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الذرية والمتجددة K•A•CARE

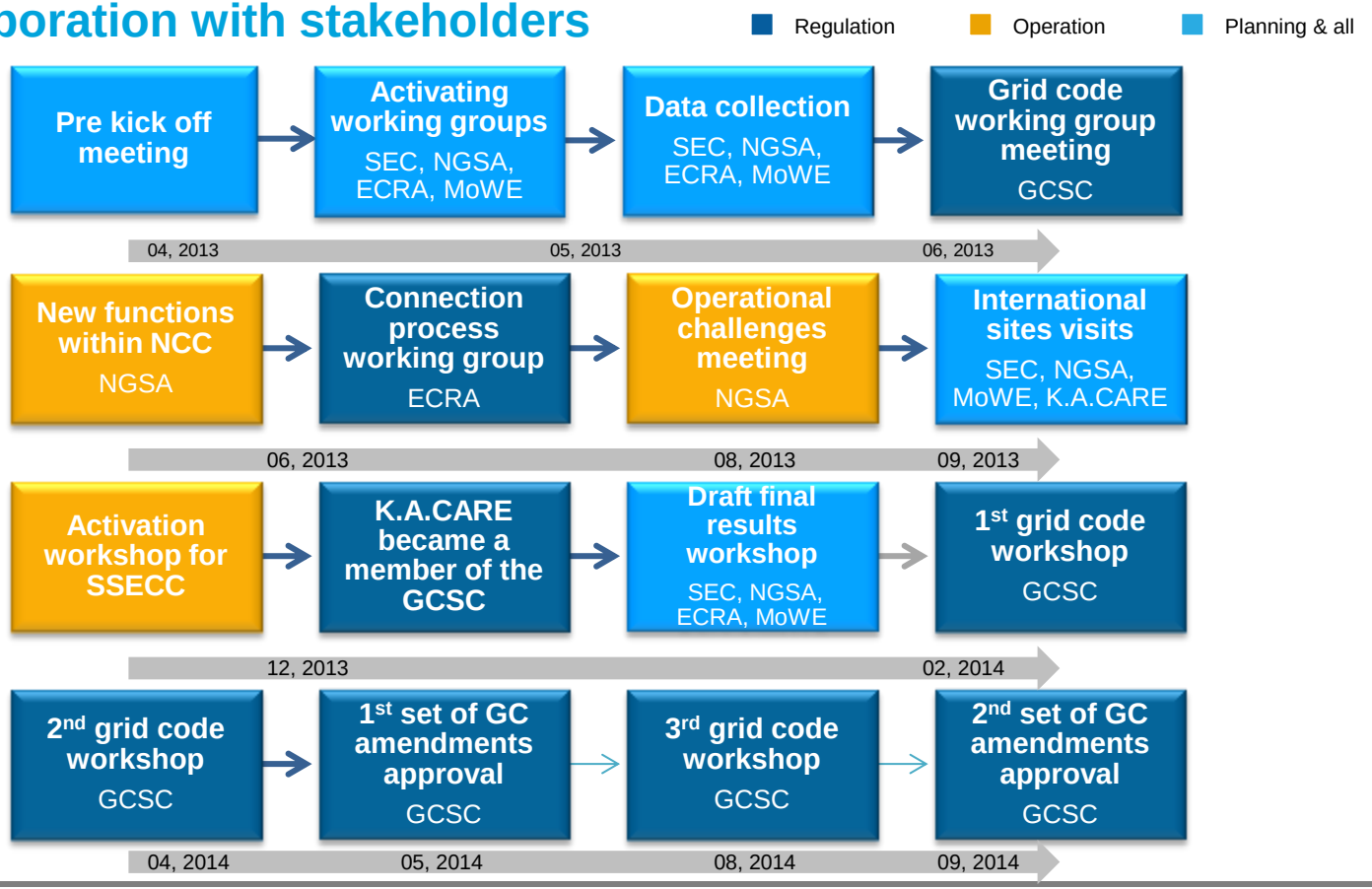
Synthesis of Grid Impact Project

Executive summary

- K.A.CARE has been collaborating actively with key stakeholders (SEC, ECRA, MoWE, NGSA) towards the future integration of renewables
- 3 major pillars are essential to build an economic, reliable, stable and sustainable system: regulation, planning and operation
- System regulation - On Sep 10th, the GCSC[1] approved the amendments to the grid enabling the integration of renewables
- System planning and operation - We believe the introduction of renewable will satisfy all planning and operation criteria
  - A study conducted by K.A.CARE[2] demonstrated that the integration of renewables will not jeopardize the system reliability
  - Planned SEC upgrades will allow the integration of ~14 GW renewables in the grid by 2020
  - K.A.CARE adopted a renewable-mix to minimize the effect of intermittencies on the system
  - Conventional units will have sufficient dispatch flexibility in winter and summer to maximize the output of renewables while maintaining the system stability and reliability
- The introduction of renewables and the multiplication of players in generation will require the creation of an independent entity to coordinate renewable plants and support the system operators
- K.A.CARE has initiated further collaboration with key stakeholders to develop the SSECC[3]

