DEPLOYING SMART GRIDS IN EMERGING COUNTRIES

Lessons Learned From Projects Worldwide

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YOUR NEEDS

You are a "utility", a power generator,
a supplier, an equipment manufacturer, a start-up, an industry association,
a university, a research center, a public authority etc.
You have needs and expectations in the following areas:

- Strategic positioning in the energy markets
- Implementation of the operational strategy
- Project management and development

The experts of Algorus consulting provide you with a tailor-made support. Possible financing by international
financing institutions (The World Bank, AFD, IDB, ADB etc.)

Strategic positioning on energy markets (power and gas)

Europe and North America, emerging and developing countries, centralized and local solutions, flexibilities.

Keywords

Energy transition, digitalization and data management, decentralization, territories, investments, transfer of technologies, integration of intermittent renewable energies, energy mix, disruptive innovations, agility.

Assistance to contracting

Strategy implementation, smart grid and smart meter projects, investment plans (generation, networks, IT).

Keywords

Prioritization of short term investments, search for growth opportunities: acquisitions, green field projects, pipeline of projects.

Engineering and project development

On shore and off shore Wind, solar, biomass, cogeneration projects, batteries for storage, electric vehicle, active demand.

Keywords

Integrator, EPC contract, optimized financing, O & M contract, legal and tax, permitting, search for technical and financial partners, blockchain.

Projects worldwide

Madagascar: customer management, GIS
Guinea Bissau: network operation, customer management
Guinea Conakry: MV network operation, protec- tion plan, GIS, customer mangement
Sri Lanka: network operation, protection plan, RES integration
Gabon: network operation, black-outs
Comoros: customer management, network operation

- China (SGCC, SIEG, CSG): network operation, GIS.
- Tunisia: RES integration
- Marocco: network operation improvement
- Russia: asset renovation and quality improvement
- Congo, Mali, Rwanda, Mauritanie, Sao Tomé, Benin, Uruguay, Brasil

Smart grids contribution in developping countries

- Many and substantial programms
- Customers from the World Bank and other financial bodies show interest for implementing smart grids functionalities
- Avoiding the implementation of technologies that do not fit with the needs
- The approach will be first on functionalities then on solutions offered by smart grids.
- Recommendations are proposed
- Technical and cultural habits must be first transformed

Diagnosis of the current situation

Precarious generation/demand balance

- Frequent load sheddings
- Ignorance of the real consumption load curve
- Non optimized adjustment of capacity

- Insufficient primary reserve with potential general blackout

- Many industries interested with solar PV plants. Local utilities not prepared.

- Microgrids

Archaic distribution networks

- Generation problems hide distribution problems :
- Cut offs for default or maintenance : too numerous or too long.

- Moreover this situation is reinforced by :
- Very long commuting time
- Absence of communication tools

- Increasing loads on the network

- No protection on low voltage feeders : bypassed fuses

- With lack of knowledge of the loads, no reinforcement of the network

- Too much curative maintenance. Lack of preventive maintenance.

A challenge : the customer should pay for the service

- ❑ **Access to electricity does not pay the total costs and not even the variable costs.**

- ❑ **At stake :**

- **Provide socially acceptable tariffs covering the cost.**
- **For large customers, develop a MV metering system.**
- **For small customers, deploy a LV metering system, simple but able to limit the theft risk.**
- **Struggle against illegal connections and resale of electricity.**

How can smart grids address these situations ?

Smart grids solutions

- Smart grids are not the universal solution but partial improvement in each domain.

- Real analysis of the needs rather than the last technology temptation.

- Take advantage of good quality and low cost GSM networks in many developping countries.

Generation/demand balance management

- Facilitate the introduction of intermittent RES in the network
- Observability is key
- Short term and very short term prevision for solar PV
- Reactive power managed according to the effective load
- Install remote controlled devices : manage the load shedding, integrated into a SCADA
- Load shedding automatisms will limit blackout risks
- Same procedures can be adapted to microgrids

Network domain

- **Three dimensions for smart grids to contribute to :**

- **Better know the assets :** medium voltage GIS but also low voltage. Instrumentation in primary substations to measure capacities.
- **Better operate the assets :** SCADA associated whith advanced operating functions. Remote control devices on the network.
- **Better maintain the assets :** manage interventions using an asset data base (CCMS type) and a tool for on-field programming interventions.

- **Local utilities must be supported for an optimal use of these technologies.**

Customer domain

- **Most utilities want to install smart meters.**

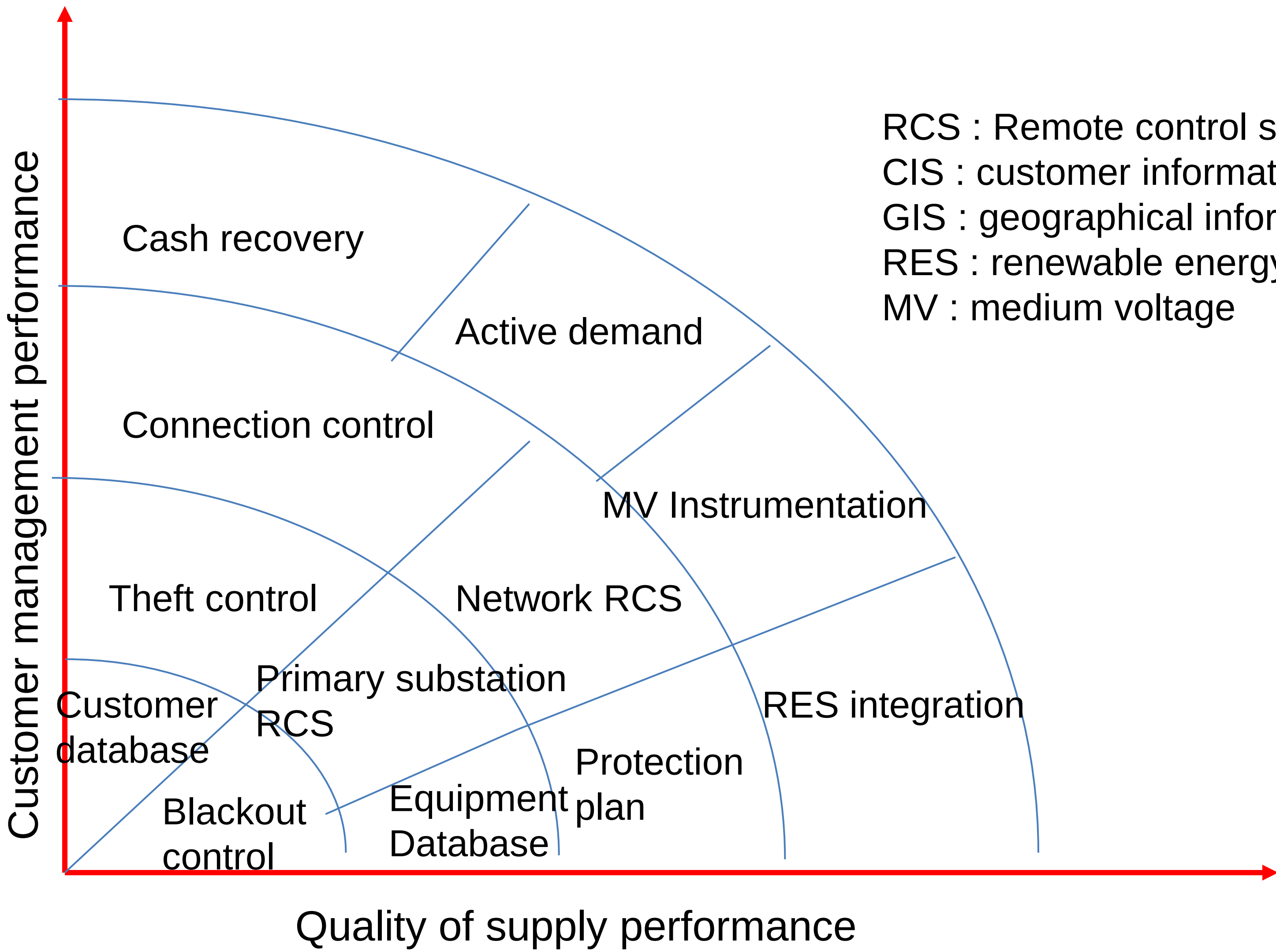
- **Priority issues :**
  - **For MV customers, deploying up-to-date, electronic, remote controlled meters**
  - **For LV customers, prepayment metering is attractive. The « Split solution » limits fraud. Expensive but effective solution.**

