Integrated Resource Plan 2019

Initial CSIR insights and risks/opportunities for South Africa

CSIR Energy Centre
Pretoria. 30 October 2019
v1.0

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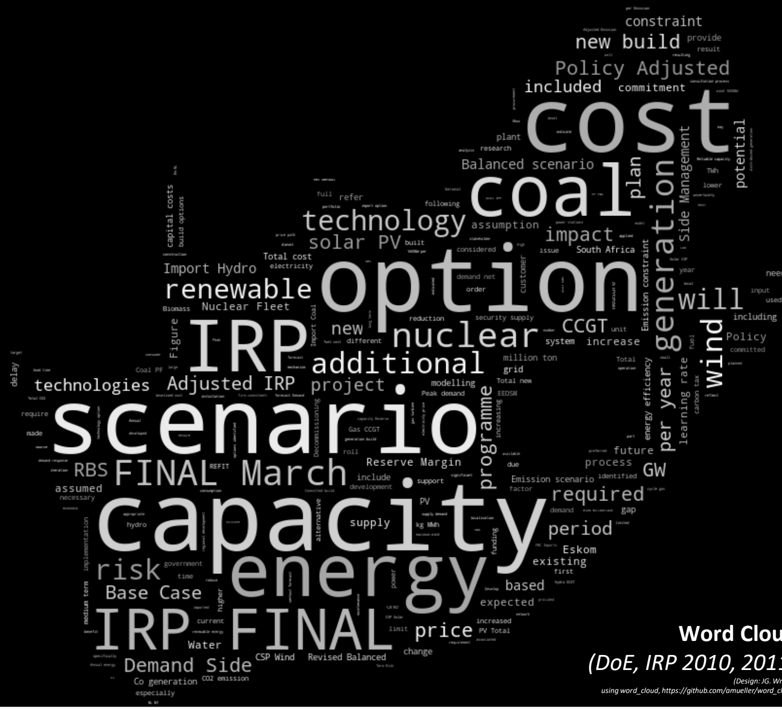

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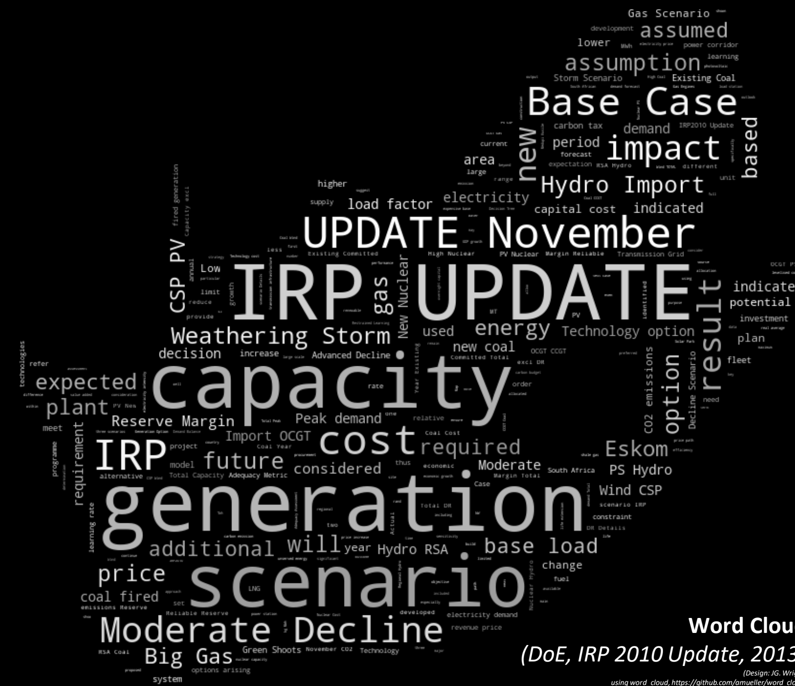

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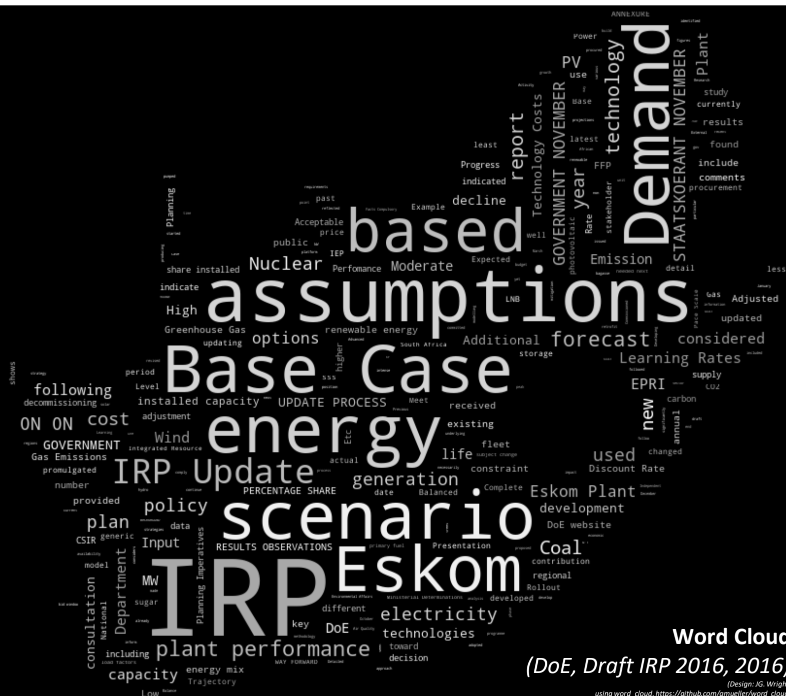

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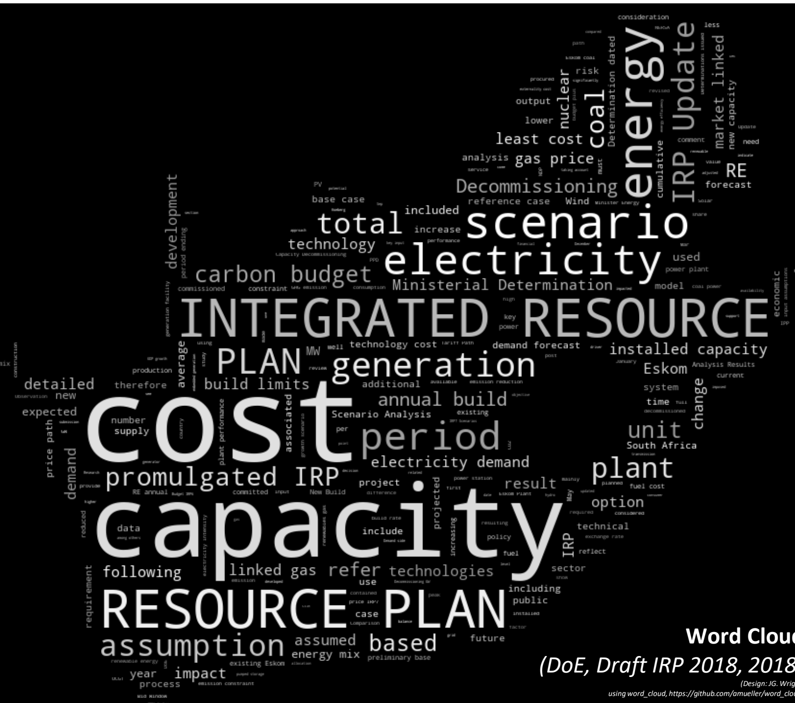