1 Grid Code Supervisory Committee
2 K.A.CARE's grid impact project
3 Saudi Sustainable Energy Control Centre

Active collaboration with stakeholders



K.A.CARE has been collaborating actively with key stakeholders towards the future integration of renewables

MoWE

- MoWE has clarified the broader KSA **electricity context and law**
  - International connections plans
  - Other long term plans

ECRA

- ECRA has clarified the **regulation framework**
  - Grid code
  - Costs allocation mechanism
  - Connection process
  - Market rules[1]

K.A.CARE Grid Impact Project

SEC

- SEC has explained the **system planning** information and requirements
  - Generation Planning
  - Transmission Planning
  - Planning methodologies and criteria
  - System modelling
  - Connection studies

National Grid SA

- NGSA has described the **system operation** and its requirements
  - Grid operation
  - Generation operation
  - Control center functions
  - Scheduling processes
  - Markets operation

1 ECRA study; Development of a Roadmap for a National Electricity Market in KSA

3 major pillars are essential to build an economic, reliable, stable and sustainable system

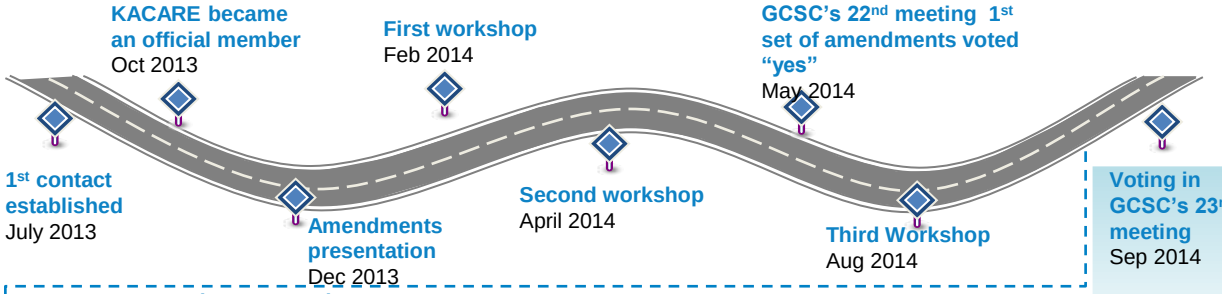
	Description	Status toward introduction of renewables
 **System Regulation**	▪ Set of rules governing the sector – Grid code – Cost allocation mechanism – Connection process	▪ Critical amendments to the grid codes were voted in Sep 2014 enabling the future introduction of renewables ▪ An active working group with ECRA has been created to follow-up progress of system regulation
 **System Planning**	▪ Long term vision of sector development – Generation mix adequacy – Transmission security	▪ Technical study regarding effect on renewable on system planning and operation finalized ▪ An active working group with SEC has been created to follow-up on system planning
 **System Operation**	▪ Day to day management of the system – generation flexibility – Grid operations	▪ An active working group with NGSA has been created to follow-up on system operation

On Sep 10th, the GCSC approved the amendments to the grid code enabling the integration of renewables

Why modifying the grid code?

- The grid code defines **obligations**, **responsibilities**, and **accountabilities** of all the parties towards ensuring **open**, **transparent**, non-discriminatory, and **economic access and use** of the grid while maintaining its safe, reliable, and efficient operation
- It was initially drafted for conventional units only, i.e. some clauses:
  - are irrelevant for renewables
  - will generate additional costs to renewables

Introduction of new amendments



On Sep 10th, the 2nd set of Amendments proposed by KA CARE were approved

8 institutions
14 votes

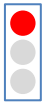
- All sets (+20) amendments have been unanimously voted YES

"This is a milestone, it has been a very long time that we haven't all agreed on so many new amendments"