- **Prepayment allows bills recovery.**

- **Smart meters with PLC technology create a direct link between the customer terminals and the central system.**

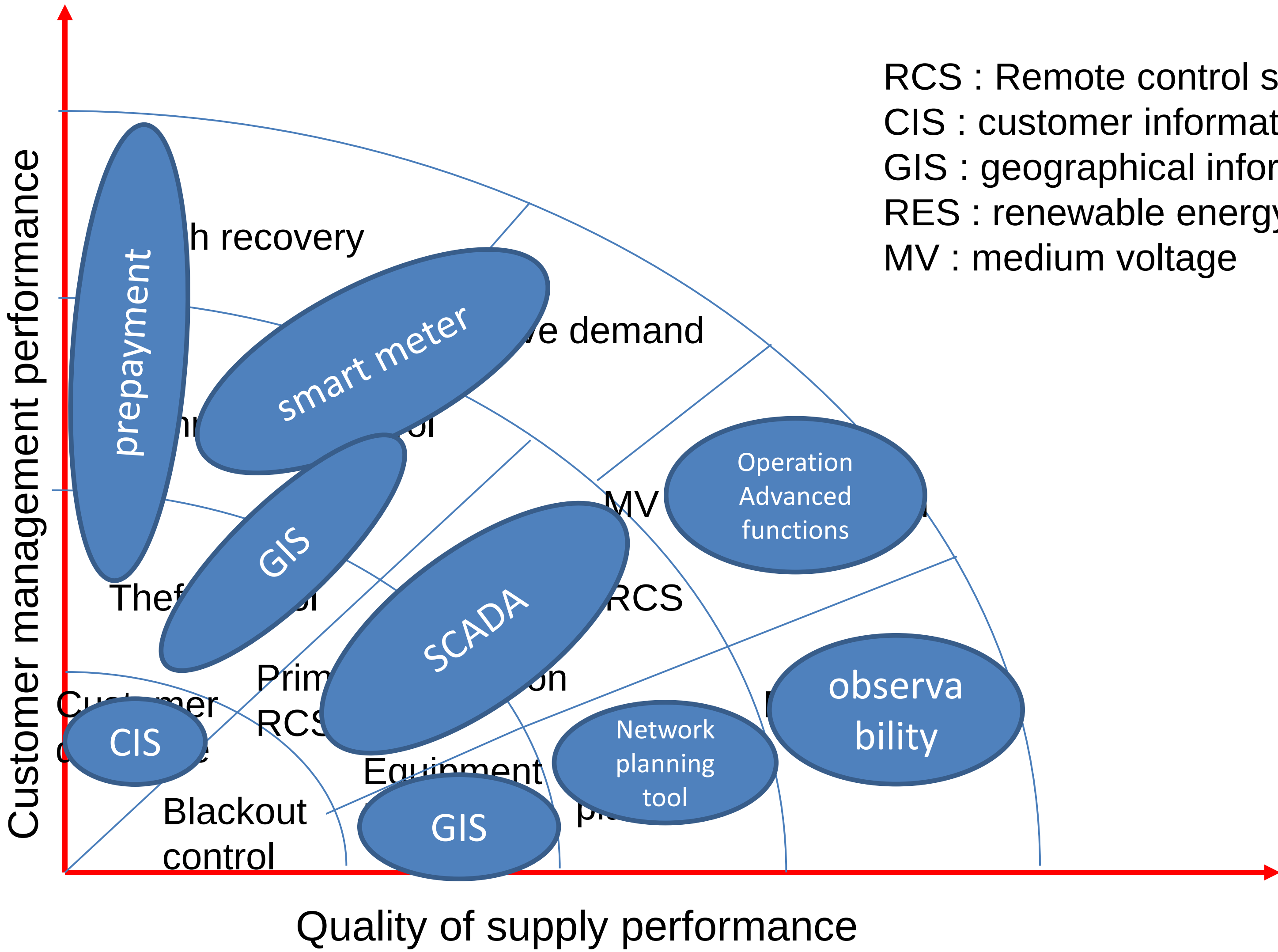
- **Regression may occur with prepayment and smart meters**

Improvement of performance



RCS : Remote control system
CIS : customer information system
GIS : geographical information system
RES : renewable energy sources
MV : medium voltage

Improvement of performance



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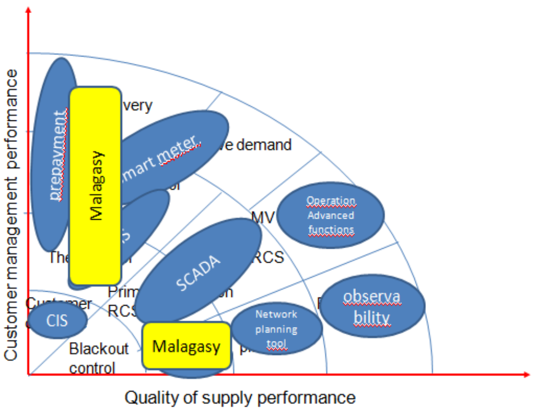
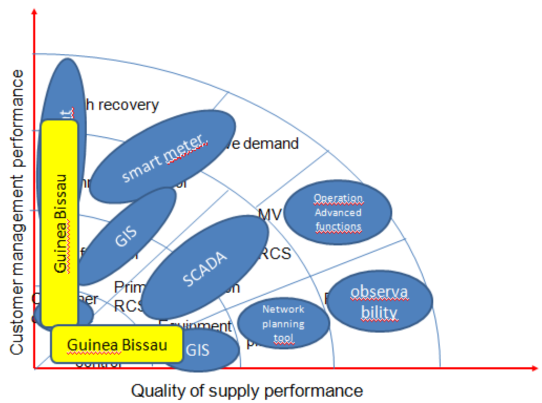
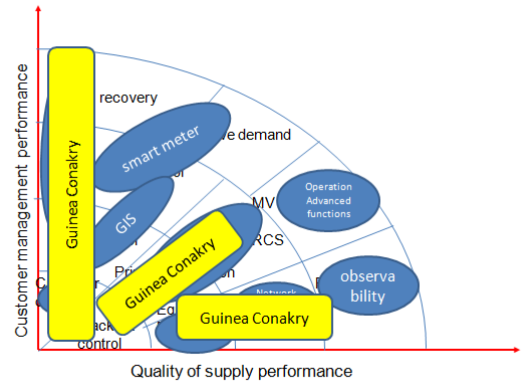
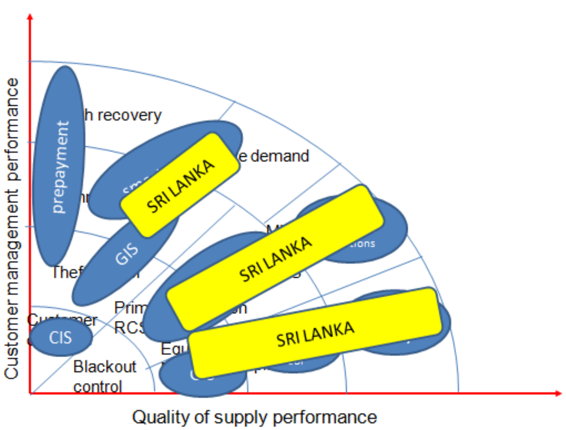
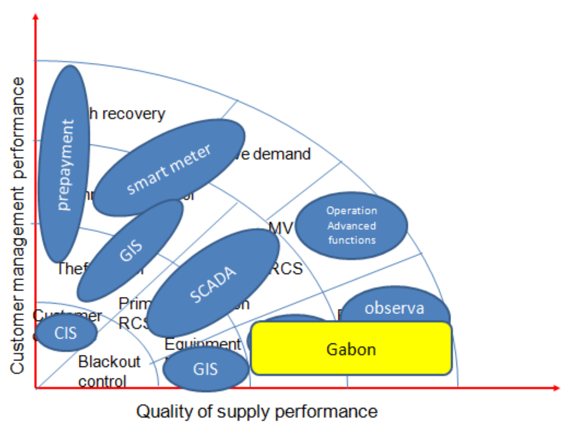
Improvement of performance (1/2)

