On Power System Paradigm Opportunities and Challenges

An African Perspective
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Introduction
Africa has ambitious targets

Sustainability goes beyond RES integration: Installing PV’s while the system is not reliable nor cost-efficient is not sustainable on the long run!
Where to head?

**External Constraints**
- Extreme growth in **power demand**
- Impressive demographic growth
- Need for access to electricity and **higher living standards**
- Lack of attractiveness for investors
- Limited **financial resources**
- Tariff reduction and **loss of revenue**
- **Climatic challenges** and scarcity of conventional resources
- Need for transparency and **long term vision**

**Internal Constraints**
- Low grid **reliability** and Lack of **generation adequacy**
- Lack of usage of interconnections
- Management of both old and brand **new infrastructures**
- Missing **Observability** and information
- High diversity of existing and new **infrastructures**
- Large territorial areas lacking **harmonization**
- Need of electrification of **rural areas**

**Possible Visions…**

**Bulk System Development:**
- Asset management strategy
- Cross-border interconnection
- HVDC based backbone network
- Energy Market and balancing Integration
  - Cost-efficient System Adequacy
  - Benefit from high RES potential regions
  - Social welfare maximisation

**Decentralized System Development:**
- Asset management strategy
- Production closer to demand
- Smaller RES integration
- Microgrids dominant electrification vector
  - Cost-efficient RES integration
  - Cost-efficient rural electrification
  - Rural economic development

• Low grid reliability and Lack of generation adequacy
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• Need of electrification of rural areas
The electricity sector must evolve to fully leverage sustainability

**EGI’s Framework encompassing electricity system paradigm**

- Energy Policies
- Energy Market Reforms
- Finance & Business Models
- Grid Access & Infrastructure
- Market Design & Flexibility
- Network Operations
- Strategic Targets
  Policies ensure that long-term objectives are met
- Structural Reforms
  Reforms pave the way for targets implementation
- System Transformation
  System evolves with increasing RES penetration

There is no **miracle standard approach**, every country have its own characteristics a systemic approach is needed to leverage sustainability in transparent, flexible and cost-efficient manner.
Setting strategic targets
Set targets efficiently

Why co-shaping strategic targets?

Create RES policies to meet objectives

1. Answer „the why“, „the what“, „the when“, „the which“ and „the how“ to create RES targets:
   - Electrification targets
   - Diversification of the energy portfolio
   - Cross-border market integration
   - RES penetration targets (utility/distributed)
   - Public private partnership

Against Long-, mid- and short-term

1. Break down goals and directives into concrete laws and allow
   - Adjustments on local fit
   - or readjustments after time
Re-designing of the power sector
Why consider legislative structural reforms?

Introduction of competition: *stimulate fair & competitive energy prices*

Increase efficiency of the network: *Sharpen the focus of each business, clearer incentives to improve business (regulation), Transparency*

Enabling privatization and new investors

Opening to new entrants

Introduction new technologies

While minimizing drawbacks

*Transaction cost, Investment risk, Lost economies of scales and scope*
Structural reforms to leverage RES integration

1. Opening to investors
   - Application of PPA to IPP
   - From PPA to open market-based investments

2. Attract investors by ensuring support schemes
   - Demand pull, such as tendering
   - Supply push, such as tariffs
   - RES leasing schemes

3. Decide how to manage generation
   - Is there a need to create/adjust markets structures?

Investor engagement

- G
- G
- IP

Support schemes

- Fixed feed in remuneration vs. tender

Manage generation

- TSO
- New markets?
- RES plant

Legislative measures

Fixed feed in remuneration vs. tender

New markets?

RES plant
Transformation of the power system
System transformation: when RES integration increases, new challenges need to be mastered.

**Phase 1**
- Renewables as a niche

**Phase 2**
- Renewables as major player

**Phase 3**
- Renewables as dominant player

Operational procedures and data management

Generation forecasting blueprint

System flexibility

Grid reinforcement

Controllability of RES

RES contribution to ancillary services

Full steering of RES

Grid Code requirements

Time (years)

0% RES

10-40% RES

>40% RES

Asset Management

Operational procedures and data management

Generation forecasting blueprint

System flexibility

Grid reinforcement

Controllability of RES

RES contribution to ancillary services

Full steering of RES

Grid Code requirements

Time (years)
European perspective on future infrastructure

Until 2000
Central generation

2000 – today
Rise of decentral generation

Tomorrow?
Rise of decentral islands

Grid capacity needed to deliver energy from central power plants

Grid capacity needed to...
- ...evacuate excess energy when low consumption
- ...deliver energy when there is no wind or sun

