EDP Distribuição Connect Program

Designing a transformational connectivity platform towards the Digital Modern DSO

Sérgio Pinto, EDP Distribuição S.A.

27th February 2019
Agenda

1. EDP in brief
2. Transformation & Connectivity
3. Connectivity challenges & opportunities
   • Geographical coverage
   • Availability
   • Diversity improvements
4. EDPD’s hybrid strategy
   • PVNO - Multi sourcing
   • Private Networks & Spectrum
5. Final remarks
From a local electricity incumbent, EDP has grown into a global energy player with strong presence in Europe, Brazil and considerable investments in the USA.

**EDP Group – overview**

- **Top position in Electric Sector in Dow Jones Sustainability Indexes**
- **#3 World wind energy company**
- **#1 Europe hydro project (+3.5 GW under development)**
- **#1 Portugal industrial group**

### Countries in which EDP has Distribution activities

- **Brazil**
  - 2,635 Employees
  - 2,831,651 Electricity Customers
  - 1,874 Installed Capacity (MW)
  - 8,043 Net Generation (GWh)
  - 100% Generation from renewable sources
  - 24,544 Electricity Distribution (GWh)

- **Portugal**
  - 7252 Employees
  - 6,053,509 Electricity Customers
  - 271,576 Gas Customers
  - 10,992 Installed Capacity (MW)
  - 34,364 Net Generation (GWh)
  - 51% Generation from renewable sources
  - 46,508 Electricity Distribution (GWh)
  - 7,138 Gas Distribution (GWh)

- **Spain**
  - 2,038 Employees
  - 1,015,543 Electricity Customers
  - 787,869 Gas Customers
  - 6,087 Installed Capacity (MW)
  - 15,331 Net Generation (GWh)
  - 37% Generation from renewable sources
  - 9,517 Electricity Distribution (GWh)
  - 48,447 Gas Distribution (GWh)

- **France/Belgium**
  - 34 Employees
  - 363 Installed Capacity (MW)
  - 705 Net Generation (GWh)
  - 100% Generation from renewable sources

- **Italy**
  - 14 Employees
  - 1,015,543 Electricity Customers
  - 787,869 Gas Customers
  - 6,087 Installed Capacity (MW)
  - 15,331 Net Generation (GWh)
  - 37% Generation from renewable sources
  - 9,517 Electricity Distribution (GWh)
  - 48,447 Gas Distribution (GWh)

- **United Kingdom**
  - 21 Employees
  - 475,543 Electricity Customers
  - 15,331 Net Generation (GWh)
  - 100% Generation from renewable sources

- **Poland/ Romania**
  - 2,038 Employees
  - 1,015,543 Electricity Customers
  - 787,869 Gas Customers
  - 6,087 Installed Capacity (MW)
  - 15,331 Net Generation (GWh)
  - 37% Generation from renewable sources
  - 9,517 Electricity Distribution (GWh)
  - 48,447 Gas Distribution (GWh)

**Top position in Electric Sector in Dow Jones Sustainability Indexes**

- **#3 World wind energy company**
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- **#1 Portugal industrial group**

**260 Employees**
- 3,422 Installed Capacity (MW)
- 9,330 Net Generation (GWh)
- 100% Generation from renewable sources
The Portuguese National Electricity System includes EDP Distribuição (EDPD) as the main electricity distribution company.

**Value chain**

**Agents**

**EDP D drivers**

**Production**
- Grid concessions from HV till LV and meters
- Agreed network investments remunerated at the IRR of Portuguese bonds

**Transportation**
- Efficient network operations & guarantee of service continuity and energy quality
- Controllable costs baseline recovered until a certain price cap (pressure for costs decrease)

**Distribution**
- Information broker and settlement between market players and consumers
- Monitor energy balance and minimize energy losses (technical and commercial)

**Retail Market**

**Assets management**

**Operations management**

**Information management**
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Accomplishing Affordable, Secure and Sustainable Energy by the Electric System transformation and digitalization

To a sustainable system, with a new market design and the emergence of 3D Utilities: Distributed Resources, Decarbonization, Diverse Assets, requiring improved permanent energy management

From Centralized, nuclear & fossil fuel

- Centralized Command
- Dispatchable energy
- Demand Curtailment
- One way energy
- Centralized SCADA

Distributed & Variable Generation
- Bidirectional energy flows
- Demand Side Management
- Virtual Power Plant
- Multi layer/party control
- Micro Grids
The electricity grid will require increased digitalization, control, supervision, demanding pervasive and permanent information flows.

