

NUCLEAR POWER & ENERGY AGENCY

Electricity Generation Energy mix in Kenya and a case study of Kenya's SMR RTA

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Kenya

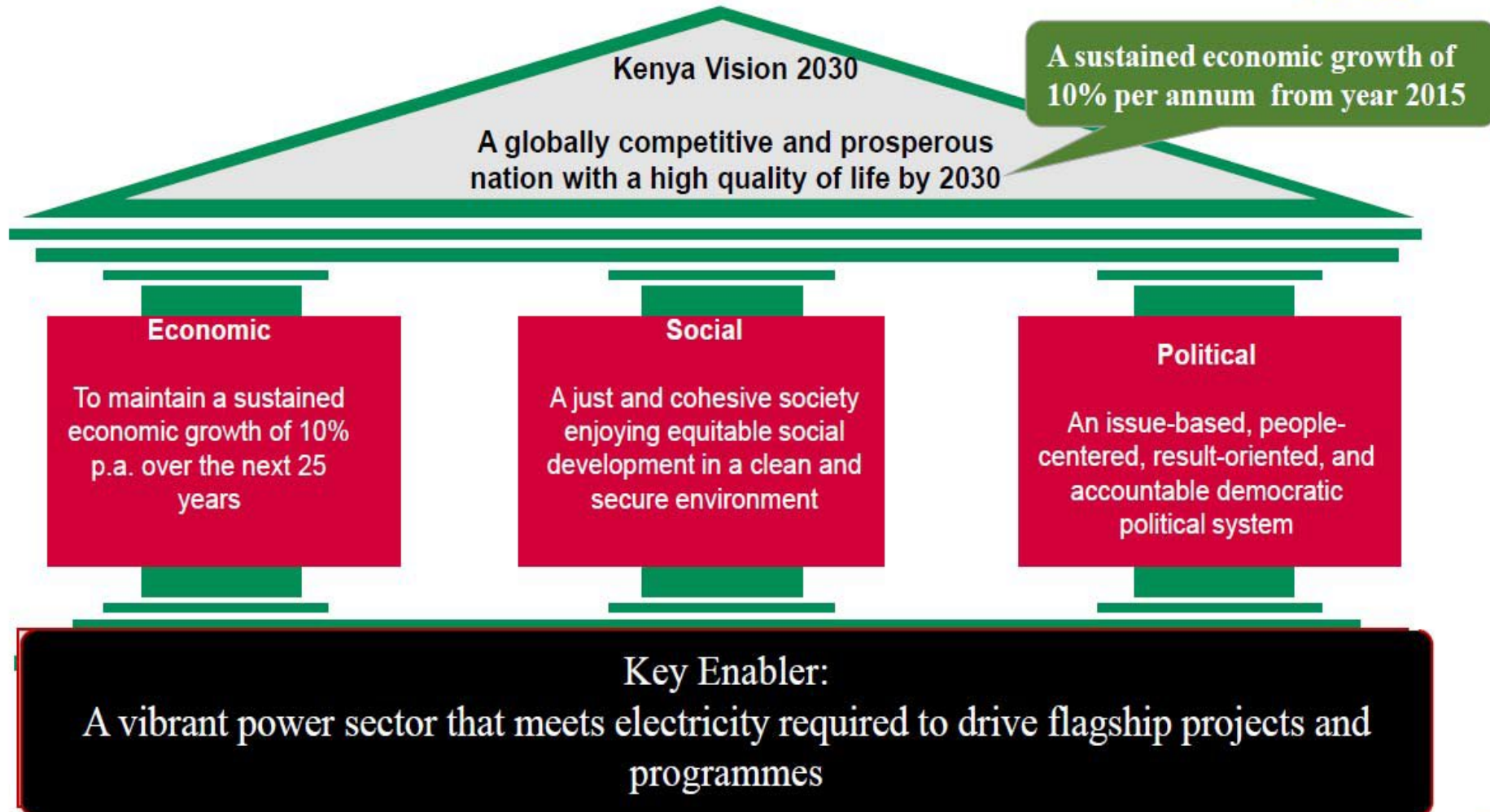
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- Location: East Africa
- Area: 581,309 Km²
- Capital City: Nairobi
- Population 48 Million (2017 Estimate)
- Governance: 47 Counties
- Official Languages: English, Swahili
- Coastline: 1420KM
- Religion: Christian (83%); Muslim (11.2%); Hindu, Bahai And Others