Grid capacity needed when...
- ...stored energy is insufficient to meet demand (e.g., winter)
- ...production exceeds storage capacity (e.g., summer)

Both transmission and decentralized investments are needed in Europe
RES and grid development the German example

Development of 3 North-South HVDC corridors
Reinforcing backbone transmission network
Reinforcing cross-border interconnections

Till 2025:
~ 25 GW
~ 20 GW

Increasing transmission need (25 GW)

Massive DG RES (currently more than 1.6M small units)
Substantial investments at distribution level

System transformation
Pan-European: Network Development Plan

System transformation
1. **Balancing and frequency control**
   - Volatility and poor predictability challenges forecasting
   - Lack of conventional regulating units changed structure of control power and participation

2. **Coordination**
   - Operational challenges with scattered generation resources: complex real-time data management
   - Lack of observability at lower voltage levels

3. **Voltage control**
   - Lack of Voltage regulating units and
   - Voltage during low demand and high RES infeed

4. **Angular stability**
   - Lack of rotational inertia and higher RoCoF
   - Lower short-circuit level and angular stability issues

5. **Grid congestion**
   - Congestion impact – due to distance between generation and load as well as in the distribution level
New generation trends and impact on operations

Synchronous injection

Non-synchronous injection

Large Generators

DG RES

Regulating Generators

HVDC

Storage, DSM

Non-synchronous injection

This reduces system inertia and short-circuit power;

Load Frequency and voltage control capability issues;

Angular stability: loss of synchronism of the remaining synchronous generation.

Scattered distributed generation

Increase the complexity of real time system controllability and operational planning;

Increase the data management for real time operation (observability) and grid development.
Harmonized state of the art grid codes

RES enhancing system not a burden

Controllability of active /reactive power to address congestions and participate in ancillary services

Maintain system robustness: FRT capabilities, fault-current support

Decentralized emergency and restauration functions (islanding, black start…)

Integration of new market players and leveraging flexibility

Demand units as significant Grid User

Level playing field for ancillary services: Voltage support Balancing and frequency support

System transformation
Microgrids leveraging cost-efficient integration of RES

System benefits

- Network resilience and security of supply for strategic infrastructures (hospital, communications..)
- Local voltage and frequency stability support for weak networks

Financial benefits

- Savings on grid development to cope with increasing demand;
- Accommodation of higher RES penetration rates closer to demand.

Potential both in Europe and Africa
The first challenge of African utilities is to deploy electricity infrastructures but the biggest and real one will be to keep these infrastructures running for decades on their own.

**Challenge #1**
Commission numerous infrastructures over a short period of time

**Challenge #2**
Operate, maintain and renew numerous infrastructures over a long period of time
Best practices to improve their performances in each key area of AM

- Proactive maintenance
  - Life cycle modeling, costing & reporting
  - OPEX vs CAPEX decision

- Disposal strategies
  - Life time estimation models & health indexing
  - Total cost of ownership
  - Risk-based capital investment plan

- Risk-based decision making embedded in all processes
  - Risk register
  - Assets criticality ranking
  - Link with corporate risk

- Level of service performance indicators
- Stakeholders consultation (suppliers, clients, shareholders, …)
  - Assets performances monitoring & benchmarking

- Reliability monitoring
  - Failures root causes analysis
  - Performances monitoring & benchmarking
  - Technical reviews & audits

- Risk-based decision making embedded in all processes
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- Whole life cycle management
- Competences management
- Technological watch
- Experience feedback and continuous improvement

- Safety, Health, Environment and Quality policies

- PAS 55 or ISO 55000 certification
- Active in CIGRE and IEC Asset Management working groups
- Stakeholders consultation

- Grid performance
- Asset performance
- Legal Compliance
- Sustainability
- Social impact
- Image
... and can demonstrate significant benefits through implementation of asset management

1. 15-35% OPEX²
2. 5-25% REPEX² ⁴
3. 10-40% Risk exposure³
4. 50% System unavailability
5. 50% Failure rate
6. 0 fines
7. Regulation incentives achieved
8. 15-25% TOTEX⁵
9. 60% Safety incidents¹
10. >Certification
11. >International recognition
12. >Credit ratings
13. >0 negative press

¹Lost time injury frequency
²While risk exposure steady
³While TOTEX steady
⁴Impact on AUGEX can be similar, but much more depending on external factors (regulation rules, accounting, …)
⁵Total Expenditures
Thank you for your attention

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