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CSIR

IRP 2019

1 Background

2 Energy mix

3 Some key takeaways

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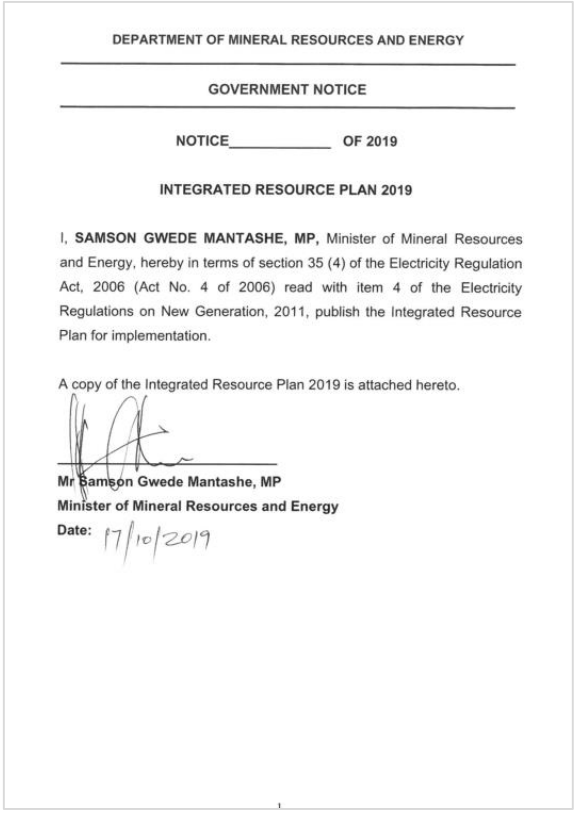
6 Long-term risks/opportunities

IRP 2019

A Promulgated IRP has arrived…

“The best time for a new IRP was 5-8 years ago, the next best time is now”

-- Anonymous



DEPARTMENT OF MINERAL RESOURCES AND ENERGY

GOVERNMENT NOTICE

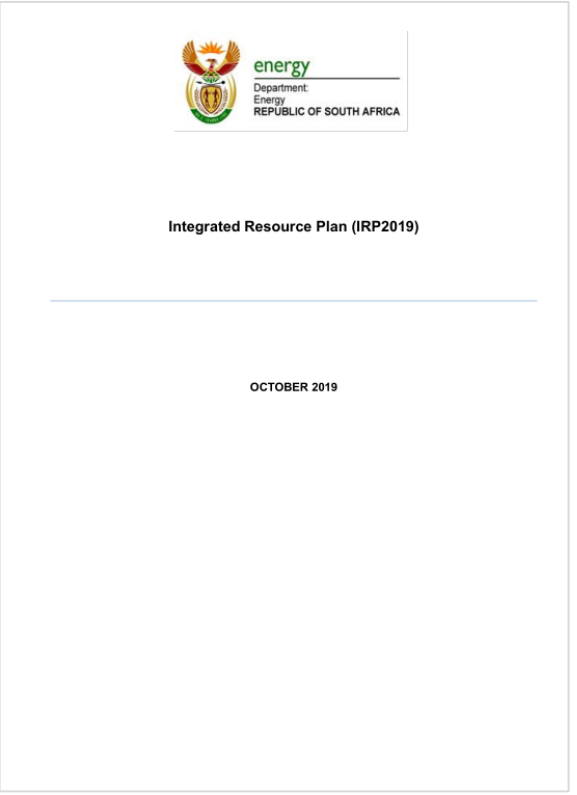
NOTICE_____ OF 2019

INTEGRATED RESOURCE PLAN 2019

I, **SAMSON GWEDE MANTASHE, MP,** Minister of Mineral Resources and Energy, hereby in terms of section 35 (4) of the Electricity Regulation Act, 2006 (Act No. 4 of 2006) read with item 4 of the Electricity Regulations on New Generation, 2011, publish the Integrated Resource Plan for implementation.

A copy of the Integrated Resource Plan 2019 is attached hereto.

Mr Samson Gwede Mantashe, MP
Minister of Mineral Resources and Energy
Date: 17/10/2019



energy
Department:
Energy
REPUBLIC OF SOUTH AFRICA

Integrated Resource Plan (IRP2019)

OCTOBER 2019

The Integrated Resource Plan (IRP) is the process to establish the need for power generation capacity expansion in South Africa

Planning/ simulation world

Inputs

Demand forecast(s)
Existing supply:
- Plants under construction
- Preferred bidders
- Decommissioning
- Plant performance

New Supply Options:
- Technology costs
- Technology technical characteristics

Constraints:
- CO2 limits
- Security/adequacy of supply level

IRP modelling framework[1] (PLEXOS)

LT[2] techno-economic least-cost optimisation

MT/ST[3] production cost testing system adequacy (security of supply)

Outputs

Output (per scenario):
- Total system costs
- Capex & Opex over time
- Capacity expansion (GW)
- Energy share (TWh)
- CO_2 emissions
- Water usage
- Employment

After policy adjustment:
- Final promulgated "IRP"
- What to build (MW)?
- When to build it (timing)?

Actuals/ real world

Inputs

Determinations/pathways for preferred new technologies and capacity (supply, demand, storage)

Procurement/ deployment

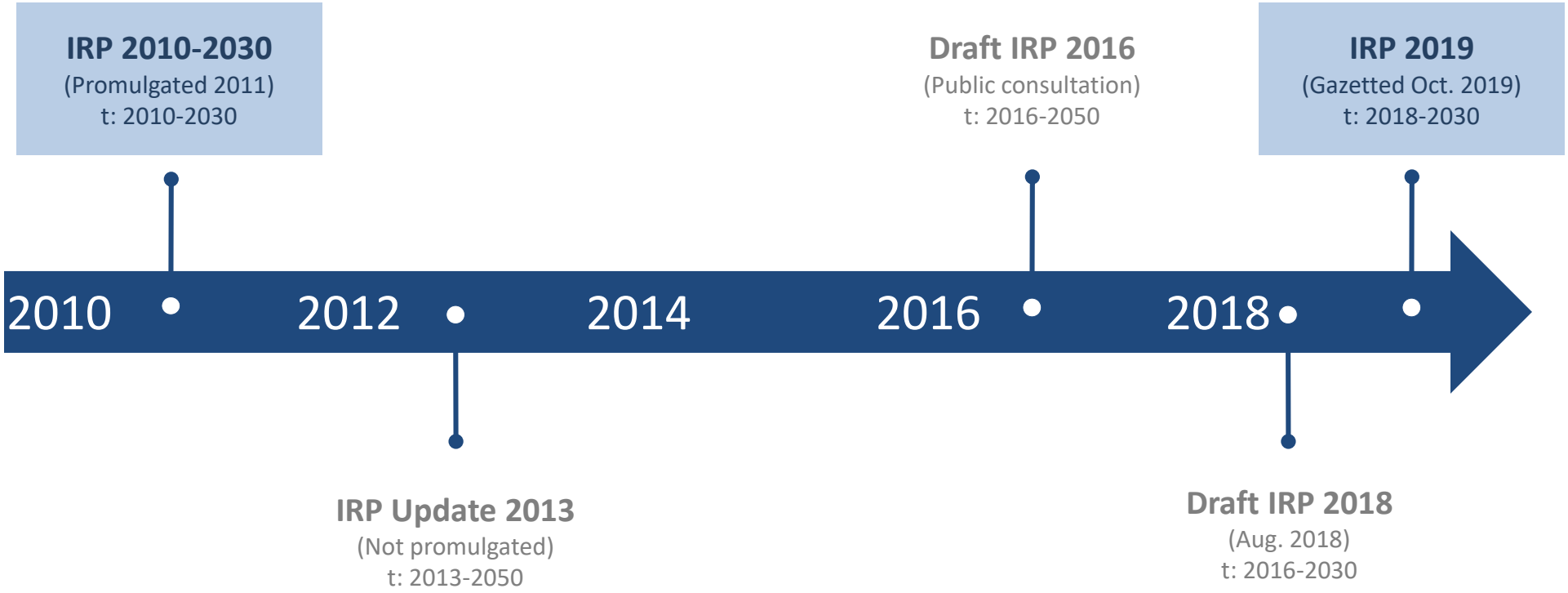
Competitive bidding, FITs, net-metering etc. e.g. REIPPPP, coal, nuclear, gas, storage etc.