- **New stakeholders** & underlying services (e.g. DER, prosumers) ...
- ... additional wide area control systems & data collection mechanisms ...
- ... higher capillarity of enabling infrastructure ...
- ... higher costs of permanent fixed systems

**INCREASING RELEVANCE OF WIRELESS COMMUNICATIONS SERVICES**
This new context requires an integrated approach, demanding pervasive connectivity in support of Grid Digitalization and its critical processes.

**Connectivity**
- **Core Network**
  - Optical Fiber
  - VHF/UHF Links
  - Satellite
- **Access Network**
  - PVNO (2G/3G/4G/5G,IoT)
  - LTE Network 450MHz
  - Satellite (LEO/ GEO)
- **Local Network**
  - PRIME PLC
  - GPRS / NB IoT / LTE M
  - FTTH / 5G

**Applications and Infrastructure**
- OSS
- OT Data Lake
- Advanced Analytics
- OT Cloud
- SDN/NFV

**Cybersecurity**
- Data Protection
- Identity and Access management
- Control system security
- Integrated SOC

**Service Operation and Management**
- Digital Platform Supervision Center
  - E2E Monitoring
  - QoS
This new context requires an integrated approach, demanding pervasive connectivity in support of Grid Digitalization and its critical processes.
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Anticipating future requirements, EU Smart Grid projects portray the dependency on performant, reliable and pervasive connectivity services

- Total Coverage of System Actors and Assets
- Adequate performance profiles
- Need for Contracts and governance
- Standard Interfaces
- “quality and performance of communication as a big technical barrier”

<table>
<thead>
<tr>
<th>Application</th>
<th>Communication Delay (msec)</th>
<th>Data Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>State Estimation</td>
<td>100</td>
<td>136.8 Kbps</td>
</tr>
<tr>
<td>Generator Synchronization</td>
<td>50</td>
<td>91.2 Kbps</td>
</tr>
<tr>
<td>Intelligent Scheduling</td>
<td>50</td>
<td>300 Kbps</td>
</tr>
<tr>
<td>Islanding</td>
<td>50</td>
<td>10 Kbps</td>
</tr>
<tr>
<td>Oscillation control</td>
<td>200</td>
<td>27.4 Kbps</td>
</tr>
</tbody>
</table>
Public networks still face challenges in adequacy to support critical always-on services, namely in non-urban environments

Pervasive service coverage

- Mass market focus
- Intense competition and margin erosion (OTT, ...)
- Extended “Neutrality”, no QoS
- Basic business continuity
- ...

An example of rural broadband KPI (Portuguese region)
By NRA (PT) – Latest available survey

Coverage differences & limitations by MNO

Wide Area Control Systems shall compete for scarce resources in regions presenting evident service limitations

Download Throughput (FTP) evidences service coverage and capacity limitations, with DL/UL unbalance

Latency reveals effects of resource limitations

Although primary focus on higher population density areas, there is a marginal service improvement when combining MNOs service capabilities
Continuity of telecom service supply limited to match critical Grid requirements, displaying a strong dependency on energy continuity

Service continuity / Major outages

National (PT) regulation on public service provider’s security obligations

Levels of service disruption that are required to be communicated to the NRA, by number of impacted services and duration