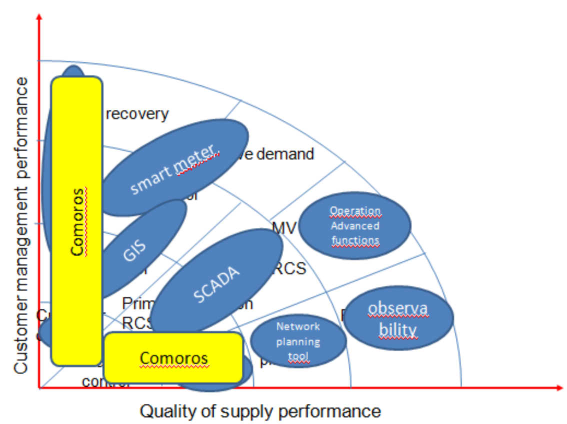




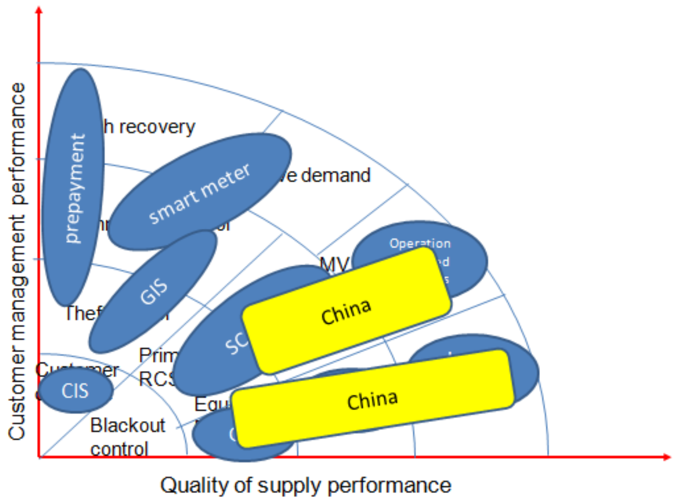


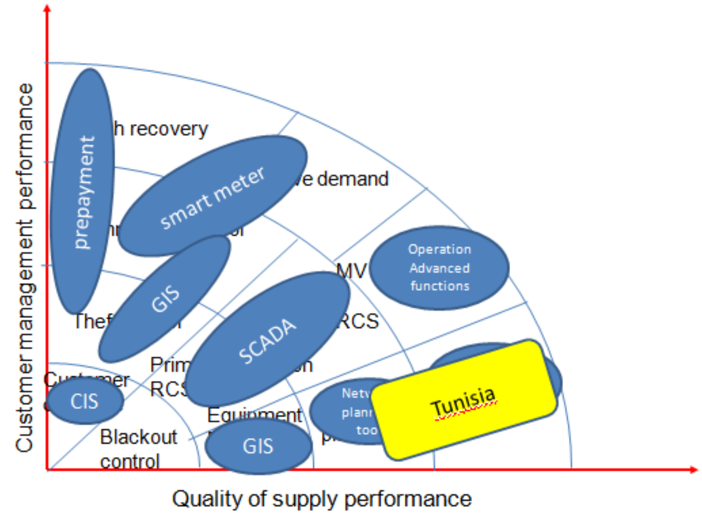


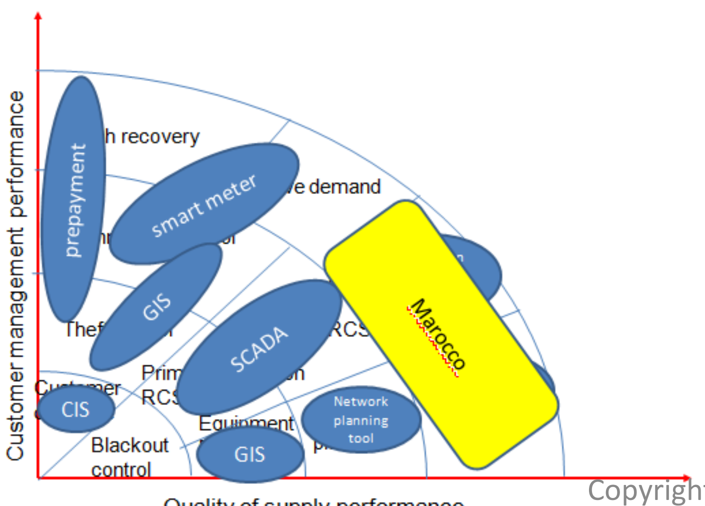


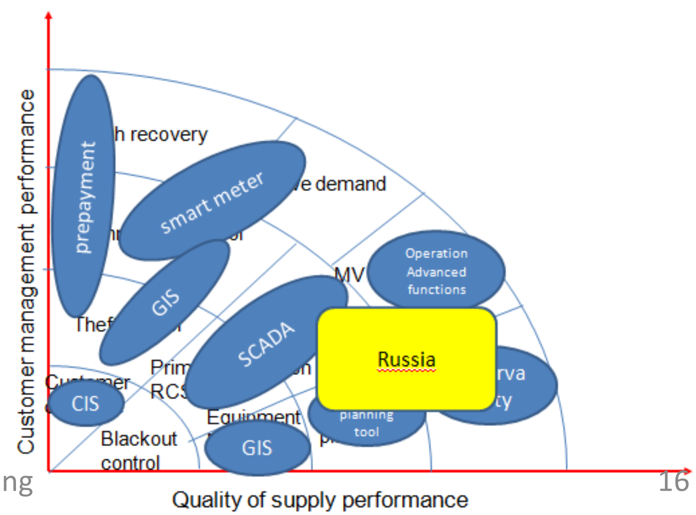


Improvement of performance (2/2)









Risks of a poor implementation

- **Lack of integration in the existing system.**

- **New systems installed without taking into account the necessary progressivity of solutions.**

- **New systems are designed using equipment manufacturers products which not always fit with local needs** (designed by Western countries, weak prescription capabilities by local utilities).

- **Limited evolution of skills which does not follow the evolution of technology.**

Key factors of success

- **Audit of the local context before launching a project**
  - **Define areas of improvement**
  - **Define conditions of evaluation of the results**

- **Strengthen local management.**

- **Develop a training program beside the equipment project.**

- **Define the content and monitor the project.**

- **Sustain cultural change during several months and perhaps years.**

- **Measure the results of the project through KPI.**

Thank You

Fraud management

Solution	Meter fraud	Human fraud	Up-stream connection	Unpaid bills
Electronic meter	No effect	No effect	No effect	No effect
Prepaid monobloc	Useful	Useful	No effect, possible regression	Suppression
Prepaid split	Very efficient	Useful	Very efficient	Suppression
Smart meter	Efficient	Useful	No effect, possible regression	No effect

Excerpt from study report, PAGOSE report Madagascar.

Specific features for developping countries

New technologies are first developped for quality and security in industrialized countries ; some specific developments have to be launched to answer to specific expectations of emerging countries.