Kenya's vision

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Kenya Installed Capacity

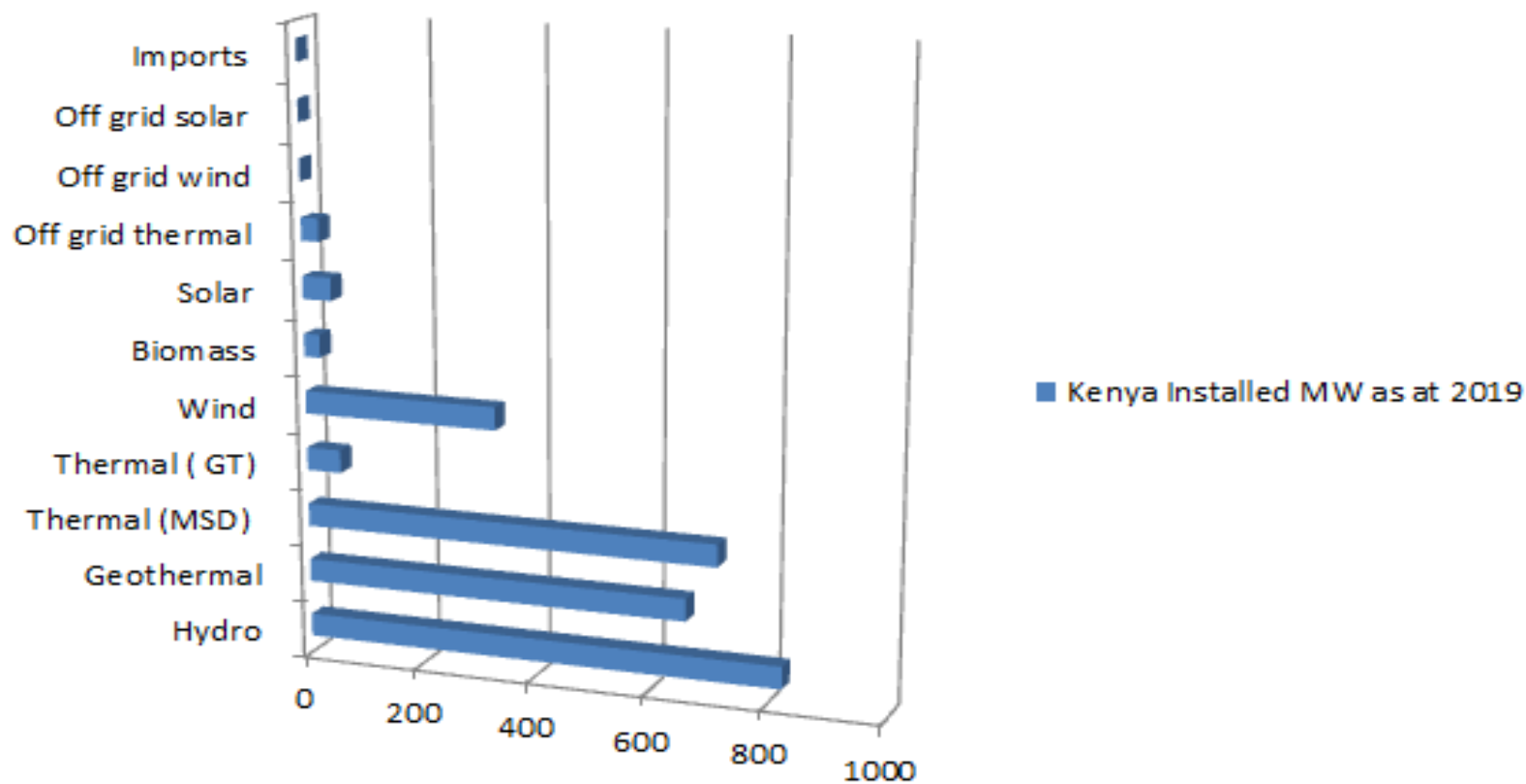
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Energy Source	Kenya Installed MW as at 2019	Share %
Hydro	826.23	30.46%
Geothermal	663	24.44%
Thermal (MSD)	716.32	26.41%
Thermal (GT)	60	2.21%
Wind	336.05	12.39%
Biomass	28	1.03%
Solar	50.25	1.85%
Off grid thermal	31	1.16%
Off grid wind	1	0.02%
Off grid solar	0.69	0.03%
Imports	0	0%
Interconnected System	2,680	98.80%
Total Capacity MW	2,712	100.00%

