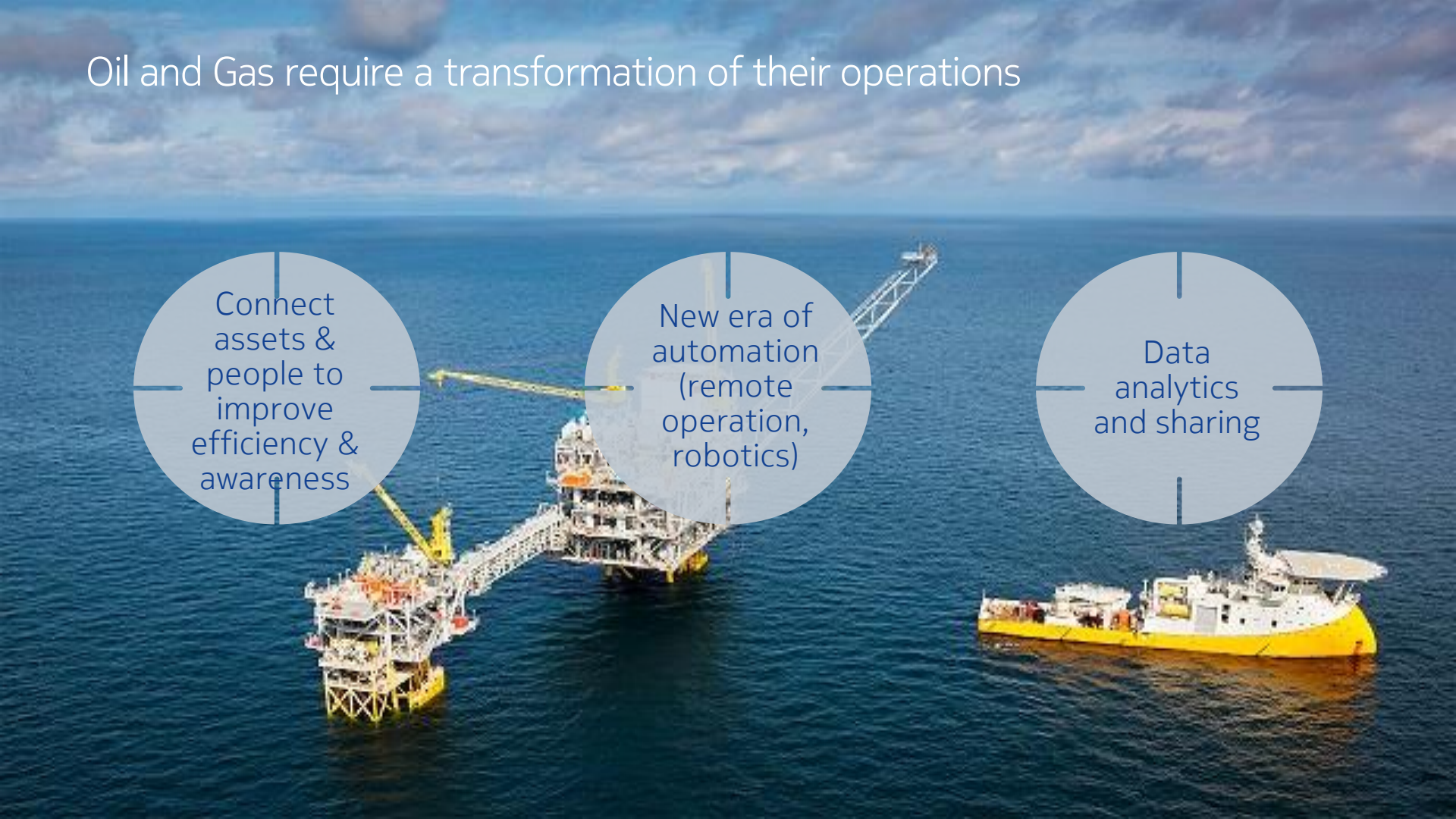
- High availability
- Higher bandwidth
- Increase tonnage