- **Small networks (<200 MW peak) :** guarantee that a default activating a protection device should not destabilize the network and produces a blackout.
  - **Very small networks (10 to 30 MW) :** very difficult to avoid any MV default to create a blackout.
- **A well adapt smart meter project** fitting with specificity of customer relationship in emerging countries: prepayment and customer management with a PLC/GPRS liaison between meter and the utility.
- **Non interconnected microgrids with PV generation.** Smart grids technologies deriving from islanding projects will well adapt.

Evaluation of NDE (€/kWh)

Tableau 4.20. Estimations du coût global d'END par PIB et des valeurs d'END utilisées dans une sélection de pays

Pays	PIB (G€)	Consommation (TWh)	Electricité per cap. (MWh/hab)	END globale Ratio PIB / élec. (€/kWh)	END[1] (€/kWh)
Australie	450	188	9,6	2,4	3 à 20
Belgique	250	78	7,6	3,2	3,1
Etats-Unis	10.800	3.613	12,8	3,0	~ 2 à 25
France	1.600	408	6,8	3,9	9,15 à 20
Norvège	220	112	24,8	2,0	0,5 à 6,3
Royaume-Uni	1.700	345	5,8	4,9	3 à 30

PIB : GDP gross domestic product

Source : WISE world information service on energy

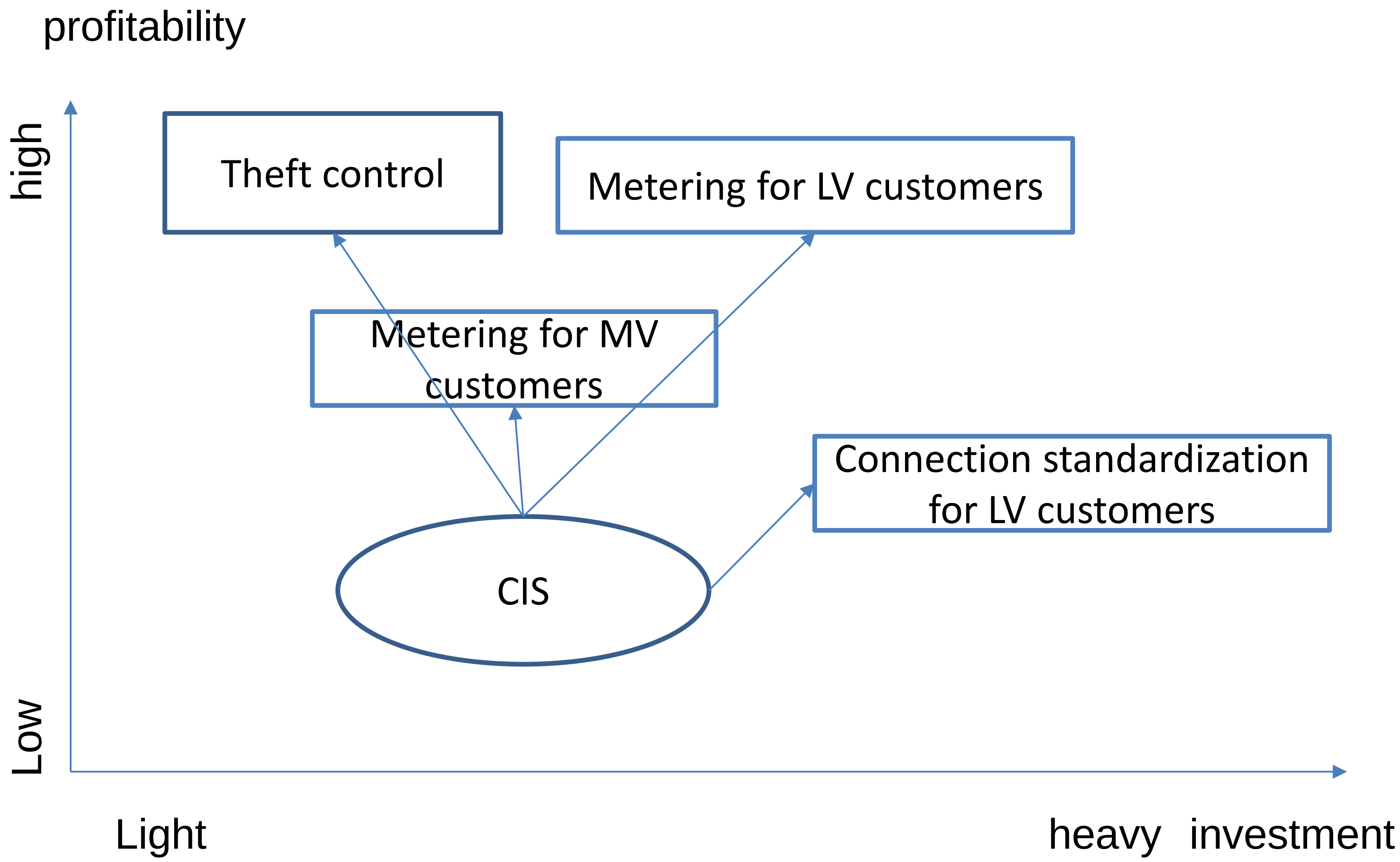
Example for network profitability : SCADA

- SAIDI : 10h
- Pmax : 200 MW
- Annual duration of use : 3000 h
- After SCADA installation : SAIDI = 6h
- NDE (kWh) saved per year : 200 x 3000/8760 x 4 = 274 MWh / year
- Value for 1 non distributed kWh = 1$
- updating rate = 8%
- Global cost of NDE for 10 years : 7,24 x 274 = 1983 k$
- Cost of a SCADA software and environment = 2 M$?

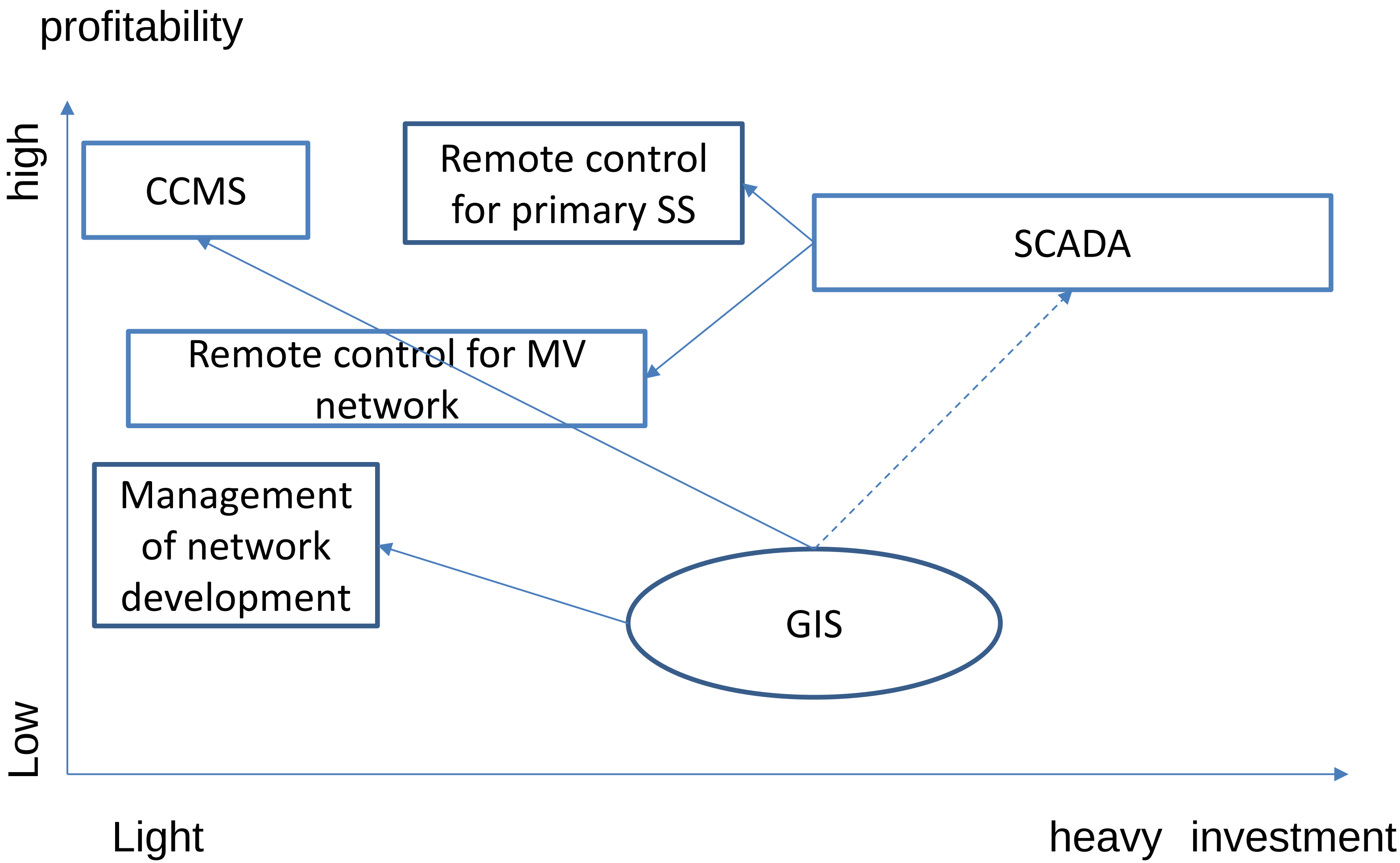
Example for customer management : prepayment