Kenya Installed MW as at 2019



Kenya Installed MW as at 2019



Justification for Nuclear Power



- Increased Power Demand – Kenya Vision 2030 Flagship Projects to wit;

§ ICT Park, § Container terminal / Port, § Standard gauge railway, § Iron and Steel smelting industry, § Light rail for Nairobi and suburbs

- Improve reliability and quality of electricity;

RTA Objectives



- Develop general criteria and requirements based on relevant national policy goals and objectives, and rank them with relative importance
- Identify SMR designs and technologies that are commercially available and have the potential to meet the general criteria
- Identify gaps in Kenya's nuclear infrastructure plan and development
- Identify the technical requirements and features of the technologies for analysis
- Find the appropriate & suitable, nuclear power plant designs Kenya can deploy to its national grid
- Capacity building through creation of knowledgeable workforce in reactor technology assessment

RTA Methodology



The RTA approach for Kenya is as follows.

- i. Establishment of a national competent team
- ii. Development of general criteria and candidate national policy objectives
- iii. Development of technical user requirements
- iv. Identify commercial nuclear power plant designs and their potential to meet the general criteria and technical user requirements
- v. Perform reactor assessment and ranking

Reactor Assessment and Ranking Approach



The ranking approach utilized for the preliminary RTA consisted of two main criteria:

- Exclusion/Rejection Criteria

These are the strategic requirements that reactor designs must have as prerequisites for further consideration.

- Functionality Criteria

These criteria are meant to show the ability of the reactor design to meet established user/utility requirements.

Data Analysis & Methodology



- Development of a multiple-criteria decision-making tools
Explore other tools such as the INPRO KIND-ET as a standard evaluation tool, but modified based on country specific needs (further analysis required on potential of its utilization)
- Development of a Database for Reactor Technology for both Large NPP and SMR
- Already developed and the next phase will be cloud data storage for regular updates and easier data collaboration between members of the TWG
- Vendor information (past projects) and economics data (LUEC) to be added