– Voter

The introduction of renewables will satisfy all planning and operation criteria


Meet criteria


Does not Meet criteria

		Criteria	Assessment
System planning	A Generation reliability	▪ LOLP – loss of load probability ▪ Reserve margin – available capacity on top of peak demand	▪ ECRA criterion of 4.8h/year LOLP will be met with K.A.CARE renewable plans ▪ Min 10% reserve margin requested by SEC is also met when the LOLP is met
	B Transmis-sion stability	▪ N-1 and N-2 planning criteria – ability of the system to support single and double contingencies and stay in an acceptable state	▪ Planned SEC upgrade of the grid will allow the integration of ~14 GW renewable by 2020 without additional reinforcements
System operation	C Generation flexibility	▪ Generation ability to follow system fluctuations	▪ The increase of peak demand will require a higher ramp-up and starting rate from conventional sources[1]
	D Generation dispatch	▪ Peak (summer) and off peak (winter) behavior ▪ Must-run units dispatched ▪ Reserve requirements	▪ Must-run units will be dispatched at low load situations ▪ Conventional units will meet the spinning reserve requirements

1 Assuming PV/CSP (with storage) mix is optimized to compensate PV intermittencies on the grid
SOURCE: ECRA, SEC, KACARE study on grid impact

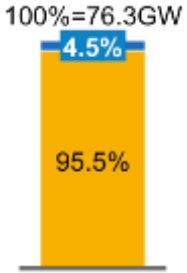
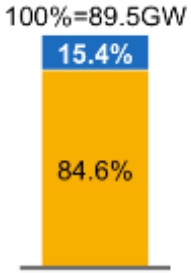
A

A study conducted by KA CARE demonstrated that the integration of renewable will not jeopardize the system reliability

Meet criteria

Renewables

Conventional

Simulated energy mix		Reserve margin Requirement at ≥10%	LOLP[1] Requirement at ≤4.8h/year
2017 simulation 70 GW peak load		~10% ✓	4.8h/year ✓
2020 simulation 80 GW peak load		~12% ✓	4.8h/year ✓

With 80 GW peak demand in 2020, reliability criteria will still be met with ~14 GW renewable integrated

1 Loss of load probability

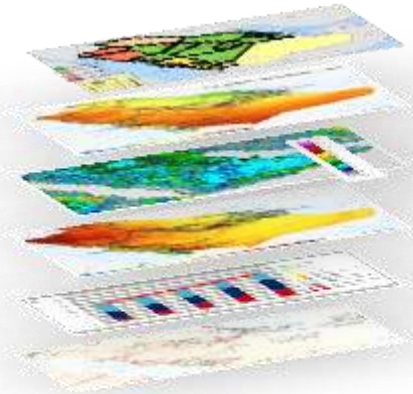
SOURCE: KACARE study on grid impact

B

Planned SEC upgrades will allow the integration of ~14 GW renewables in the grid by 2020

SEC planned upgrades by 2020[1]

- Development of 1500km HVDC transmission corridors
- Reinforcements of 380kV interconnections between operating areas
- Connection of isolated areas
- Other reinforcements inside the operating areas



Scenario of 2020 KSA grid with renewables

~14 GW renewables could be integrated in specific mode of the 2020 grid without major reinforcements

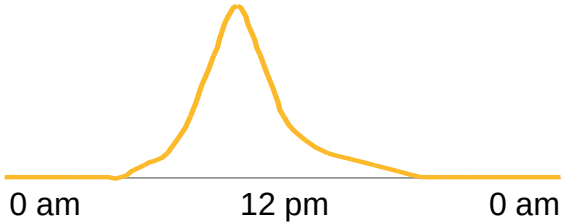
K.A.CARE adopted a renewable-mix to minimize the effect of intermittencies on the system

CONCEPTUAL

Renewable generation is intermittent

Typical PV output[1]

MW

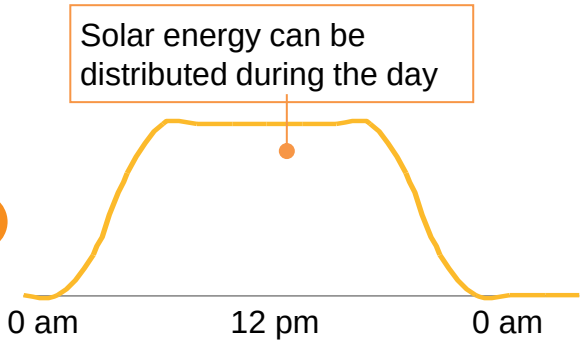


- PV do not generate energy at night
- Weather disturbance during the day could reduce energy output
- Wind power is also intermittent across the day

CSP with storage can help compensate intermittencies

Possible CSP with storage output[1]

MW



- Storage allows for a controlled distribution of energy during the day
- KSA could leverage this technology to compensate other renewable intermittencies

KSA could develop an optimized renewable mix that will minimize the need for compensation from conventional capacity