- Monthly consumption : 50 kWh
- Tariff rate : 0.15 $
- Percentage of customer paying : 30%
- Percentage of payment after prepayment : 80%
- Income saved for each customer through prepayement : 3,75 $/month
- Cost of a prepayment split meter including control system : 70$
- Return time (in months) 70 / 3,75 = 19 months

Investment level and profitability (1)



Investment level and profitability (2)



Transmission Grid and distribution network (1)

- System less than 30 MW
  - Transmission operated in MV , so no clear boarder between T & D
  - Generation and major MV feeders often operated by the same team
  - Distribution focused on repair (LV and MV)
  - Inter action between T & D on protection plan
  - Difficulty to avoid generation disconnection after MV network fault
- System between 30 and 200 MW
  - Transmission operated in HV ; generally primary SS operated by T (HV and MV)
  - Distribution activity focused on MV and LV lines ; no SCADA
  - Light interaction between T & D protection plan still exists
  - It is possible to avoid blackout after MV network fault
- System larger than 200 MW
  - Transmission operated in HV and VHV
  - Primary SS entering in Distribution area : SCADA distribution operating primary SS
  - T & D Protection plans clearly splitted
  - MV fault has no impact on T grid ; generation fault has no impact on D according to spinning reserve level

Transmission grid and distribution network (2)

- **The difficulties encountered**
  - Create a real distribution function not only focused on fault repair
  - Formalise the T & D boarder
  - Transfer MV control to distribution
  - Set a clear objective based on suppress of blackouts after MV faults
  - Separate T & D control in 2 SCADA
  - Build a competency for distribution protection setting
- **To deploy SG on distribution grid in an effcient way**
  - Distribution area must cover HV/MV transformers, MV part of primary SS and MV grid

Lessons learned by projects

- **Malagasy** : customer management, GIS
- **Guinea Bissau** : network operation, customer management
- **Guinea Conakry** : MV network operation, protection plan, GIS, customer mangement
- **Sri Lanka** : network operation, protection plan, RES integration
- **Gabon** : network operation, black-outs
- **Comoros** **:** customer management, network operation
- **China** (SGCC, SIEG, CSG): network operation, GIS.
- **Tunisia** : RES integration
- **Marocco** : network operation improvement
- **Russia** : asset renovation and quality improvement
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PAGOSE Program in Malagasy

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❑ **The launching of the PAGOSE program**

- **Diagnosis on JIRAMA**
- **Project improving the governance and operations**

❑ **Technical aspects have to be managed :**

- **Lack of generation**
- **Lack of preventive maintenance**
- **Lack of anticipation**
- **Low recovery rate**

PAGOSE Program in Malagasy (2)

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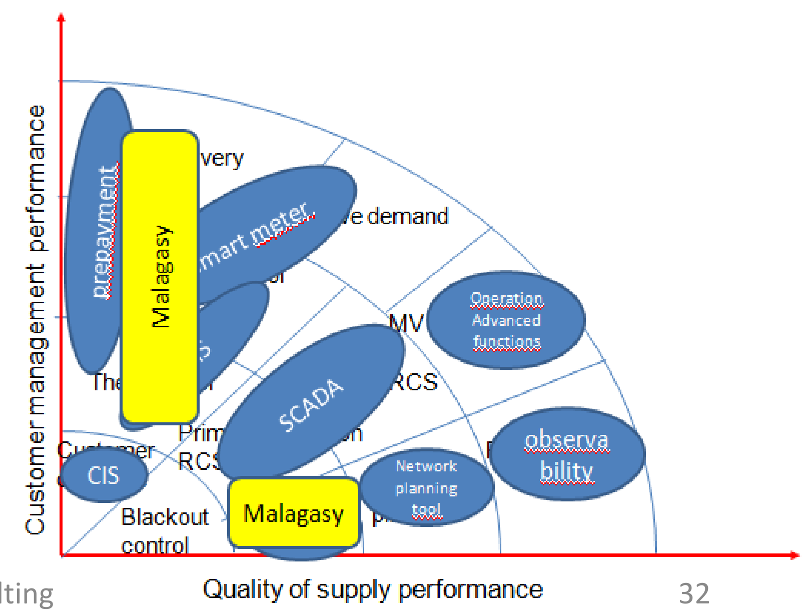
- ❑ **Some challenges remain :**
- ➢ **A better knowledge of the infrastructure components and their loads**
- ➢ **Monitoring tools for maintenance**
- ➢ **Improve customer management**
- ➢ **New RES production should be anticipated**

- ❑ **Possible contributions from smart grids :**
- **GIS**
- **Metering management**
- **Protection plan**