Increased Rail Usage via reduced separation



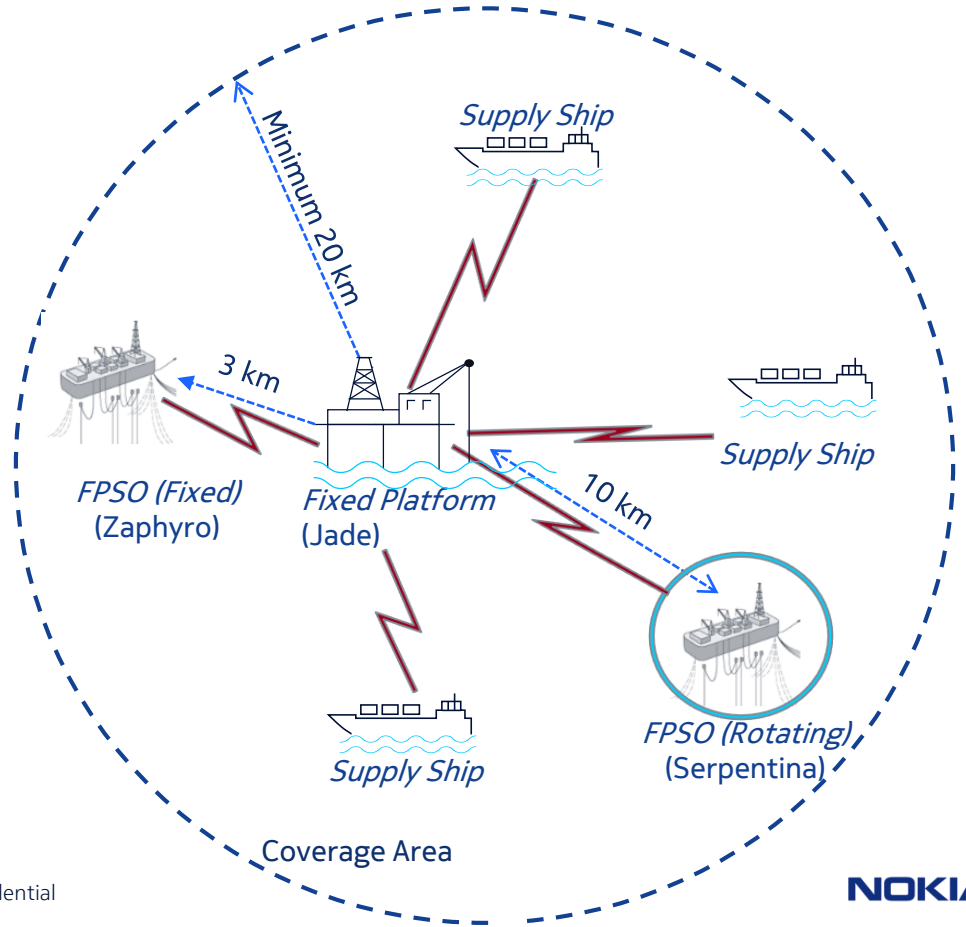
NOKIA

Oil and Gas require a transformation of their operations



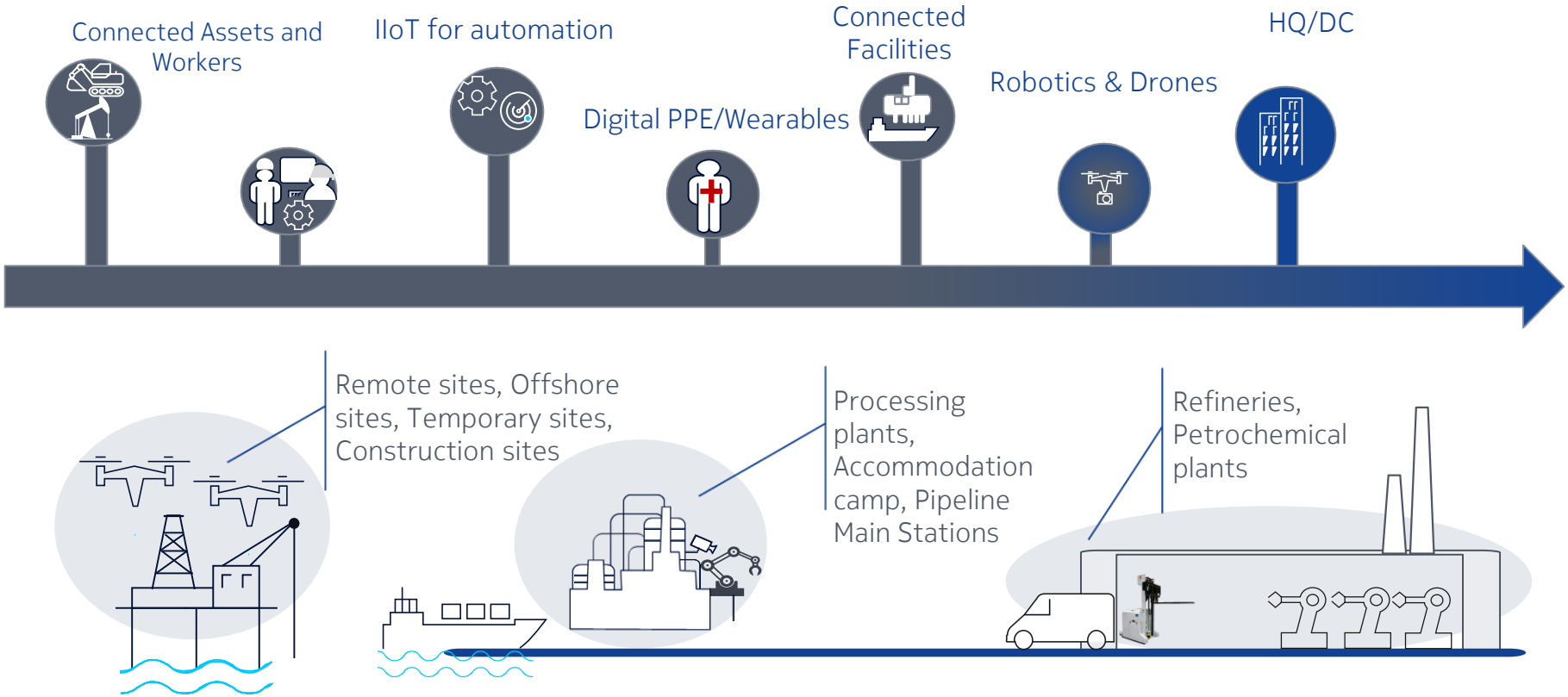
Equatorial Guinea - ExxonMobil
General Requirement