SMR database

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KNEB SMR Database

File Help

Export Selected Table Export Everything

File exports

Exports

All Data.csv

Core Materials.csv

Nuclear Steam Supply System.csv

Overview.csv

Reactor Coolant System.csv

Reactor Core.csv

Reactor Pressure Vessel.csv

Country

All US Canada China France India Rep. of Korea Russia EU Other

Type

All LWR Non-LWR PWR BWR HWR GCR SFR MSR

Overview of Reactors

Nuclear Steam Supply System

Reactor Coolant System

Reactor Core

Core Materials

Reactor Pressure Vessel

All Data of Reactors

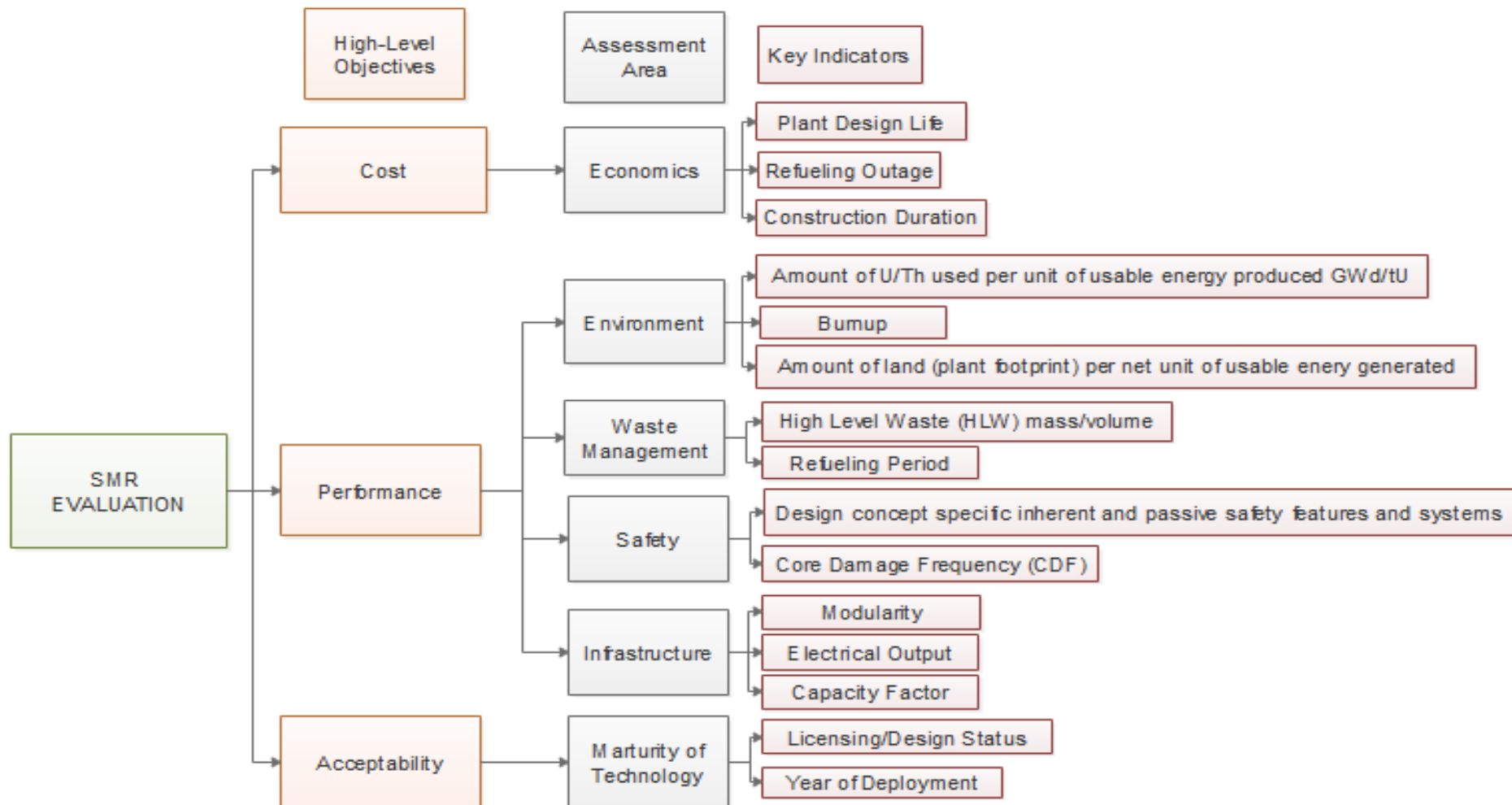
name	technology	origin	eCapacity	tCapacity	capacityFactor	life	reactorType	moderator	designStatus
CAP200	SNERDI/SNPTC	China	200.0	660.0	93.0	60	PWR	Light water	Conceptual des...
IRIS	IRIS	Internatioanal C...	335.0	1000.0	96.0	60	Integral PWR	Light water	Basic design
DMS	Hitach-GE Nucl...	Japan	300.0	840.0	87.0	60	BWR	Light water	Basic design
IMR	Mitsubishi Heav...	Japan	350.0	1000.0	87.0	60	Integral PWR	Light water	Conceptual des...
SMART	KAERI	Republic of Korea	100.0	330.0	90.0	60	Integral PWR	Light water	-
UNITHERM	NIKIET Researc...	Russian Federat...	6.6	30.0	70.0	25	PWR	-	Conceptual des...
KARAT-45	NIKIET	Russian Federat...	50.0	180.0	50.0	92	BWR	Light water	Conceptual des...
KARAT-100	NIKIET Researc...	Russian Federat...	100.0	360.0	92.0	80	BWR	Light water	Conceptual des...
ELENA	Russian Researc...	Russian Federat...	68.0	3300.0	87.0	0	PWR	Light water	Conceptual des...
RUTA-70	NIKIET	Russian Federat...	0.0	70.0	95.0	60	Pool-type	Light water	Conceptual des...
NuScale	NuScale Power ...	USA	50.0	160.0	95.0	60	Integral PWR	Light water	Conceptual des...
mPower	Generation mP...	United States of...	195.0	595.0	95.0	60	Integral PWR	Light water	Conceptual des...
Westinghouse S...	Westinghouse E...	United States	225.0	800.0	95.0	60	Integral PWR	Light water	Conceptual des...
SRM-160	Holtec Internati...	USA	160.0	525.0	98.0	80	PWR	Light water	-
ACPR50S	China Nuclear P...	China	60.0	200.0	95.0	40	Pool-type	Light water	Conceptual des...
Flexblue	DCNS	France	160.0	530.0	91.0	60	PWR	Light water	-
KLT-40S	Afrikantov OKBM	Russian Federat...	35.0	150.0	70.0	40	PWR	Light water	Conceptual des...
RITM-200	OKBM Afrikantov	Russian Federat...	50.0	175.0	65.0	40	Integral PWR	Light water	Conceptual des...
VBER-300	Afrikantov OKBM	Russian Federat...	325.0	917.0	92.0	60	Integral PWR	Light water	Licensing
ADV-BF	OKBM Afrikantov	Russian Federat...	6.0	14.0	70.0	40	PWR	Light water	Detailed design