Outcomes

- 'Winning' technologies
- Capacity allocated/deployed
- Actual technology costs

[1] Could include various other commercailly available and/or other open-source tools (South Africa currently opts for PLEXOS)
[2] LT = Long-term
[3] MT/ST = Medium-term/Short-term

Following a notable gap and resulting outdated IRP 2010-2030 we now have a gazetted IRP 2019



Sources: CSIR Energy Centre analysis

Key considerations and focus areas have shifted in some dimensions but remained largely unchanged in others

	IRP 2010-2030 (Promulgated 2011) t: 2010-2030	**IRP Update 2013** (Not promulgated) t: 2013-2050	**Draft IRP 2016** (Public consultation) t: 2016-2050	**Draft IRP 2018** (Aug. 2018) t: 2016-2030	**IRP 2019** (Gazetted Oct. 2019) t: 2018-2030
Expected energy mix	Scenario-based; **Big**: Coal, nuclear **Medium**: VRE, gas **Small**: imports (hydro)	Decision trees; **Big**: Coal, nuclear **Medium**: VRE, gas, CSP **Small**: Imports (hydro, coal), others	Scenario-based **Big**: Coal **Medium**: Nuclear, Gas, VRE **Small**: Imports (hydro), others	Scenario-based **Big**: Coal, VRE **Medium**: Gas **Small**: Nuclear, DG/EG imports (hydro), others	Scenario-based; **Big**: Coal, VRE **Medium**: Gas, DG/EG **Small**: Nuclear, Imports (hydro), Storage, others
Demand	454 TWh (2030)	409 TWh (2030) 522 TWh (2050)	350 TWh (2030) 527 TWh (2050)	313 TWh (2030) 392 TWh (2050)	307 TWh (2030) 382 TWh (2050)
Emissions (CO_2-eq)	Peak only, EM1 (275 Mt from 2025)	PPD (Moderate)	PPD (Moderate)	PPD (Moderate)	PPD (Moderate)
Nuclear options	Commit to 9.6 GW	Delay option (2025-2035)	No new nuclear pre-2030; 1st units (2037)	No new nuclear pre-2030; (pace/scale/affordability) 1st units (2036-2037)	No new nuclear pre-2030; (pace/scale/affordability) 2.5 GW (≥2030)
Import options	Coal, hydro/PS, gas (fuel)	Coal, hydro/PS, gas (fuel)	Hydro, gas (fuel)	Hydro, gas (fuel)	Hydro, gas (fuel)

[1] Performance (energy production & cost level/certainty); [2] For each technology option; EM1 – Emissions Limit 1 (whilst other scenarios EM2/EM3/CT (carbon-tax) with increasingly stricter CO2 emissions limits were explored non were adopted); PPD - Peak-plateau-decline; EAF – Energy Availability Factor; Sources: LC – least-cost; MES – minimum emissions standards; LT – long-term; ST – short-term; Tx – transmission networks; Dx – distribution networks; DG – distributed generation; EG – embedded generation;
Sources: DoE; CSIR Energy Centre analysis

Key considerations and focus areas have shifted in some dimensions but remained largely unchanged in others

	IRP 2010-2030 (Promulgated 2011) t: 2010-2030	IRP Update 2013 (Not promulgated) t: 2013-2050	Draft IRP 2016 (Public consultation) t: 2016-2050	Draft IRP 2018 (Aug. 2018) t: 2016-2030	IRP 2019 (Gazetted Oct. 2019) t: 2018-2030
Coal fleet performance	>85% EAF	~80% EAF; LifeEx (10 yrs)	72-80% EAF; MES delay (2020/25)	72-80%; MES delay (2020/25)	67-76%; MES delay (2020/25)
New-build coal	1st units forced earlier 1.0 GW (2014) 6.3 GW (2030)	Displaced by LifeEx (10 yrs) 1.0 GW (2025) <3.0 GW by 2030	1st 1.5 GW (2028) 4.3 GW (2030)	0.5 GW (2023) 1.0 GW (2030)	0.75 GW (2023) 1.5 GW (2030)
New technologies[1]	Uncertain VRE cost/perf. CSP (marginal); Annual constr.: 0.3-1.0 GW/yr (PV) 1.6 GW/yr (wind)	Uncertain VRE cost/perf. CSP (notable); Annual constr.: 1.0 GW/yr (PV) 1.6 GW/yr (wind)	VRE cost/perf. proven CSP (minimal); Battery/CAES (option); Annual constr.: 1.0 GW/yr (PV) 1.6 GW/yr (wind)	VRE cost/perf. proven CSP (minimal); Batteries (option); Annual constr.: 1.0 GW/yr (PV) 1.6 GW/yr (wind)	VRE cost/perf. proven CSP (minimal); Batteries (notable); Annual constr.: 1.0 GW/yr (PV) 1.6 GW/yr (wind)
Security of supply	LT (reserve margin); ST (hourly dispatch); Immediate ST need; Research: Fuel supply, base-load, backup, high VRE	LT (reserve margin); ST (hourly dispatch); Research: Fuel supply, base-load, backup, high VRE	Assumed similar Research: None highlighted	Assumed similar Research: Gas supply, high VRE, just transition	Assumed similar; Immediate ST need; Research: Gas supply, high VRE, just transition
Network requirements[2]	Not considered; Tx/Dx research need	Not a concern (Tx power corridors) Dx networks research need (DG/EG)	None	Explicit Tx needs costed (per tech.)	Explicit Tx needs costed (per tech.)

[1] Performance (energy production & cost level/certainty); [2] For each technology option; EM1 – Emissions Limit 1 (whilst other scenarios EM2/EM3/CT (carbon-tax) with increasingly stricter CO2 emissions limits were explored non were adopted); PPD - Peak-plateau-decline; EAF – Energy Availability Factor; Sources: LC – least-cost; MES – minimum emissions standards; LT – long-term; ST – short-term; Tx – transmission networks; Dx – distribution networks; DG – distributed generation; EG – embedded generation;
Sources: DoE; CSIR Energy Centre analysis

Summary of decisions in IRP 2019 are far reaching but sometimes lack evidence-base or are contradictory to the established evidence-base

Decision 1

Undertake a power purchase programme to assist with the acquisition of capacity needed to supplement Eskom's declining plant performance and to reduce the extensive utilisation of diesel peaking generators in the immediate to medium term. Lead-time is therefore key.

Decision 2

Koeberg power plant design life must be extended by another 20 years by undertaking the necessary technical and regulatory work.

Decision 3

Support Eskom to comply with MES over time, taking into account the energy security imperative and the risk of adverse economic impact.

Decision 4

For coherent policy development in support of the development of a just transition plan, consolidate into a single team the various initiatives being undertaken on just transition.

Decision 5

Retain the current annual build limits on renewables (wind and PV) pending the finalisation of a just transition plan.

Decision 6

South Africa should not sterilise the development of its coal resources for purposes of power generation, instead all new coal power projects must be based on high efficiency, low emission technologies and other cleaner coal technologies.

Decision 7

To support the development of gas infrastructure and in addition to the new gas to power capacity in Table 5, convert existing diesel-fired power plants (Peakers) to gas.

Decision 8

Commence preparations for a nuclear build programme to the extent of 2500 MW at a pace and scale that the country can afford because it is a no-regret option in the long term.

Decision 9

In support of regional electricity interconnection including hydropower and gas, South Africa will participate in strategic power projects that enable the development of cross- border infrastructure needed for the regional energy trading.