<table>
<thead>
<tr>
<th>Patamar</th>
<th>Duração</th>
<th>Número de assinantes ou de acessos afetados</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>≥ 30 minutos</td>
<td>Nº assinantes/acessos ≥ 500.000</td>
</tr>
<tr>
<td>II</td>
<td>≥ 1 hora</td>
<td>500.000 &gt; Nº assinantes/acessos ≥ 100.000</td>
</tr>
<tr>
<td>III</td>
<td>≥ 2 horas</td>
<td>100.000 &gt; Nº assinantes/acessos ≥ 30.000</td>
</tr>
<tr>
<td>IV</td>
<td>≥ 4 horas</td>
<td>30.000 &gt; Nº assinantes/acessos ≥ 10.000</td>
</tr>
<tr>
<td>V</td>
<td>≥ 6 horas</td>
<td>10.000 &gt; Nº assinantes/acessos ≥ 5.000</td>
</tr>
<tr>
<td>VI</td>
<td>≥ 8 horas</td>
<td>5.000 &gt; Nº assinantes/acessos ≥ 1.000</td>
</tr>
</tbody>
</table>

Storms and wild fires have direct impact on infrastructures and on major external supplies as it is the case of electric energy supply and absence of suitable Uninterruptable Units
EDPD’s “always-on” wide area control systems confirms significant and recurrent service fluctuations by current MNO providers (BaU & Storms)

**Average daily availability of current cellular connectivity used by Medium Voltage SCADA (MNO1 and MNO 2, nationwide)**

- Inadequate availability from the 2 used MNOs to fulfill BaU Grid operation
- Significant service impairments attributed to MNO internal and technical causes
- Atmospheric extreme conditions impacting MNO with higher regional incidence, matching higher Grid control requirements and command volume
- Switching service between MNO selecting best instant network would maximize availability (+20% Improvement)

**KEY FINDINGS**

- Using additional networks and performing service selection would further improve overall availability
MNO severe service impairments occurrences display a geographical diverse profile, with MNOs differentiation, revealing the inherent optimization potential of MNO diversity.

Connectivity impairments due to STORMS vary in geography according to MNO Infrastructure condition.

MNO Network differentiation represents a service reliability maximization opportunity.

Similar network layout but different performance Viana do Castelo (BTS).

MNO Service Switching could promote:
- + 27 Grid Commands (+31.7%)
- + 11% Of success confirmed commands
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EDPD devised a Service Orchestration paradigm as an inclusive system, enabling suitable risk management and quality control, sourced by private and public networks.

**Key question**

How to support business evolution with the most suitable and cost effective telecom solutions?

And

Adequate accountability and risk profile?

**Main drivers**

**Fulfill requirements:**
- High resiliency, availability, coverage and performance (latency)
- Emergency support, high security and control
- Grid flexibility for evolving services

**Improve service of public operators’ offers:**
- Leverage on existing good coverage (e.g. urban areas)
- Increase resilience using a multi operator system

**Update/enhance private means:**
- Ensure service in critical and underserved areas
- Optimize investments & costs

**Conceptual solution**

**A Private network**

**Objective**
- Coverage and resilience by design
- Vertical control and priority management
- Improve ecosystem life cycle control

**Challenge**
- Obtain Spectrum and choose technology
- Built internal technical capabilities to manage & operate

**B Public service offer**

**Objective**
- Benefit from existing infrastructures, innovation and competition
- MNO knowledge and experience on mass volume operations

**Challenge**
- Motivate MNOs to interconnect
- Get legal and regulatory approval

**Benefits**

- Maximize resilience and geographical service coverage
- Promote competition, commercial and QoS
- Better operational and financial efficiency
- Improved Risk management (no-lockin / business continuity)

**Statistical probability of external extreme events**

- **Red**
  - A
  - B

- **Orange**
  - B

- **Blue**
  - A

- **Green**
The multi-function/technology/stakeholder orchestration scenario can benefit from wide convergence and support of current 3GPP and ETSI standards – Private MVNO