Editor Reactor

Add Reactor

Delete Reactor

Evaluation criteria



RANKING RESULTS – Weight assignment

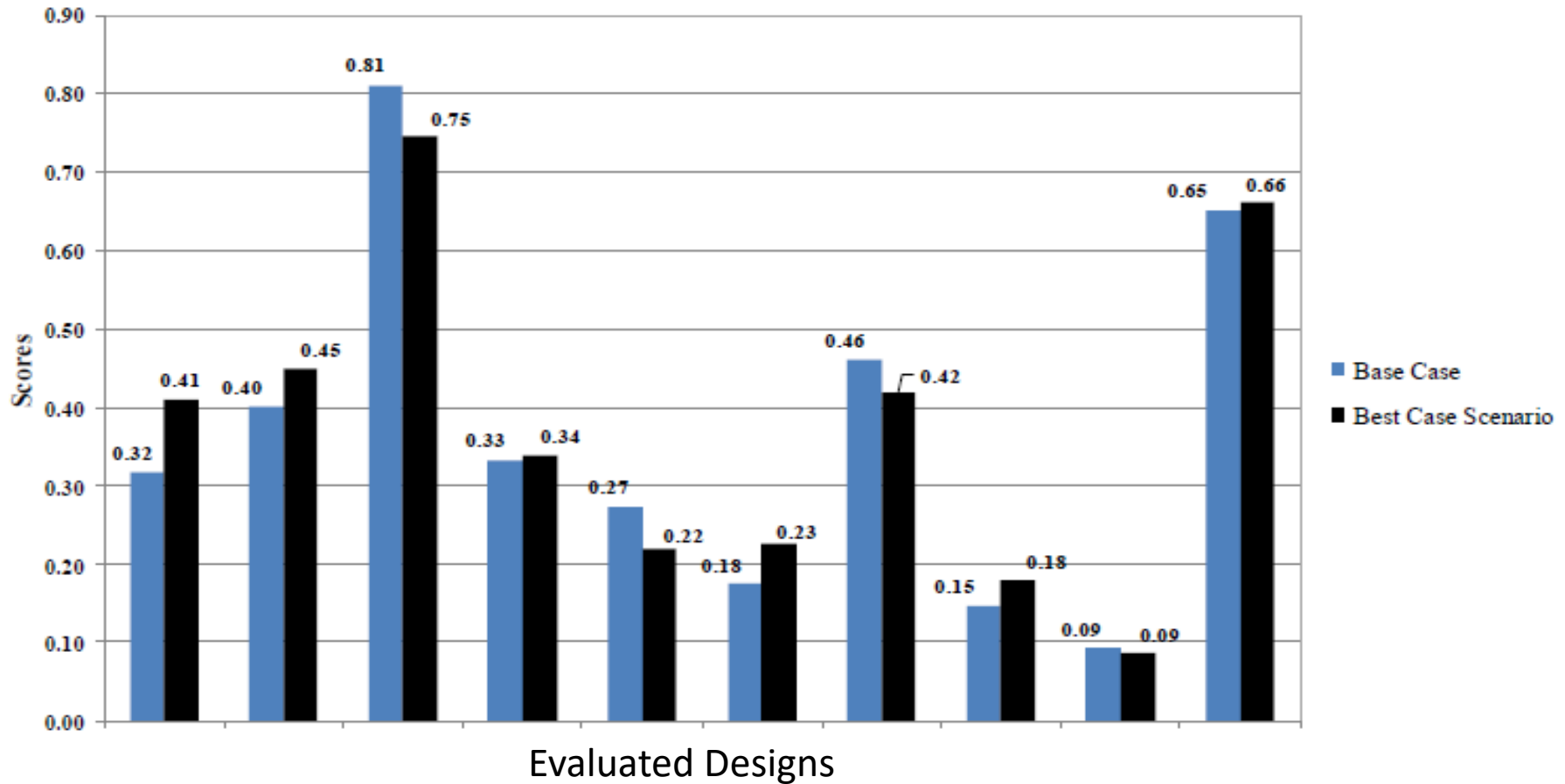
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High-Level Objectives	Base Case Scenario	Best Case Scenario
Cost	0.3	0.2
Performance	0.3	0.6
Acceptability	0.4	0.2