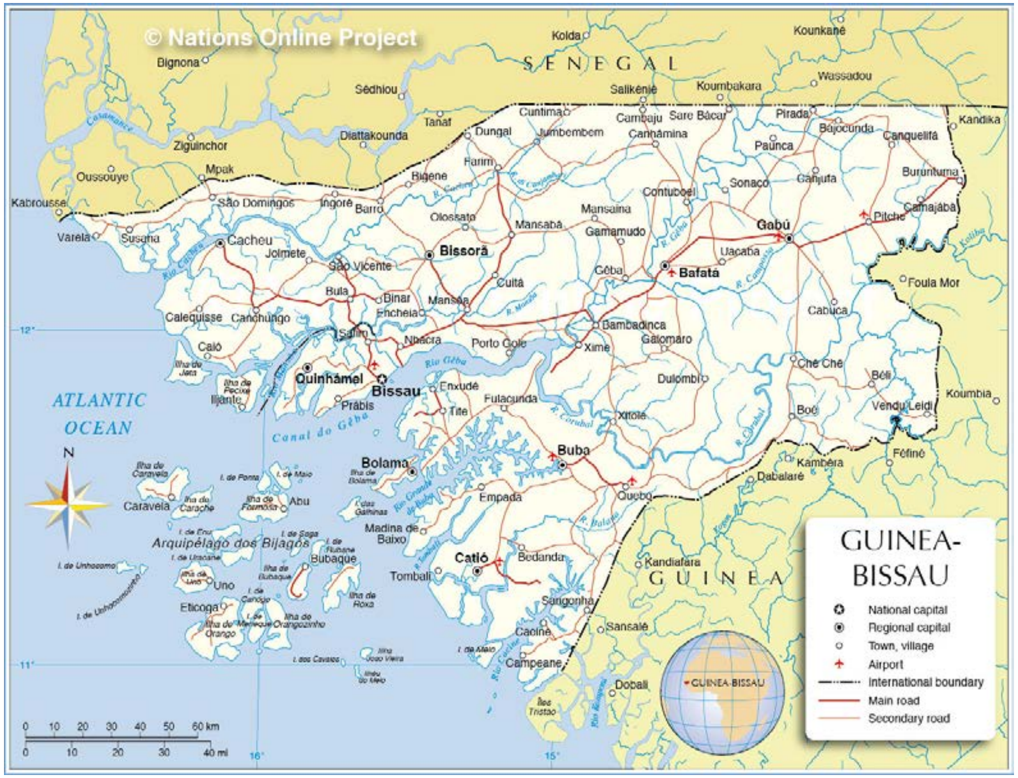
EAGB in Guinea Bissau

- **Progress expected in the coming years are really little.**
- **Two main challenges :**

1- Improve maintenance of the generation facilities :

- **A simple CMMS**
- **Rigorous management.**

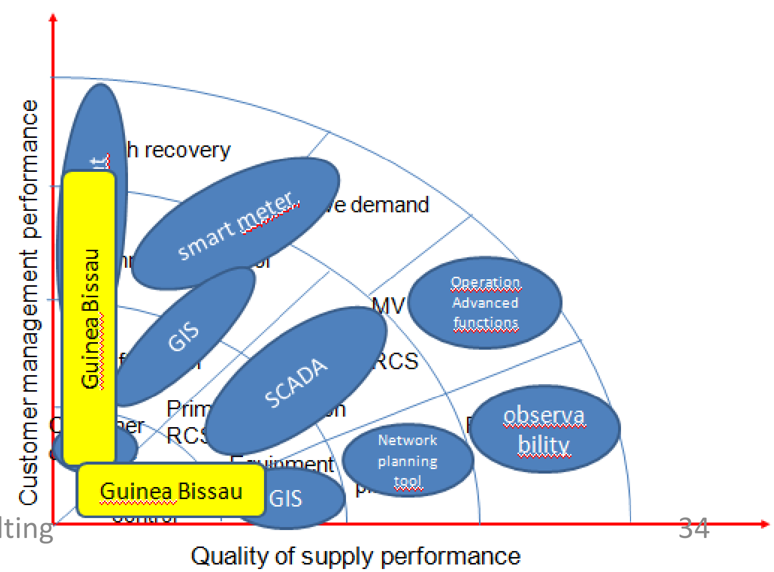
2- As a priority, improve recovery rate.



EAGB in Guinea Bissau

- **Then, other challenges need to be addressed :**
- **A protection plan :**
- **Mapping :**
- **Diagnosis of underground networks :**

- **Possible contributions from smart grids :**
- **Data base for infrastructures**
- **Metering data base management**
- **Instrumentation**
- **Protection plan.**



Guinea Conakry

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❑ **Weaknesses and priority actions :**

➢ **Priority to new meters for all customers**
- **Prepayment meters for LV customers**
- **Electronic meter with reactive power**

➢ **A better knowledge of infrastructure components:**
- **Implementation of a data base**
- **Management tools for maintenance**

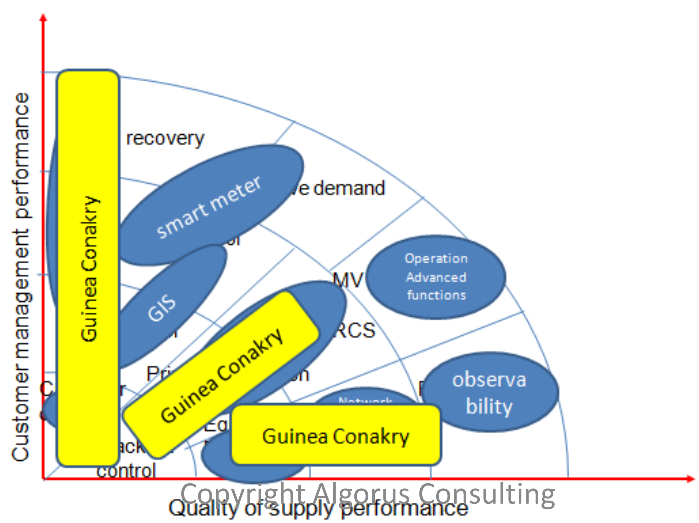
➢ **Update of the protection plan**

Define a medium-term target, using a smart grid approach.

Guinea Conakry

- ❑ **Good example to analyze ex post consequences of funded programs :**
- **No real management of technical choices by EDG in the different projects.**
- **Operation.**
- **Insufficient involvement of EDG in defining the projects upstream.**

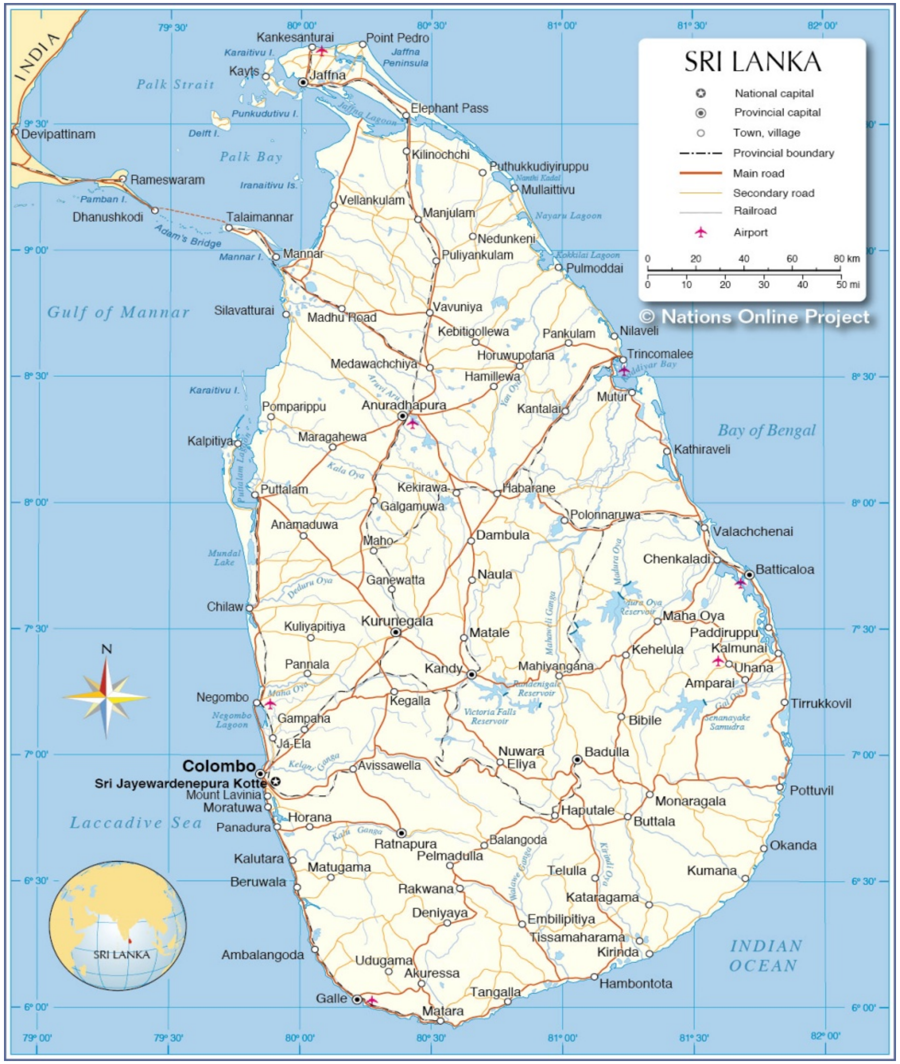
- ❑ **Indispensable prerequisites for an effective project integration.**