NOTE: Decisions in grey lack evidence-base or are contradictory to the available evidence-base; Sources: IRP 2019; CSIR Energy Centre analysis

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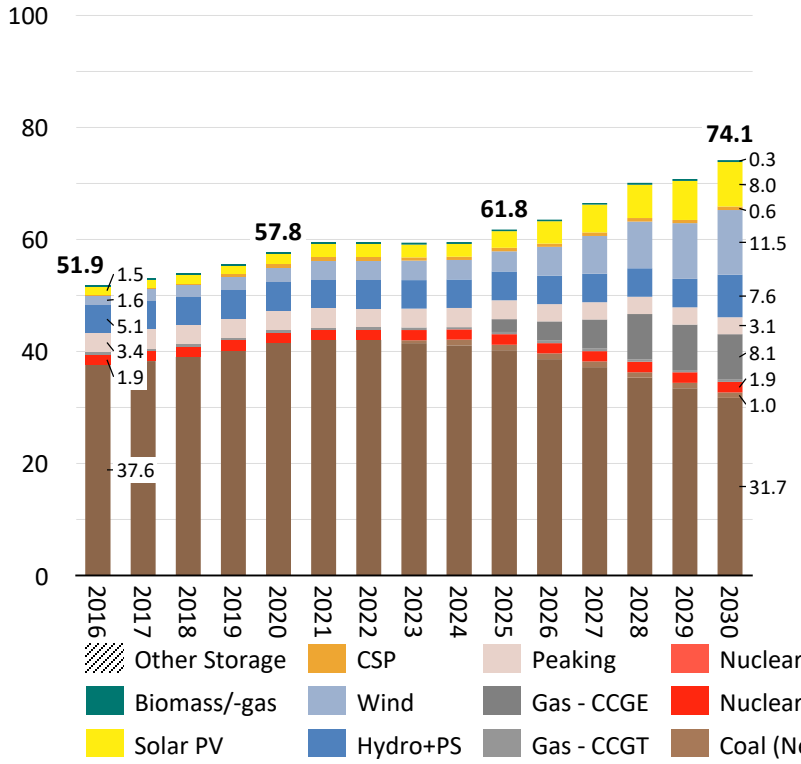
Draft IRP 2018 (Recommended Plan) included RE new-build limits and policy adjustment for new-build coal and imported hydro

Installed capacity and electricity supplied from 2016 to 2030 as planned in the Draft IRP 2018

IRP 2018 Rec. Plan (from DoE)

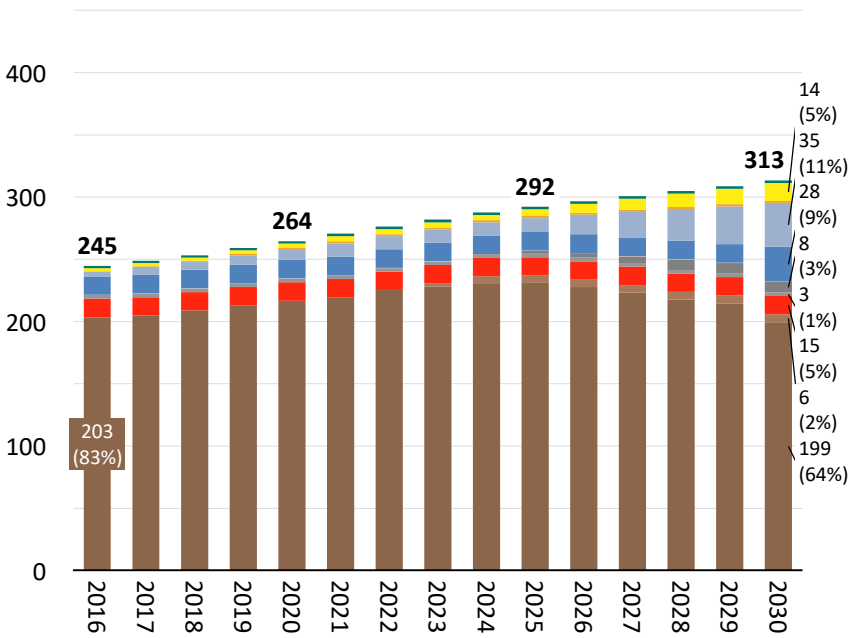
Installed capacity

Total installed capacity (net) [GW]



Energy mix

Electricity production [TWh/yr]



First new-builds:

Coal (2023)	*1.0 GW*
PV (2025)	*0.7 GW*
Wind (2025)	*0.2 GW*
CC-GE (2026)	*2.3 GW*

DSR – Demand Side Response; DG = Distributed Generation
Sources: Draft IRP 2018. CSIR Energy Centre analysis

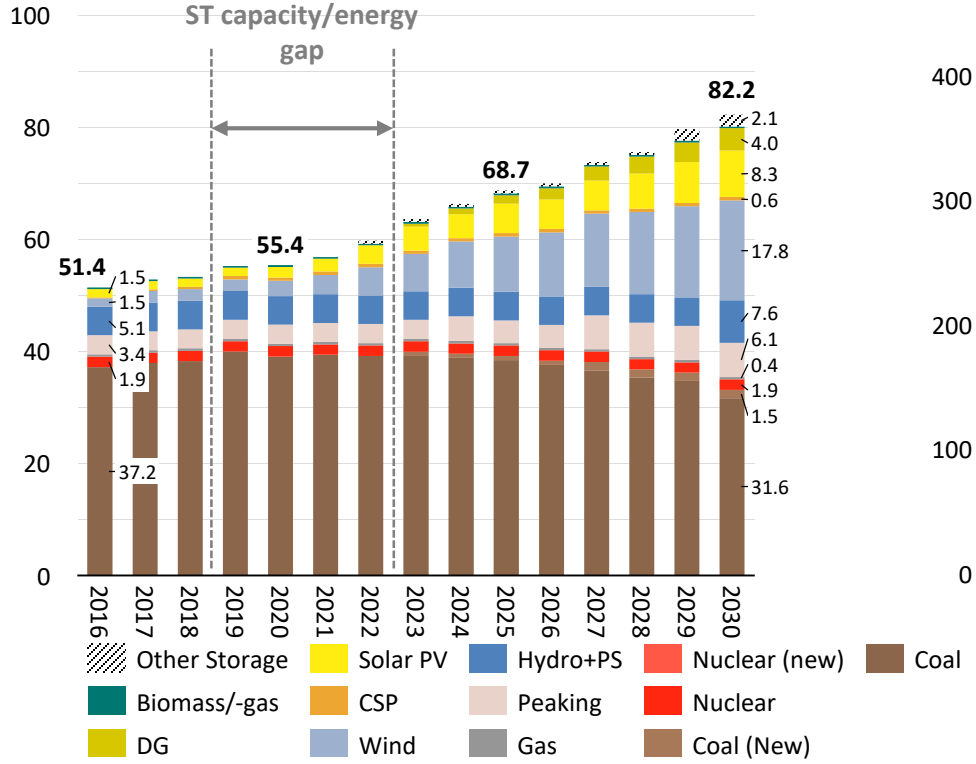
IRP 2019 only runs to 2030 (not long-term) & includes adjustments for new coal, imported hydro & constraints on new VRE but now includes storage

Installed capacity and electricity supplied from 2016 to 2030 as planned in the IRP 2019

IRP 2019 Policy Adjusted (from DoE)

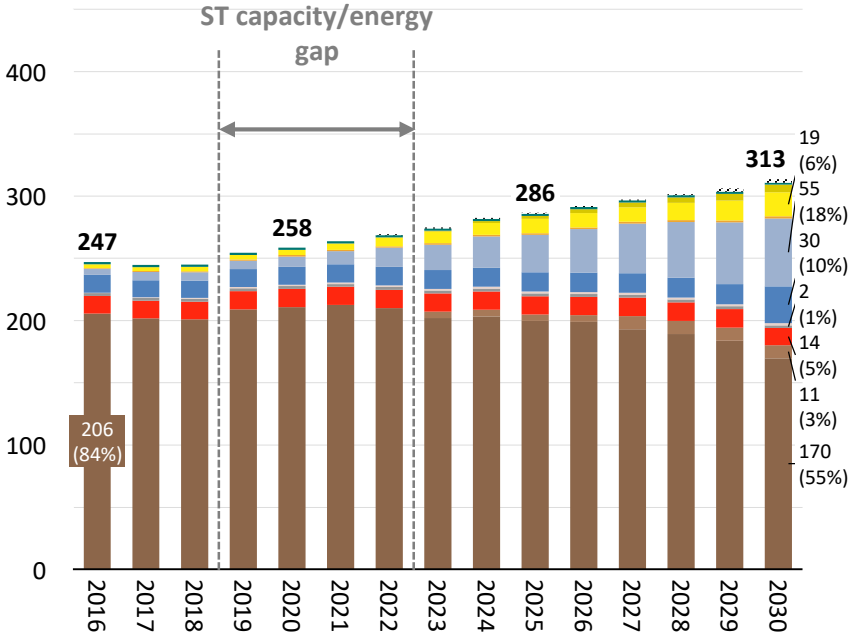
Installed capacity

Total installed capacity (net) [GW]