High-Level Objectives	Base Case Scenario	Worst Case Scenario
Cost	0.3	0.33
Performance	0.3	0.34
Acceptability	0.4	0.33

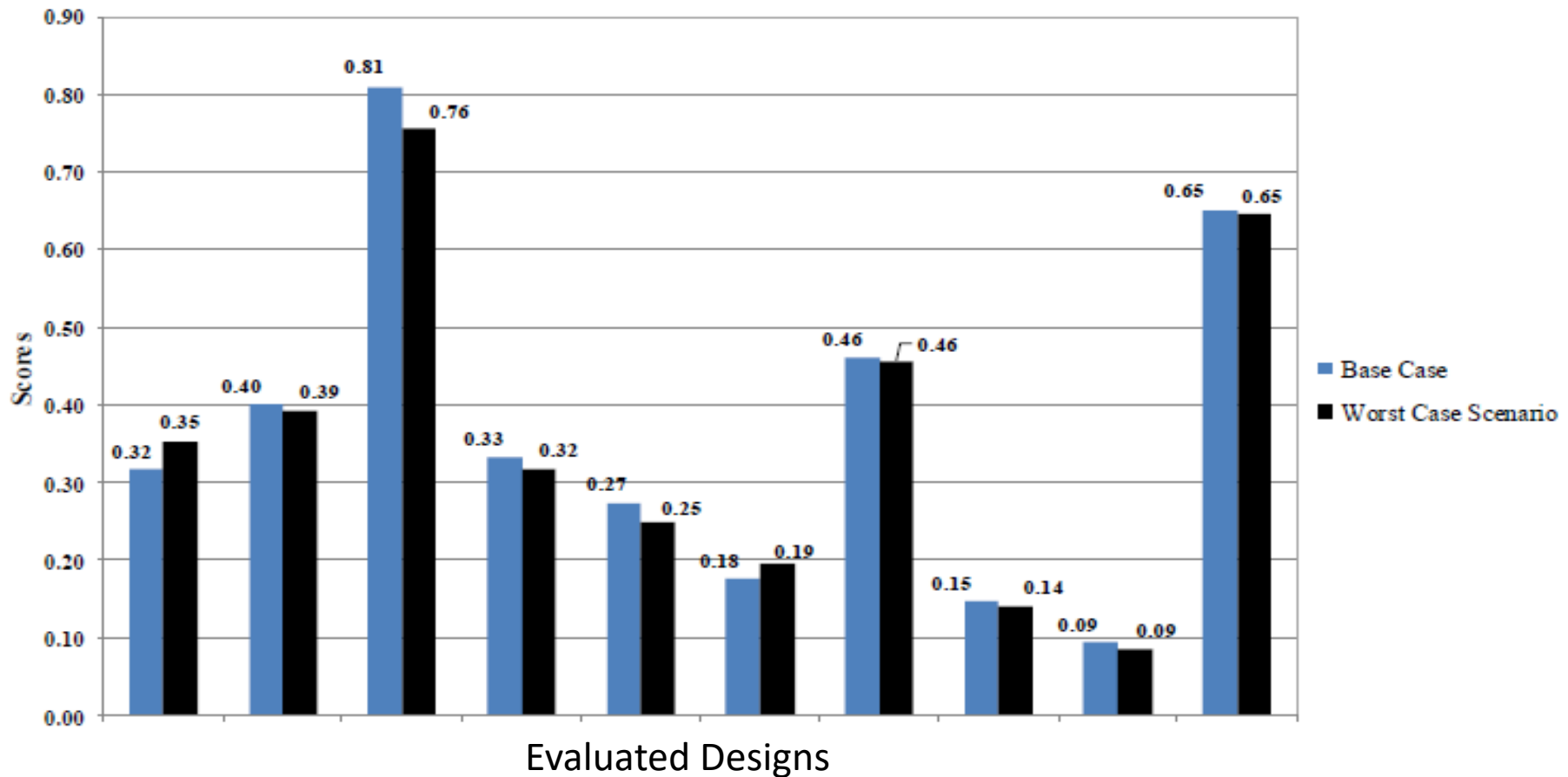