All renewables will be connected to the grid

1 During a 24hours period

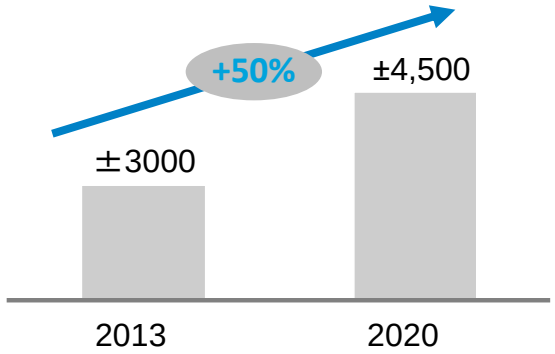
C

Hence, the increase in peak demand will be the main driver for higher ramp-up and starting rate requirement from conventional sources

Increase in fluctuations by 2020

Evolution of demand maximum fluctuation per hour

MW/h



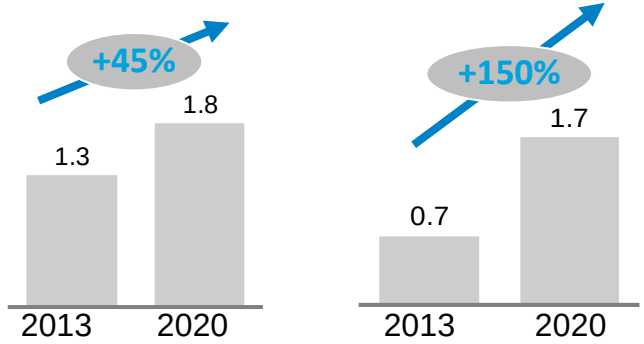
Drivers

- Major driver is the growth of peak demand
- With the optimized solar approach, renewables will play a minor role in ramping requirements[1]

Increase in start-up and ramping requirement

Average number of weekly start-up and ramping per online conventional unit

Unit per week



Implications

- Ramping and startup requirement for conventional units are going to increase

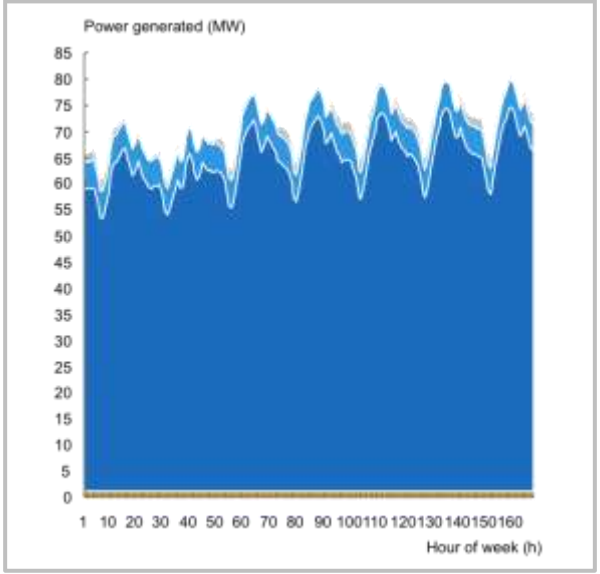
1 Assume CSP with storage in optimized to compensate PV fluctuations

SOURCE: KACARE study on grid impact

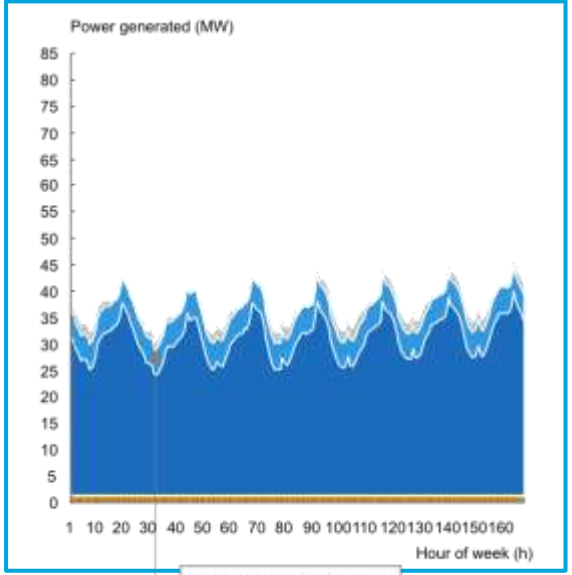
D

Conventional unit will have sufficient dispatch flexibility in winter and summer to maximize the output of renewables while maintaining the system stability and reliability

Dispatch in summer peak week 2020 with 15% renewable[1]



Dispatch in winter off-peak week in 2020 with 15% renewable[1]