Energy mix

Electricity production [TWh/yr]

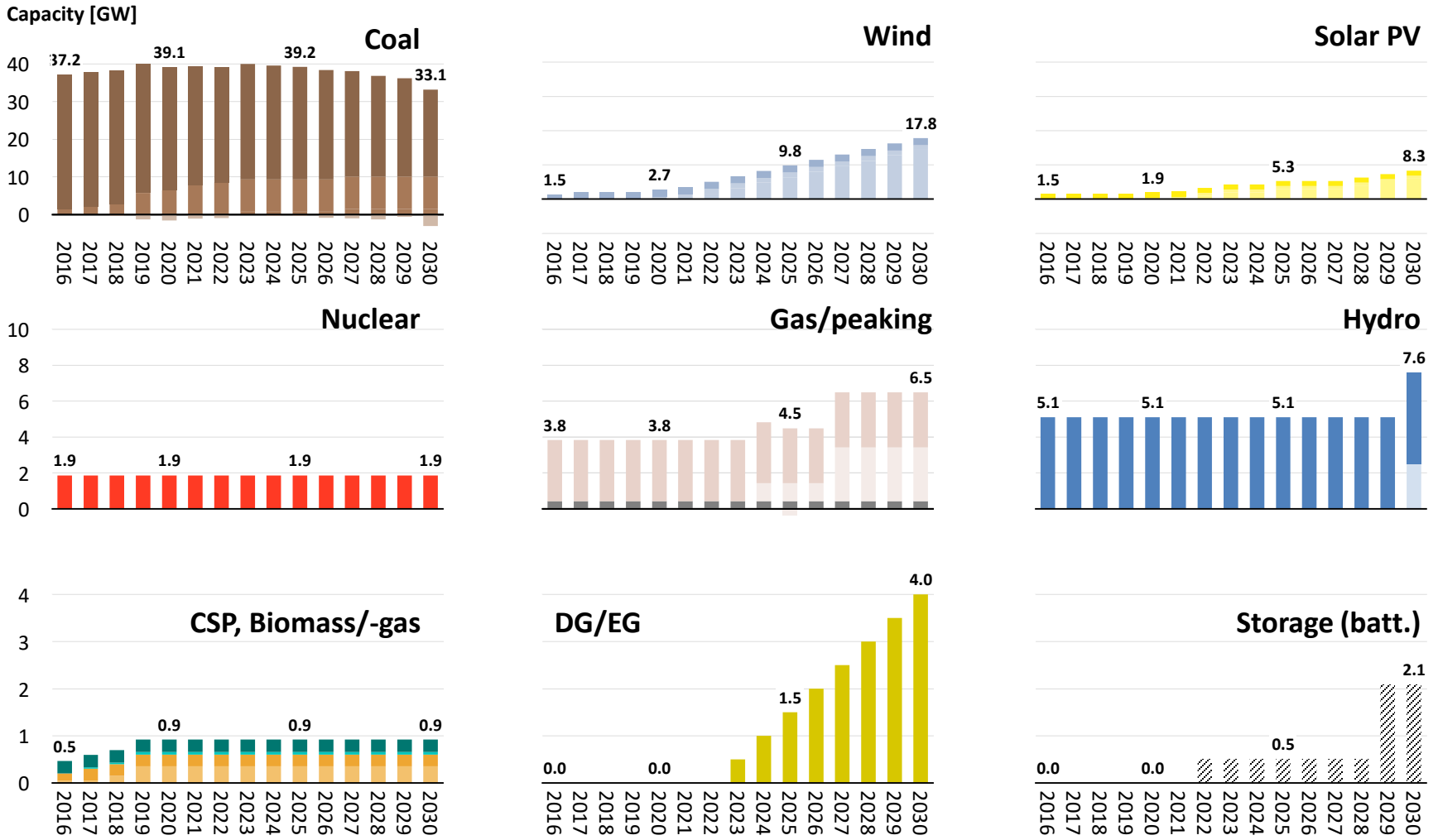


First new-builds:

Wind (2022)	*1.6 GW*
PV (2022)	*1.0 GW*
Storage (2022)	*0.5 GW*
Coal (2023)	*0.75 GW*
Gas (2024)	*1.0 GW*

DSR – Demand Side Response; DG = Distributed Generation; VRE – variable renewable energy;
NOTE: Energy share is a best estimate based on available data.
Sources: IRP 2019. CSIR Energy Centre analysis

IRP 2019 highlights clear medium-term policy positions (to 2030) whilst long-term trends (to 2050) could show a range of further insights



NOTE: Dark shade indicates existing capacity whilst light shade indicates under construction/committed and new-build capacity (negative values indicate decommissioning); DSR (Demand Side Response) not included

Sources: IRP 2019. CSIR Energy Centre analysis

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IRP 2019 is not a long-term visionary plan, does not report transparently & comprehensively & still applies arbitrary new-build constraints on VRE

Draft IRP 2018 very different to Draft IRP 2016 with solid principles - IRP 2019 reverts back

- No unconstrained least-cost scenario published for comparison to Policy Adjusted IRP 2019
- Generally - minimal comprehensive information or comparisons made in most important and relevant dimensions for scenarios considered (installed capacity, energy mix, cost, emissions or water usage)

IRP meant to be long-term visionary plan – not anymore

- IRP 2019 does not provide insight beyond 2030 (only 10 years from now)
- Of course, technological disruption makes it difficult to plan beyond 2030 but long-term vision is needed

Transparent and comprehensive reporting is essential

- Comprehensive reporting of input assumptions & scenario outcomes not included
- VRE (PV and wind) with flexibility[1] confirmed again as least-cost new-build energy mix[2]
- VRE (PV and wind) with flexibility[1] also previously shown to exhibit least CO_2 emissions & water usage
- Need to establish cost, CO_2 emissions & water-use difference relative to unconstrained least-cost

Arbitrary annual new-build constraints on VRE technologies still included

- Still unjustified, constant as power system grows & misaligned with international experience
- New-build constraints distort least-cost new-build options

[1] Natural gas fired peaking and mid-merit capacity considered as a proxy for this; [2] While the existing coal fleet decommissions as expected
EAF – Energy Availability Factor; MES – Minimum Emission Standards; VRE – Variable Renewable Energy; DG – Distributed Generation
Sources: CSIR Energy Centre analysis

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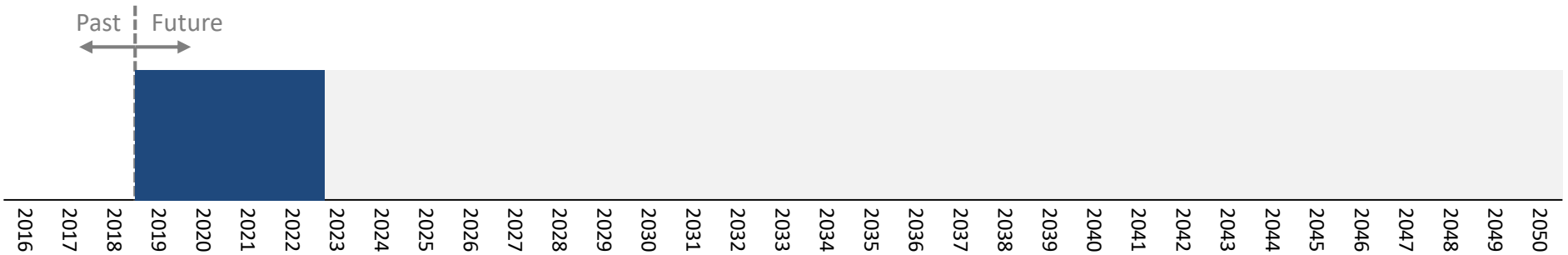
In the short-term – filling the gap is critical (all options), Medupi/Kusile completion, uncertainty around Eskom EAF recovery & MES compliance



CSIR views on key short-term risks/opportunities that exist and require further investigation (2019-2022)