RANKING RESULTS

Best Case Scenario Overall Ranking Results



RANKING RESULTS

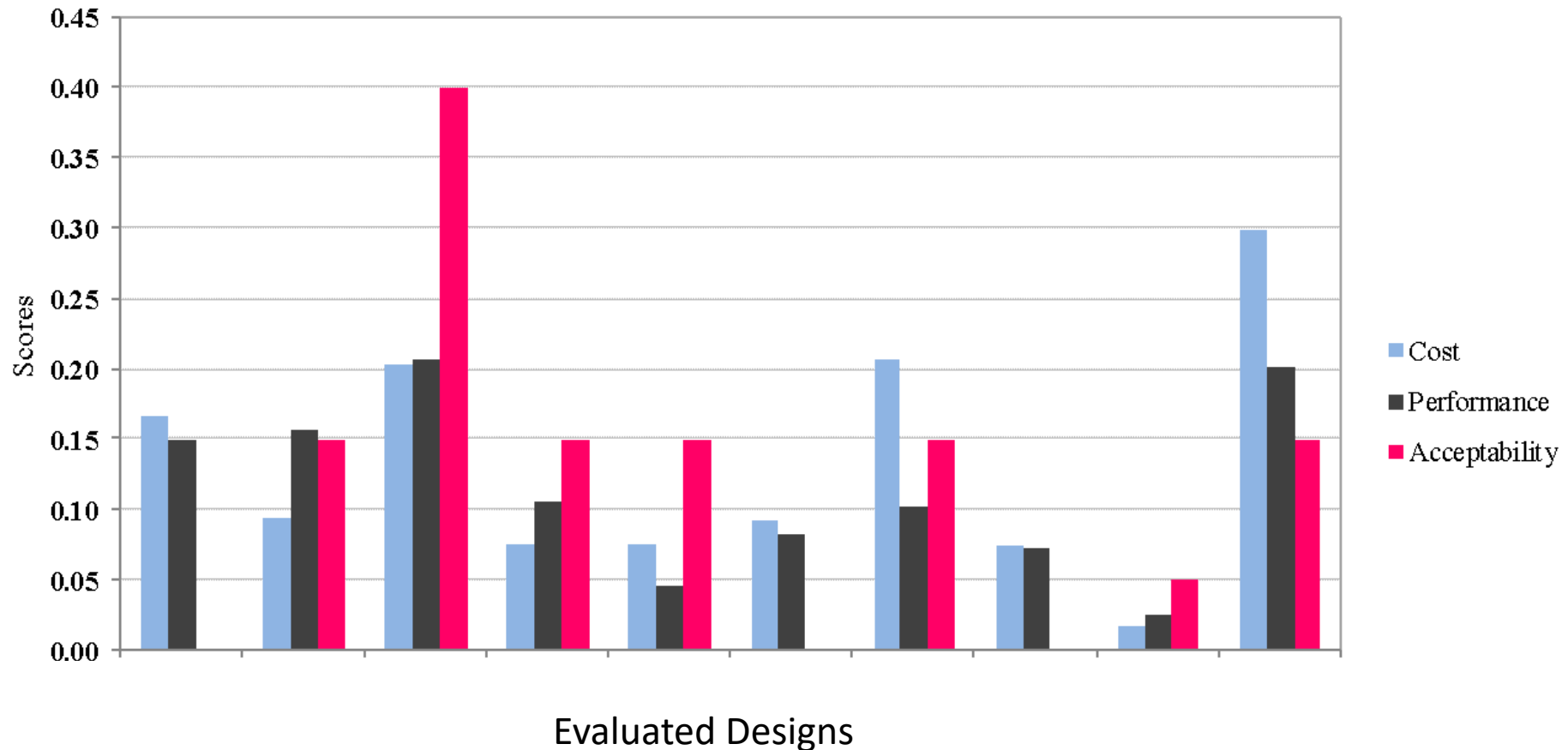
Worst Case Scenario Overall Ranking Results