Wind
Hydrocarbons (conventional)
CSP/PV block
WTE & Geothermal

- If the objective is to maximize renewable output and minimize conventional unit for remaining demand
  - Conventional units offer sufficient flexibility for summer peak week
  - Minimum must-run of conventional units will create a 1.8 GW excess in winter off-peak
- The latter can be mitigated with tailored maintenance schedule

1 Assuming all renewable units are online in both seasons

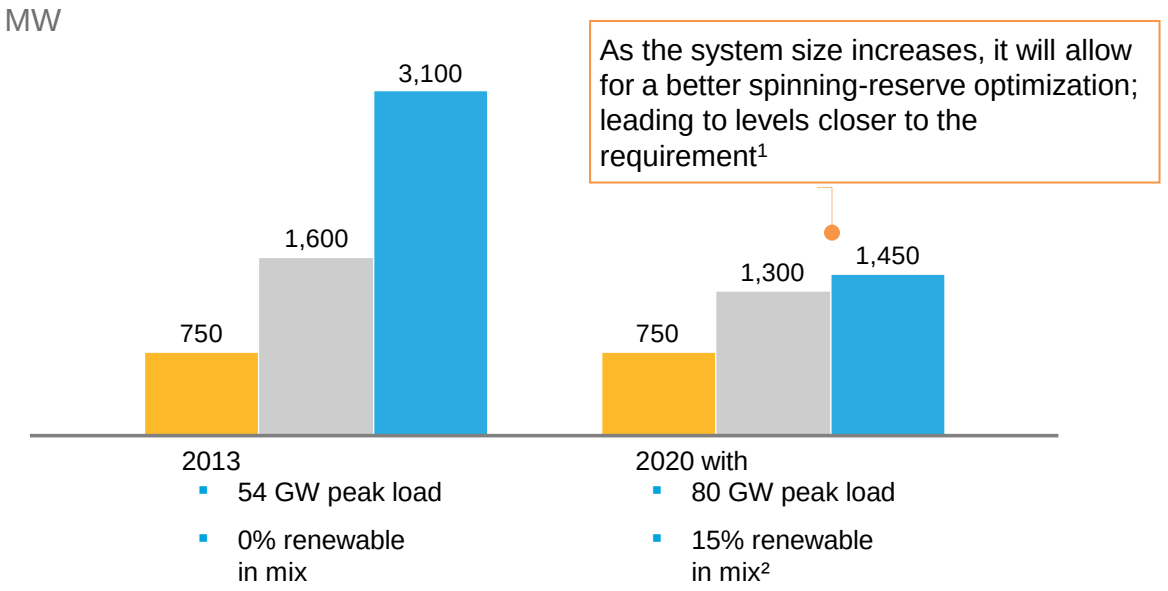
SOURCE: KACARE study on grid impact

D

The 10 minutes spinning reserve requirement will still be met after the introduction of renewable

Reserve requirement
Summer peak
Winter off-peak

Average reserve available vs. required serve for spinning requirement (10 minutes)



1 SEC may also utilize large consumers (e.g., Hadeed Arc-Furnaces)
2 90 GW installed capacity
SOURCE: SEC, KACARE study on grid impact

The introduction of renewable and the multiplication of players in generation will require the creation of a national entity to coordinate renewable plants and support the system operators

Development of generation

- KSA will see a multiplication of players in generation
  - KSA has seen the introduction of new generation players with the introduction of IPP in the past 10 years
  - While this is expected to continue, the introduction of renewables and nuclear will bring other players
- The introduction of renewable will require further coordination between generation units
  - Intermittencies will require compensation within renewable sources and from conventional plants
  - Dispatch and maintenance optimization schedule will be required

Creation of a new national coordination entity

- As observed in many countries leveraging significant renewable capacity, the Saudi Sustainable Energy Control Center (SSECC) will:
  - facilitate the integration of sustainable generation in the power system and support the TSP[1]
  - organize and centralize data from generation plants (e.g., forecast, maintenance requirements, etc.)
  - coordinate generation plants forecasted dispatch

1 Transmission system provider
SOURCE: KACARE study on grid impact

K.A.CARE has initiated further collaboration with key stakeholders to develop the SSECC

A joined taskforce was created in March 2014[1]

Role of the taskforce

- Define the high level mandate and functions of the SSECC
- Launch RFP for the detailed development roadmap of the SSECC
- Work with awarded consultant to define it
- Execute the development of the SSECC

1 ECRA and MoWE officially named the representive in the task force. SEC & NGSA confirmation in progress

SOURCE: KACARE's SSECC initiative

For More Information, Please Visit our Website

WWW.KACARE.GOV.SA