- Realistic and achievable coal fleet EAF (MTSAO should assist but may not answer - what next?)
- Optimised/implicit decommissioning and/or life extension of coal fleet (not investigated)
- Beginnings of a just energy transition need to be more carefully considered (immediate socio-economic impacts of decommissioning coal power stations & need for funds/investments earmarked to mitigate[1])
- MES compliance and/or cost thereof relative to alternatives (dire system consequences)
- Completion and performance of under construction coal stations at Medupi/Kusile (EAF, capacity derating)
- Role of existing capacity for short-term procurement not established e.g. MTPPP, DG/EG
- Portfolio of short lead new supply/demand/storage options can assist if optimised & regulatory constraints removed[2]

CSIR intend to assist in a range of these activities by engaging with key stakeholders/custodians

[1] Unemployment, labour migration & economic activity changes; [2] Key role of DG/EG in alleviating system constraints in high-demand hours (even if only solar PV).
EAF – Energy Availability Factor; MTSAO – Medium-term System Adequacy Outlook; MES – Minimum Emission Standards; VRE – Variable Renewable Energy; DG – Distributed Generation; EG – Embedded Generation
Sources: CSIR Energy Centre analysis

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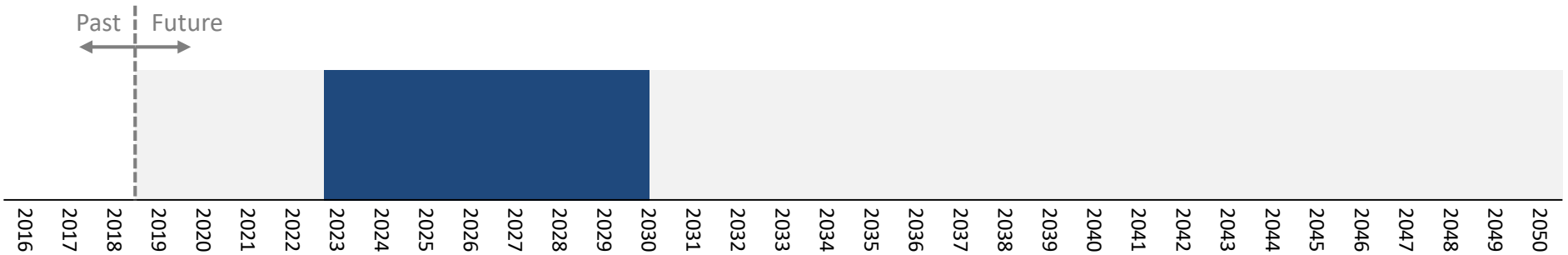
Medium-term needs a clear view on what realistic gas volumes can be expected (& when), best flexibility providers and demand uncertainty

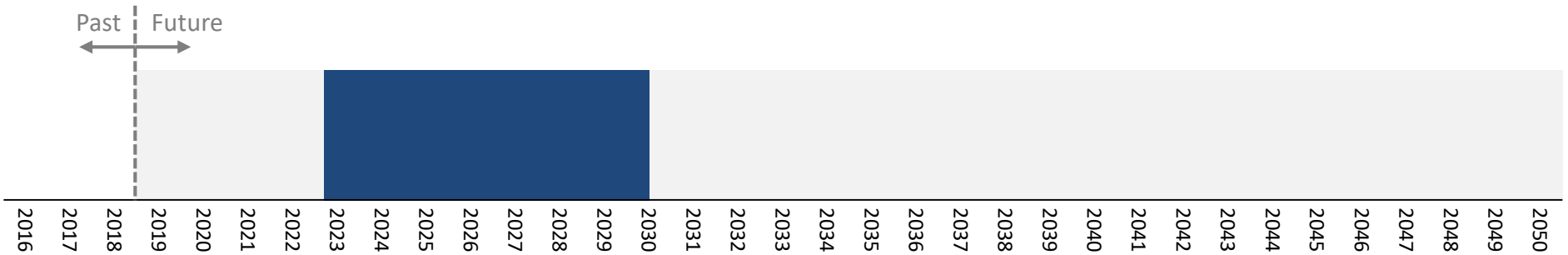


CSIR views on key medium-term risks/opportunities that exist and require further investigation (2023-2030)

- What to build and where to build next considering supply/demand side options & realistic lead-times
- Demand forecast risk not dealt with sufficiently (linkages to optimal DG/EG deployment & residual demand profile shape to be met by the complimentary least-cost energy mix)
- Which technologies would be the optimal flexibility providers if natural gas imports are a concern?
- Optimisation of existing older coal fleet considering limited capital availability (repurposing as new power system assets; retrofitting for improved reliability, efficiency and flexibility)
- Timing & role of storage at scale for a range of system use cases (in addition to energy arbitrage)

EAF – Energy Availability Factor; MES – Minimum Emission Standards; VRE – Variable Renewable Energy; DG – Distributed Generation; DSR = demand-side response; EG – Embedded Generation.
Sources: CSIR Energy Centre analysis

Medium-term requires just transition plan, explicit linkages between IRP & MTSAO (periodic) and program of work on system integration topics



CSIR views on key medium-term risks/opportunities that exist and require further investigation (2023-2030)

- Impact of notably faster and deeper learning of disruptive technologies (especially mainstream VRE)
- Localised employment risk as further coal power stations decommission in 2023-2030 (remainder to 2050)
- Establish just transition plan & implement associated pilot programmes
- Institutionalised establishment of links/triggers between IRP and MTSAO processes (or equivalent) addressing dynamic planning environment
- Although no system integration issues foreseen pre-2030, an informed & co-ordinated work program should be established to prepare for expected relatively high VRE penetration levels (post-2030)

CSIR intend to assist in a range of these activities by engaging with key stakeholders/custodians

EAF – Energy Availability Factor; MES – Minimum Emission Standards; VRE – Variable Renewable Energy; DG – Distributed Generation; DSR = demand-side response.
Sources: CSIR Energy Centre analysis

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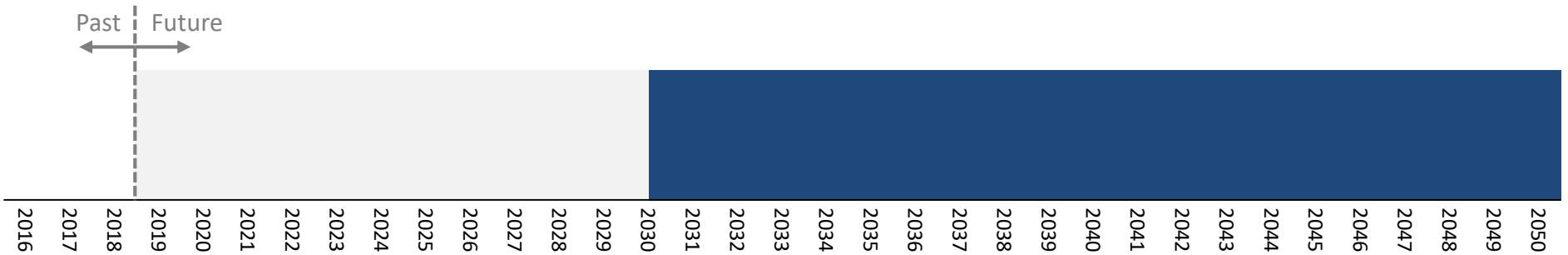
Long-term requires a vision, local & national energy integration, understanding systems integration needs (high VRE) & implementation of just transition



CSIR views on key long-term risks/opportunities that exist and require further investigation (>2030):

- Establish a long-term power sector vision for South Africa (2050 and beyond)
- Integrating national & local energy planning for improved co-ordination & leveraging of opportunities
- High VRE penetration will require implementing outcomes from work on system integration issues
- Sector-coupling opportunities across the full energy sector (not just electricity)
- Further investigate geospatial component of supply/network/storage/demand co-optimisation
- Implementation of just-transition for South Africa (cost, land rehabilitation, health & air quality, biodiversity)

