Power system stability improvement with Geotherm
as major source of power in Kenya

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1.Introduction

- In 2013, out of 1766.6 MW of total installed Kenya's capacity, 816.1MW (46.2%) hydropower and the geothermal energy is 250.2 MW (14.2%).
- Kenya's installed generation capacity is projected to increase to about 14,676 MW by 2030; geothermal 5,450.00 (37.13%) hydro 3,000MW (20.44%), diesel 500 MW (3.40 %), natural gas 1,500 MW (10.22%), and other sources will account for 12.32%.
- Thus, geothermal energy will be a major source of electrical energy in Kenya.

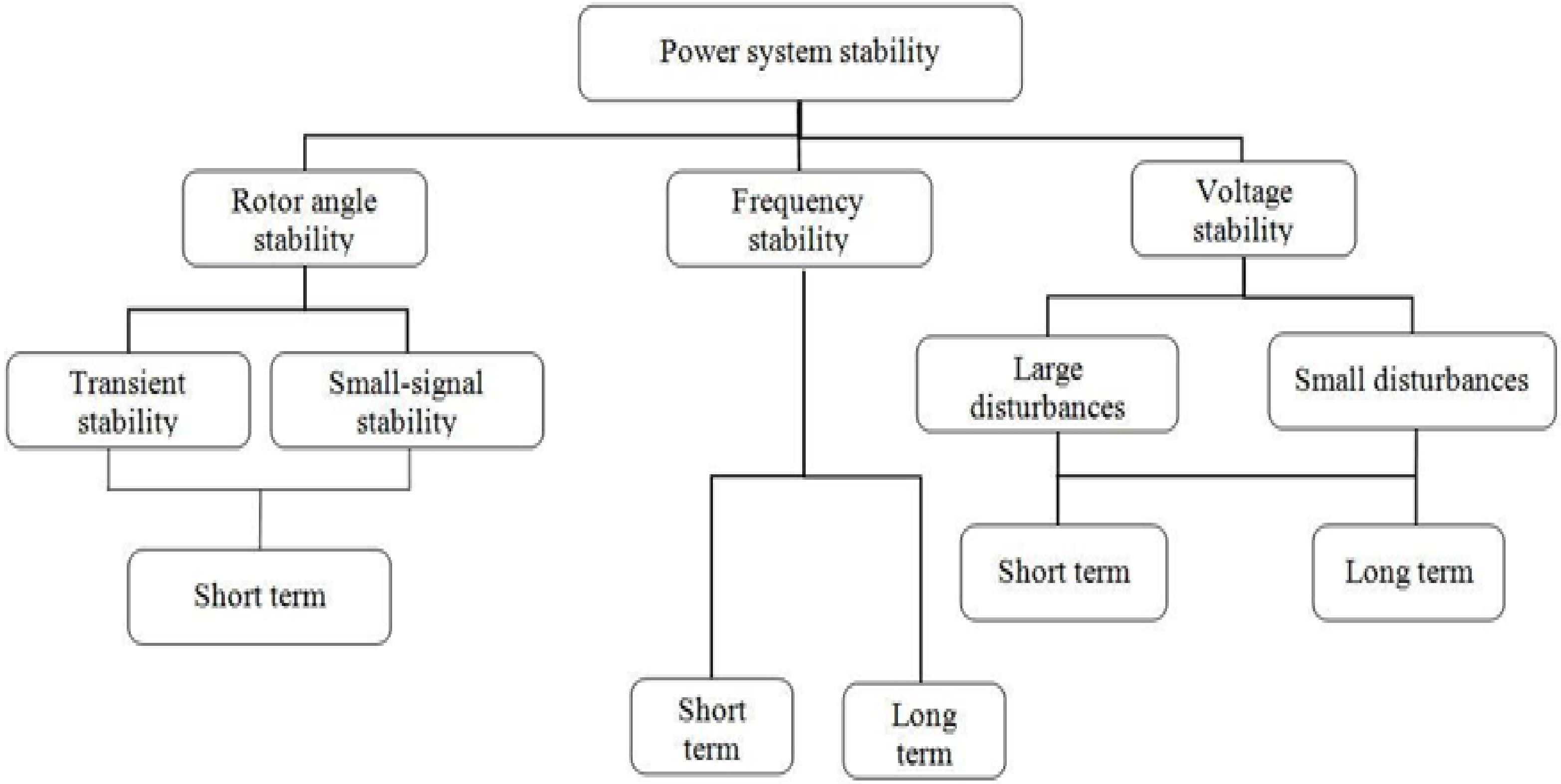
1.Introduction- cont.

- Geothermal power plants are interconnected into the Kenyan power system, hence the impact and effects on system stability/reliability need to be interrogated.
- All GPPs are mostly made of synchronous generators

2. Overview of Power System Stability

- Power system stability is that property of a power system that enables it to remain in a state of equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to a disturbance.
- Stability studies on geothermal power plants are gaining momentum amongst countries with this resource.
- Past research tends to be more focused on geothermal heat and its applications, fluid thermodynamics and environmental factors more is envisaged on electrical properties of a geothermal systems.

3. Classification of power system stability



4. Operation of Synchronous Machines

- Geothermal power plants are mainly synchronous generators
- During network transients or faults, the reactance of the synchronous generator is not constant. During disturbances, the machine reactance itself undergoes transient changes as the machine passes through the sub-transient, transient, and steady-state stages.
- An important parameter of rotor oscillations is the total moment of inertia of the synchronous machine J; sum of all moments of inertia of all rotating parts.