How various SMRs faired wrt the high level objectives

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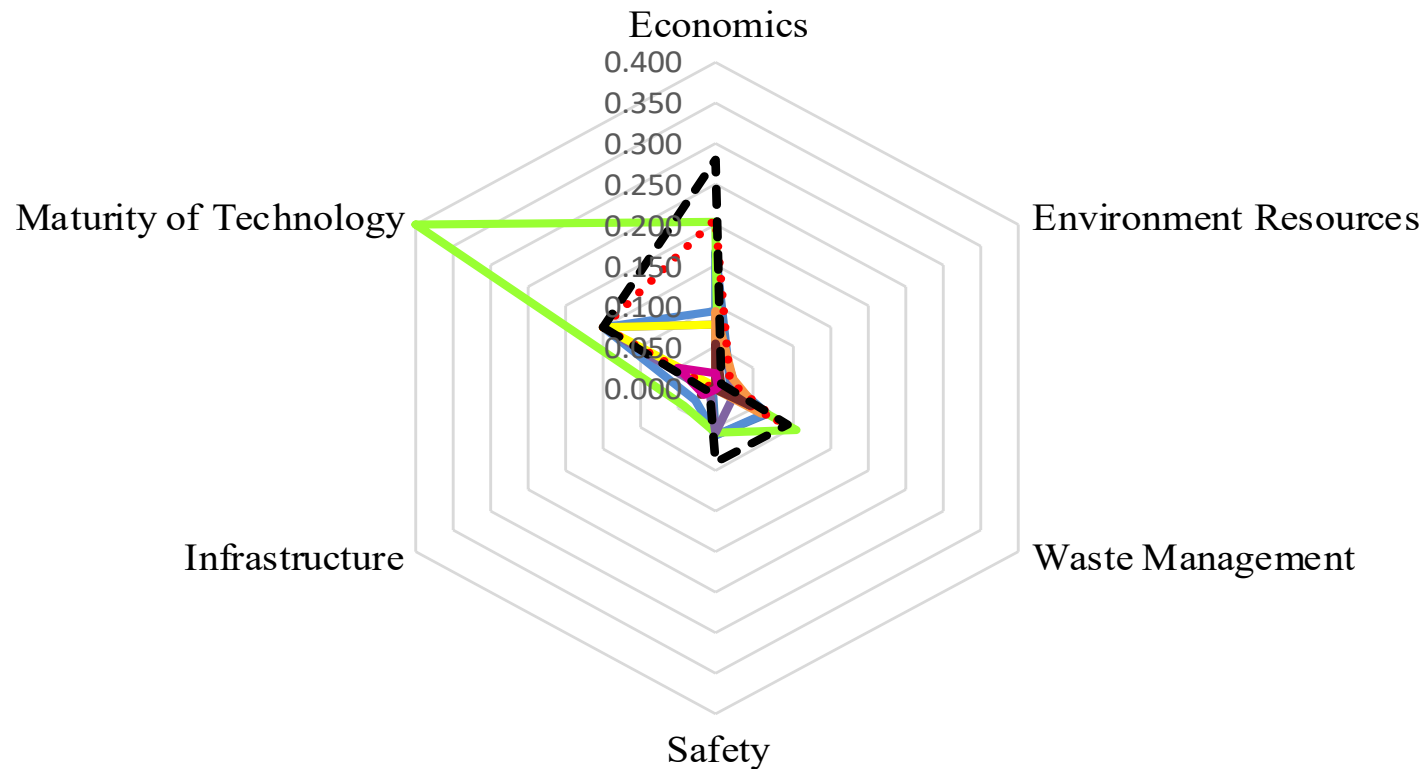
High Level Objectives Scores



How the SMRs fared wrt the evaluation attributes

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Areas Scores



Conclusion



- The sensitivity analysis confirms that the overall ranking order are generally stable to possible changes in the weights' range.
- Most of the SMRs are First-of-a-Kind (FOAK) technology and are still at the early stages of development (conceptual and design stages). Hence, intense fact finding plus careful and comprehensive analyses are required.
- Data collection was a big challenge
- The lack of information was seen to influence the outcomes significantly (it was given a zero rating)
- It is recognized that a RTA assessment is very specific for the Member State and its evaluation criteria – and that the specific results or ranking are not relevant for any other member state (that will have its own set of requirements and assigned importances)
- This initial Kenya study for SMRs may be updated as more vendor information became available

Thank you