Wireless technologies combination – overall vision & steering mechanism

<table>
<thead>
<tr>
<th>Business</th>
<th>Service Orchestration</th>
<th>Networks (public &amp; private resources)</th>
<th>Terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity grid dispatch</td>
<td></td>
<td>2G</td>
<td>Telecom grid Assets</td>
</tr>
<tr>
<td>Smart meter operations</td>
<td></td>
<td>3G</td>
<td>Sensors</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td>4G LTE</td>
<td>Routers</td>
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<tr>
<td>Digital platform supervision</td>
<td></td>
<td>NB-IoT/LTE-M</td>
<td>DTCs</td>
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<tr>
<td></td>
<td></td>
<td>WiFi</td>
<td>Smart meters</td>
</tr>
<tr>
<td></td>
<td>Service control</td>
<td>WiFi</td>
<td>Storage</td>
</tr>
<tr>
<td></td>
<td>Steering mechanism</td>
<td>WiFi</td>
<td>Appliances</td>
</tr>
<tr>
<td></td>
<td>3GPP standard</td>
<td>Satellites</td>
<td>Operational teams</td>
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<td></td>
<td></td>
<td></td>
<td>Command &amp; Supervision</td>
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<td></td>
<td></td>
<td></td>
<td>Technical Center</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>Field force</td>
</tr>
</tbody>
</table>

DPDR Networks Digital Platform
Besides the fundamental 3GPP core functions (Authentication, Policy, Accounting, …) the system will require strong OSS capabilities for service steering.

Service aware active management – steering mechanism

- **Business**
  - Electricity grid dispatch
  - Smart meter operations
  - Maintenance
  - Digital platform supervision

**Service control**

**Steering mechanism**

- Authentication & authorization (HLR, HSS)
- Policies (PCRF)
- Gateways (GGSN, P-GW)
- Service Steering

**Future evolution into 5G**

**API**

**Service** Based on Slice

**Network Service** NaaS/PaaS

**Entity N**

2G

3G

LTE

Other (NB-IoT/ LTE-M, WiFi, Satellite, …)
The PVNO faced regulatory and technical challenges, from regulatory acceptance and resource allocation to the adoption of technology “not yet” mainstream

Regulation and Technology

- Common understanding on project’s objectives
- E.212 IMSI resources, supporting existing SIM-CARDS
- E.164 Numbering
- One Regulator’s revenue is the other’s cost!!

Full Virtualized Core (NFV & SDN)

ETSI NFV Framework

Network Functions Virtualization (NFV) with a Touch of SDN, 2017, Rajendra Chayapathi & Syed Farrukh Hassan
The operational and business impact promoted by the PVNO QoS Upside represents a significative economic value that adds to “No Lock-in” competitive benefits.
On the Private Network domain, EDPD developed a phased approach, electing LTE technology and formally requesting spectrum

From PoC Reality Check to formal proposal

**Ideation**
- Service requirements
- Technology selection
- Potential Spectrum (< 4 years) and preferences
- Promote simulation and technology ecosystem testing

**Field PoC**
- Obtain temporary frequencies for pilot (450 MHz)
- Regulatory engagement
- Process & Share results and tune models

**Formal Request**
- Confirm LTE-450 MHz
- Spectrum request
- Enrol energy regulator on spectrum interest
- Respond to public consultation

**Regulatory developments**
- 450 MHz spectrum availability, previously used by public trunking operator
- 2018, public consultation within 700MHz multi band enquiry, indicating EDPD as the only entity requesting 450MHz
- No other entity besides EDPD manifesting interest in licensing 450 MHz
- MNOs referring their capability to satisfy EDPD’s service requirements, obviating the need to licence EDPD with this scarce resource
- Awaits for regulatory decision
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Final Remarks
Challenges and Concerns

1. Multi-sourcing strategy enables better risk management and promotes price and quality competition

2. Standard architectures and systems are able to delivery adequate Service management capabilities

3. Moving forward, 5G will further increase the need to manage heterogeneous network and service environments

4. Regulator engagement and cross sector alignment is of utmost importance

5. Private network components play an essential role in assuring adequate business continuity and complementing market “holes”

6. Connectivity assurance is a new Utility’s Core asset, requiring adequate skills and staffing
Thank you for your attention

Sérgio Pinto
EDP Distribuição, S.A.
sergioramos.pinto@edp.pt