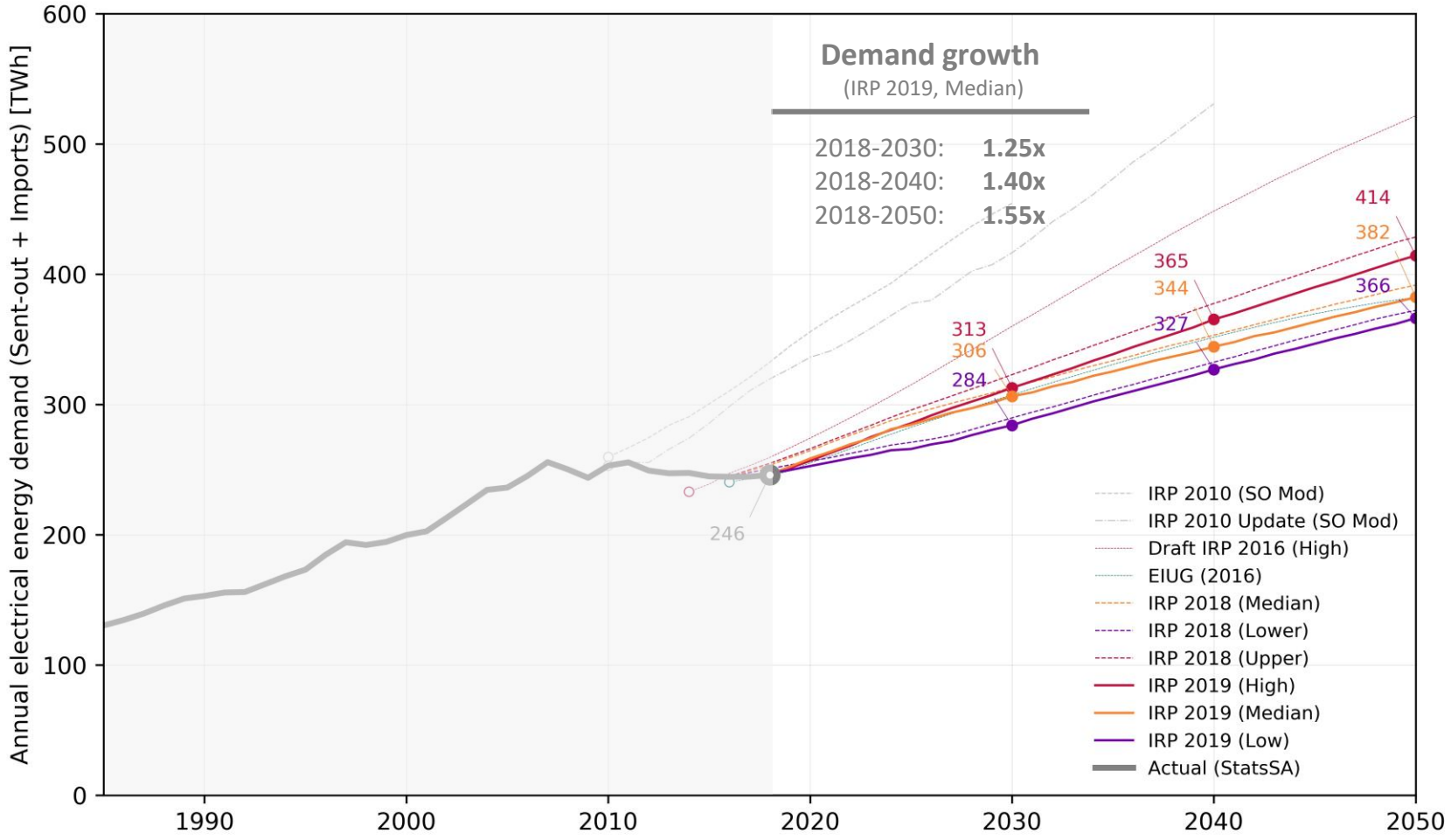
CSIR intend to assist in a range of these activities by engaging with key stakeholders/custodians

EAF – Energy Availability Factor; MES – Minimum Emission Standards; VRE – Variable Renewable Energy; DG – Distributed Generation; DSR = demand-side response.
Sources: CSIR Energy Centre analysis

Thank you

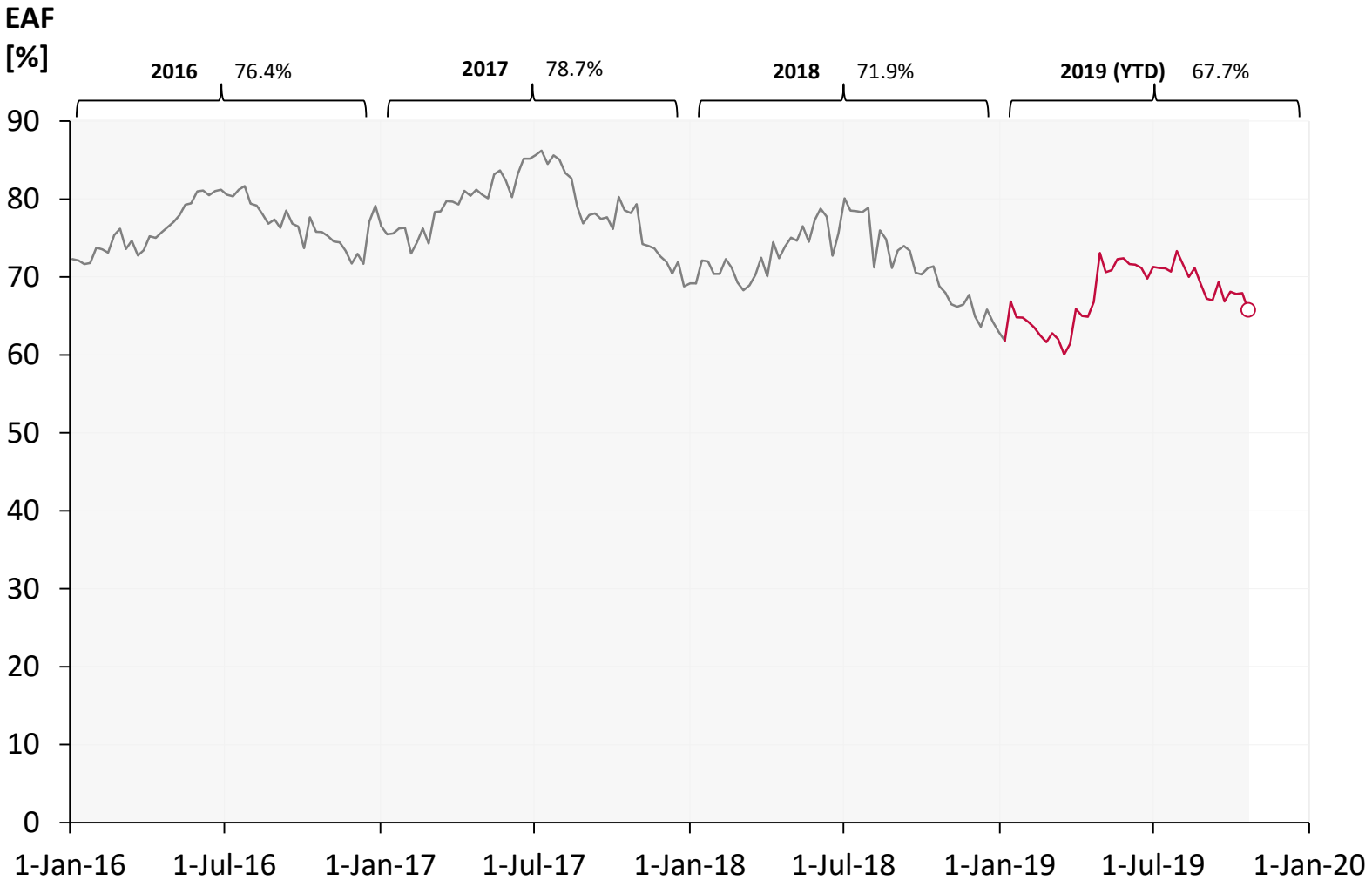
Additional information: IRP 2019 (and Draft IRP 2018)

IRP 2019 applies Median forecast with average growth 1.7%/yr (2018-2030), 1.2%/yr (2030-2040), 1.1%/yr (2040-2050)