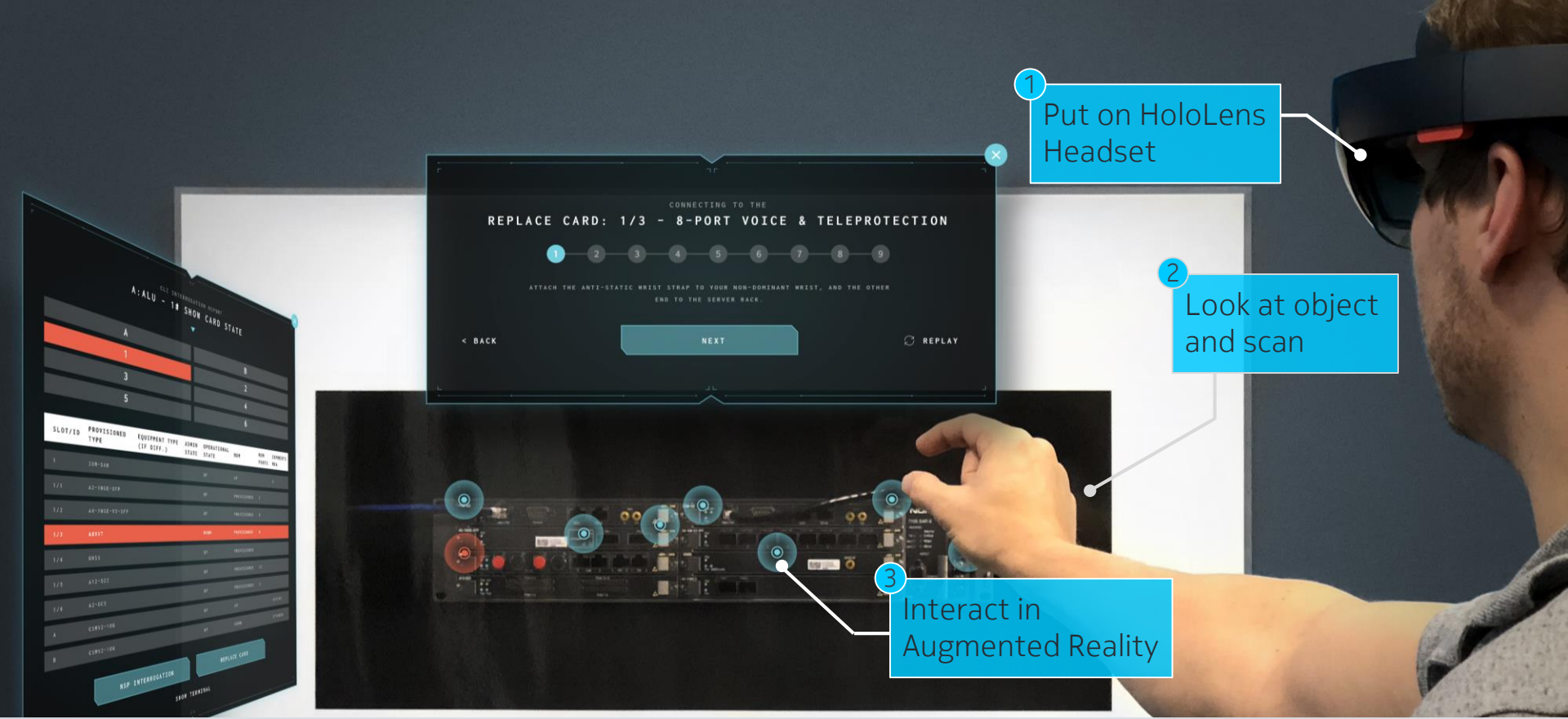
- **Wireless Connectivity Required**
  - Offshore Assets:
    - Production Platform “Jade”
    - Fixed FPSO (Zaphiro)
    - Rotating FPSO (Serpentina)
    - Visiting Vessels
  - Offshore Units have high speed point to point microwave.
- **Coverage Radius Requested**
  - Minimum 20 km radius from platform
  - Topside coverage only for data CPE’s
- **Future Enhancement**
  - Below decks coverage
  - MC-PTT



Future Oil & Gas Digital Transformation

Beyond Connectivity for Challenging Environments





How the Nokia AR Training works

Creating high-performance, mission-critical networks

On land, air, sea and soon to the Moon


NOKIA