Sri Lanka

- CEB serves around 5.6 million customers with a peak of 2,400 MW.
- SCADA
- GIS
- Smart meters

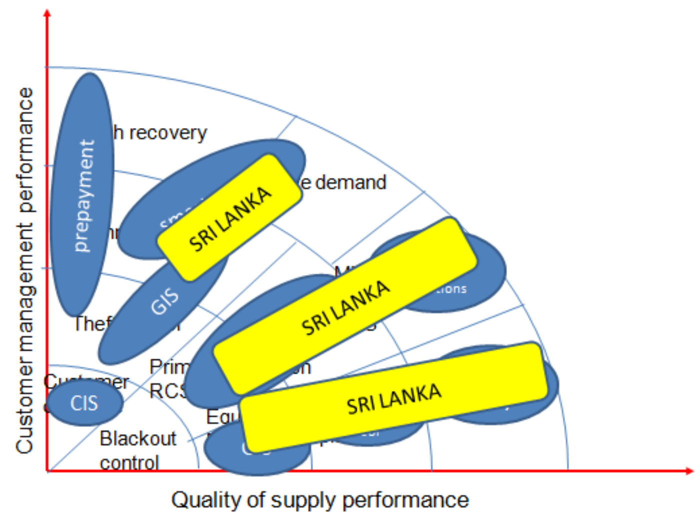
- **Deploy 12 SCADA :**
- This can lead to a significant overinvestment.



Sri Lanka

➢ **Deploy GIS :**

- **MV or LV+MV networks ?**
- **Which IT tools with GIS?**
- **How to organize the update ?**



➢ **Deploy smart meters :**

- **What is the desired functional framework ?**
- **What strategy for operating control rooms?**

❑ **Excellent example of the way smart grids should be customized.**

❑ **CEB will also work on the protection plan and will prepare the integration of RES.**

Gabon

- ❑ **Audit realized at the request of SEEG after major incidents leading to blackouts.**

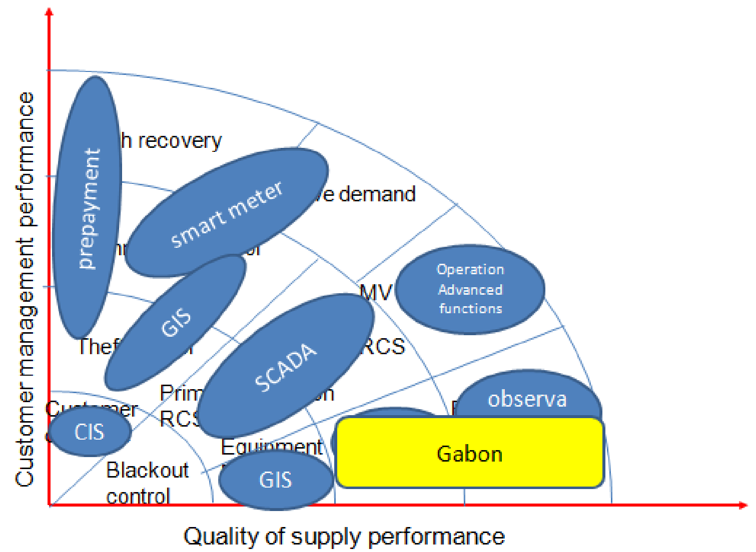
- ➢ **Causes have been identified:**
- \- **Failure of the primary reserve**
- \- **Incorrect setting of power group regulation**
- \- ***Defective* protection Plan**

- ➢ **Due to :**
- \- **Insufficient knowledge of the network components**
- \- **Inadequate maintenance**
- \- ***Inadapted* network operation management**

Gabon

❑ **Contribution from Smart grids :**

- **Faster automation**
- **A protection plan**
- **A database**
- **Organization of the maintenance.**



Comoros Islands

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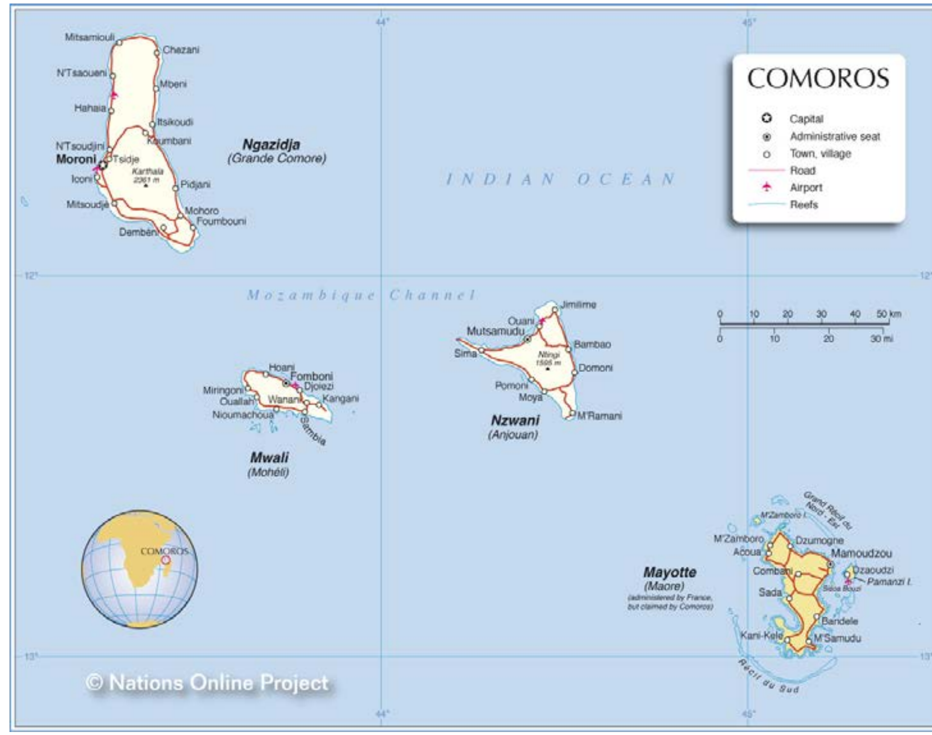
- ❑ **Comoros Islands : a small network and less than 100 000 customers on each island**

- ❑ **Weaknesses are threefold:**
- **Lack of generation and maintenance**
- **Inability to provide selectivity of protections**
- **Defective customer management**