5. Inertias (H) of synchronous machines

- Typical values of H for different types of synchronous machines

Type of Synchronous Machine	Inertia Constant H (s)
Thermal Power • Steam Turbine • Gas Turbine	 4 – 9 7 – 10
Hydro Power • Slow (< 200 min−1) • Fast (≥ 200 min−1)	 2 – 3 2 – 4
Synchronous Compensators	1 – 1.5
Synchronous Motors	≈ 2

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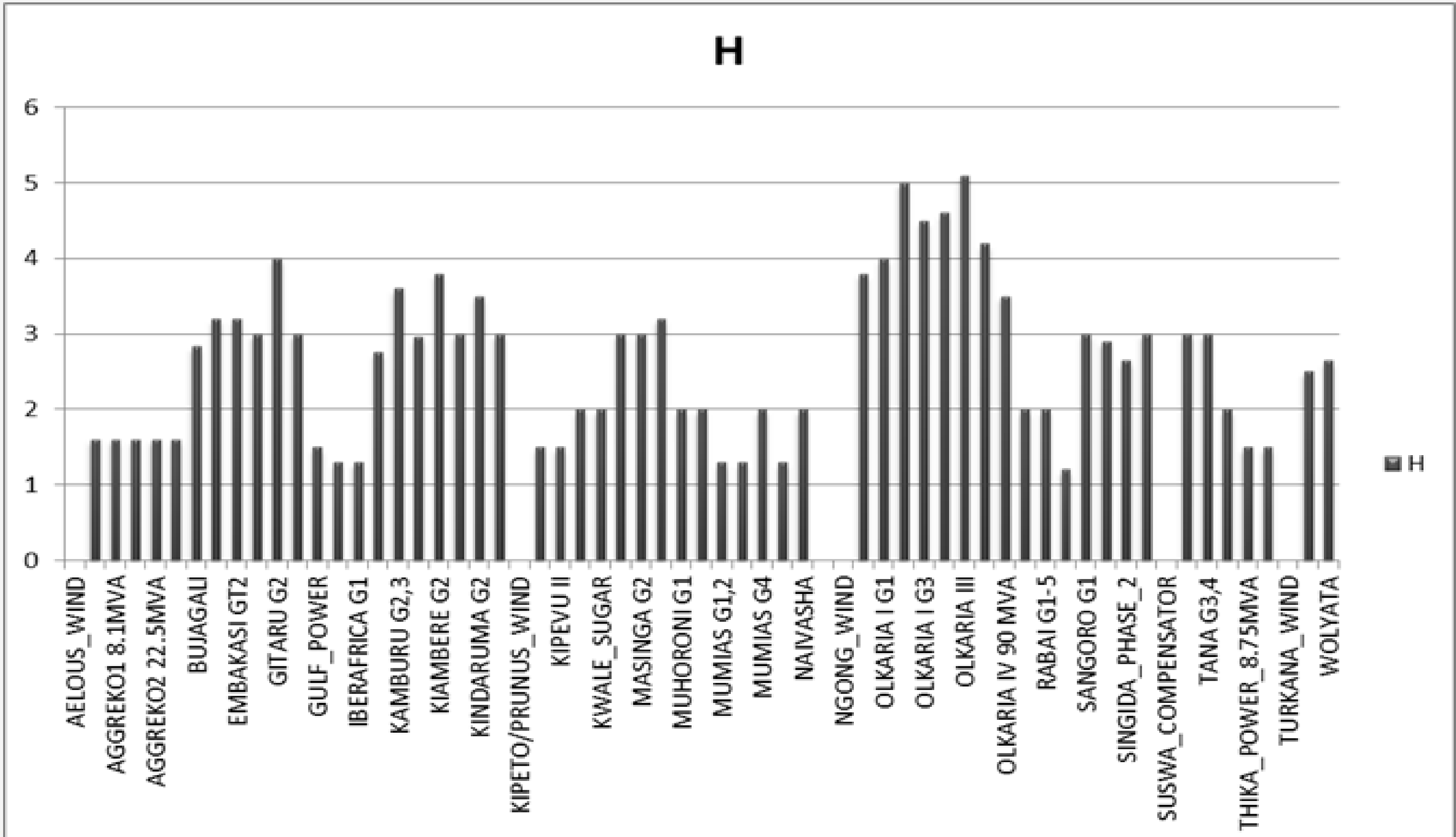
6. Significance of inertia constant in stability

- A smaller inertia decreases the critical clearing time. The reason is that the smaller the H constant the smaller the machine's peak power. A smaller peak power constrains a machine to swing through a smaller angle from its original position before it reaches the fault critical clearing angle.
- Therefore, smaller H constant decreases the critical clearing angle hence time, lowering the probability of the system to maintain stability.

7. H values for power plants in Kenya



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7. H values for power plants in Kenya

- The inertia constant of power plants in Kenya range from 1.2 to 5.1. The power plants with largest inertias located mainly at hydro and geothermal power plants.
- Hydro plants inertia constants range from Turkwel's 2.5 to 3.6 in Kamburu while GPPS have an inertia constant of between 3.1 in Olkaria 1 to 5.1 in Olkaria 3. It is evident that that inertia constant of geothermal power plants are higher than those of hydro power plants for the plants already installed in Kenyan power system. The inertia constants of the other power plants are generally low.

8. Discussions and Conclusion

- From the projections, geothermal power plants will constitute 37.13 % of total power generation, hydro 20.44% making geothermal the major source of electrical power after 2030.
- From power systems analysis, during disturbances or faults, the H constant of the machine is crucial for system stability.
- Since the constant (H) is higher for GPPs compared to with hydro generating units, Kenya’s electrical power system stability margins will increase as more and more geothermal plants are interconnected.

THANK YOU

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