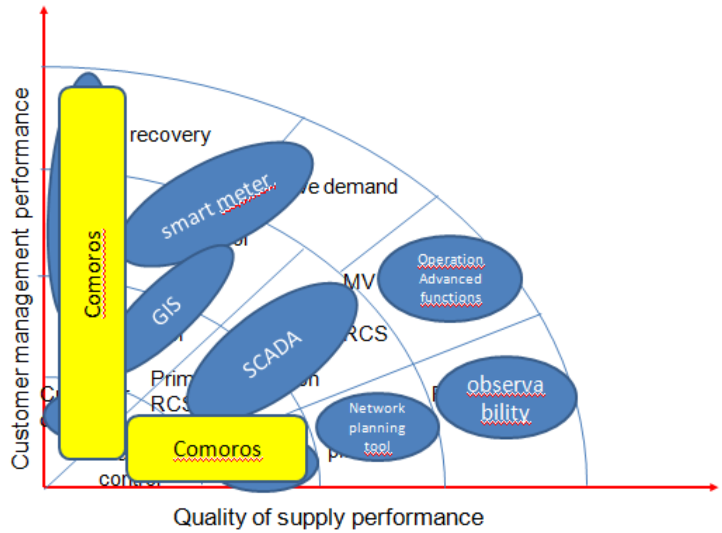
- ❑ **Very limited skills.**



Comoros Islands

❑ **Urgencies :**

- **Metering and Billing**
- **Database**
- **Protection plan**



❑ **Contributions from Smart grids :**

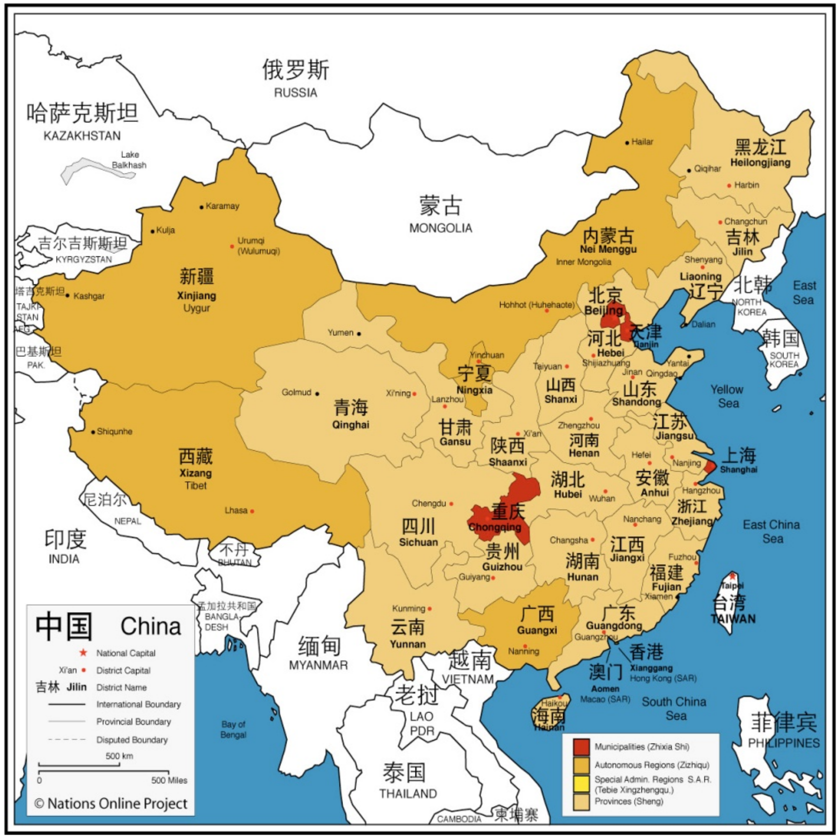
- **Support for protection plan.**
- **Support for system mapping.**
- **Support for the integration of RES (PV, wind and geothermal energies).**

China

- ❑ **Numerous audits at the request of major Chinese companies**

- ❑ **Assessment of the performance of the electrical systems :**

- **Control of network development, planning, technical choices**
- **Operation, maintenance**
- **Information systems**



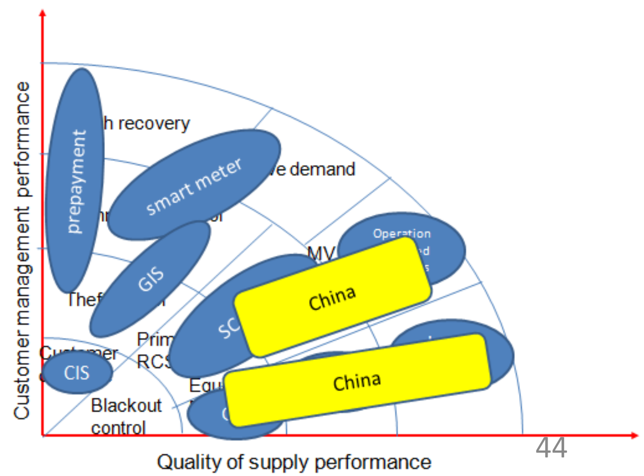
China

- ❑ **The observations are quite similar to one another:**
- **Good technical choices but not optimized**
- **Operation based on old principles**
- **A well developed instrumentation**
- **Insufficient automation**
- **Advanced information systems but lack of IT masterplan**

- ❑ **Lack of system control and strong dependence on manufacturers**

- ❑ **Contributions from smart grids:**
- **Mapping and GIS**
- **Network remote controls and advanced functions**
- **Maintenance support**

- ❑ **Insertion of distributed generation (preparation)**

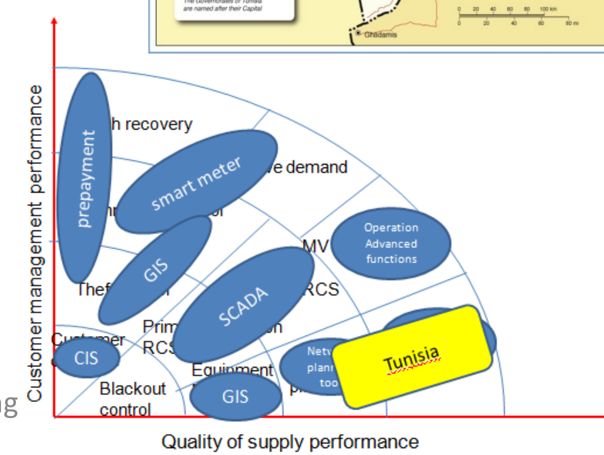


Tunisia

- ❑ **Preparing for the aftermath of "natural gas" :**
  - **Set up a governance**
  - **STEG (the national company) slows the arrival of these new players**

- ❑ **Smart grids pilot projects conclusions :**
  - **Define technical principles of connection and operation.**
  - **Provide protection plan settings tools.**
  - **Provide guidance on observability.**

- ❑ **Anticipation is key**



Morocco

- ❑ **Audits carried out in Morocco in 3 local utilities (Rabat, Tangier and Tetouan)**

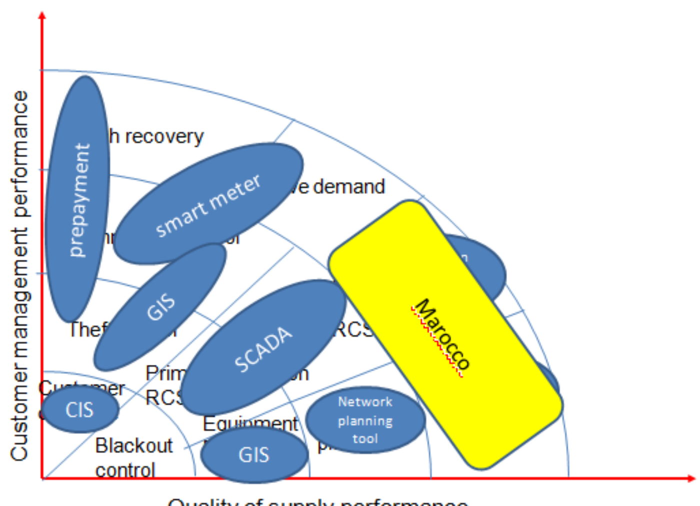
- ❑ **Four Main conclusions :**
  - **A metering strategy**
  - **Adaptation of the protection plan**
  - **Strengthening of MV feeders**
  - **Modernization of database and CCMS management**

Morocco

- ❑ **Projects all in the scope of smart grids:**

- **Smart meters.**
- **Protection Plan and automation.**
- **Database and software assistance to performance management.**

- ❑ **Currently, the integration of RES is not a concern for the operator**



Russia

- Four audits in Russia (Tomsk, Ekaterinburg and Samara)

- Similarities :

- Old assets and important needs for upgrading
- No investment master plan
- Working methods do not benefit from the recent progress.
- Modern tools (SCADA, Call centers) associated to an existing but non-integrated organization.

Russia

- ❑ **Russian electrical systems are natural candidates for the integration of smart grid functions with some key objectives:**
- **Modernize operations**
- **Improve knowledge of network components**
- **Anticipate an important action in skills development**