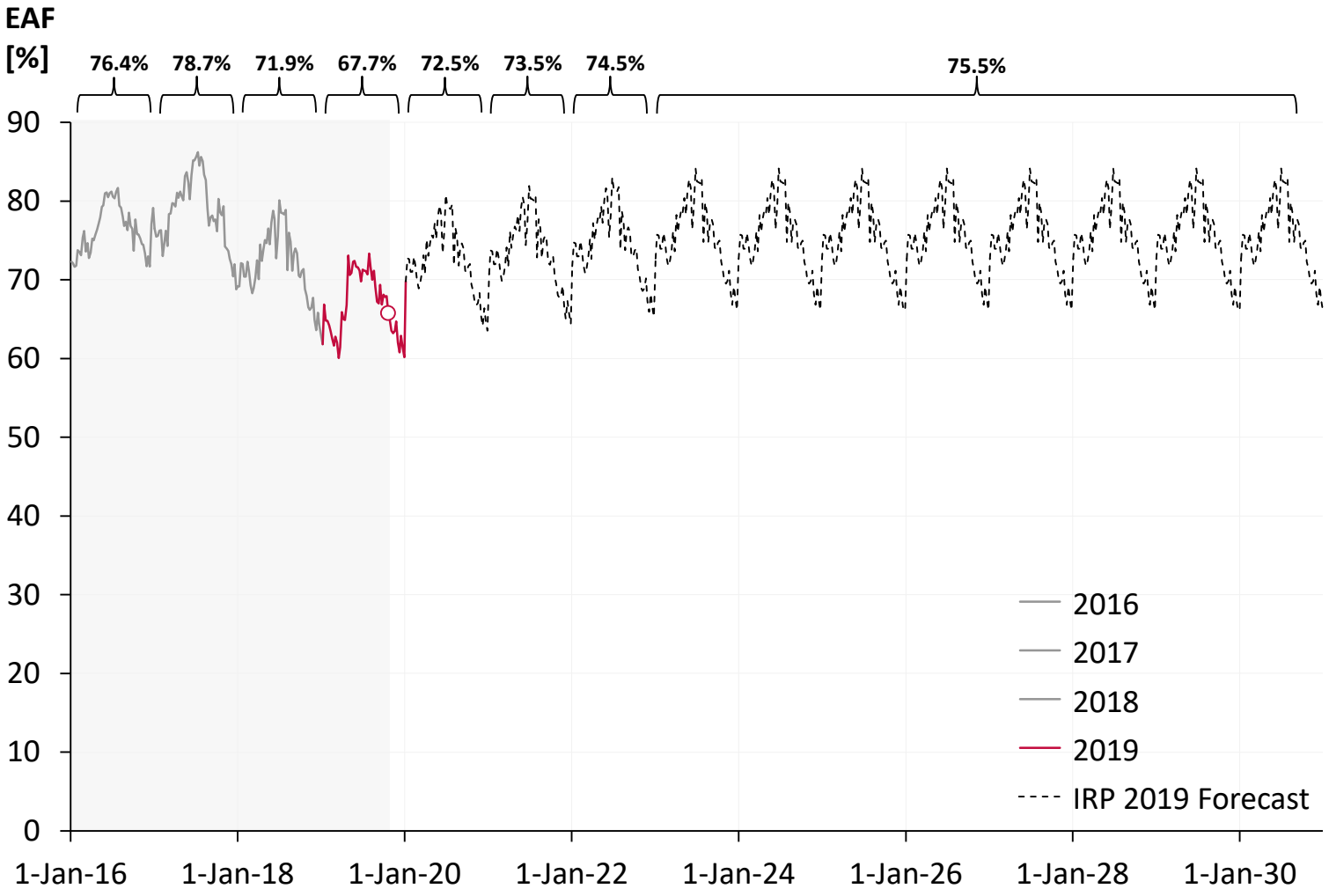
Sources: StatsSA; Draft IRP 2018

Recent Eskom fleet EAF has been declining with unfortunate consequences of a highly constrained power system



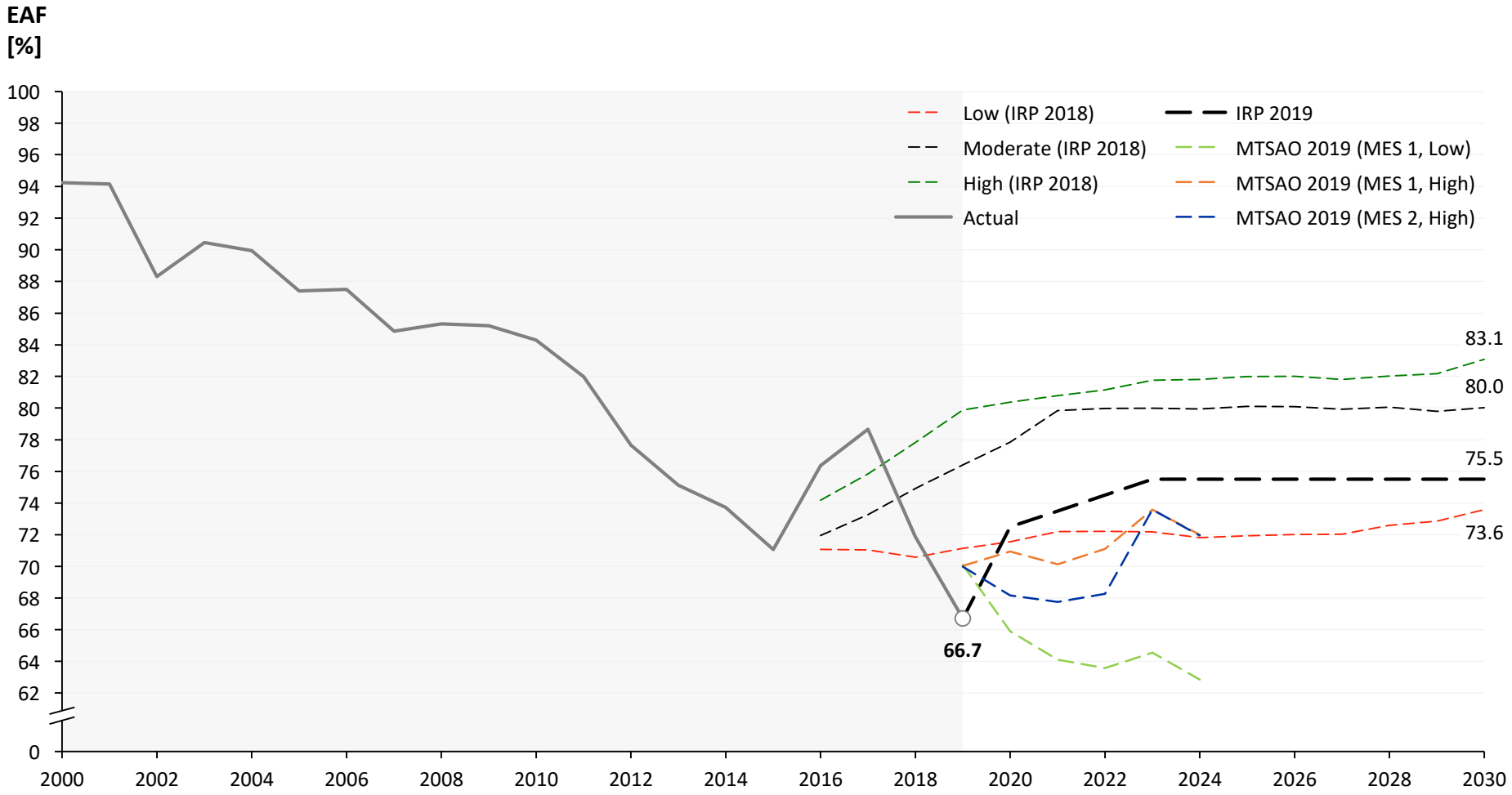
Notes: EAF - Energy Availability Factor
Sources: Eskom; CSIR Energy Centre analysis

IRP 2019 assumes a recovery of the Eskom fleet EAF to 75.5 % from ≈68% over the next 4 years and remains at 75.5% to 2030



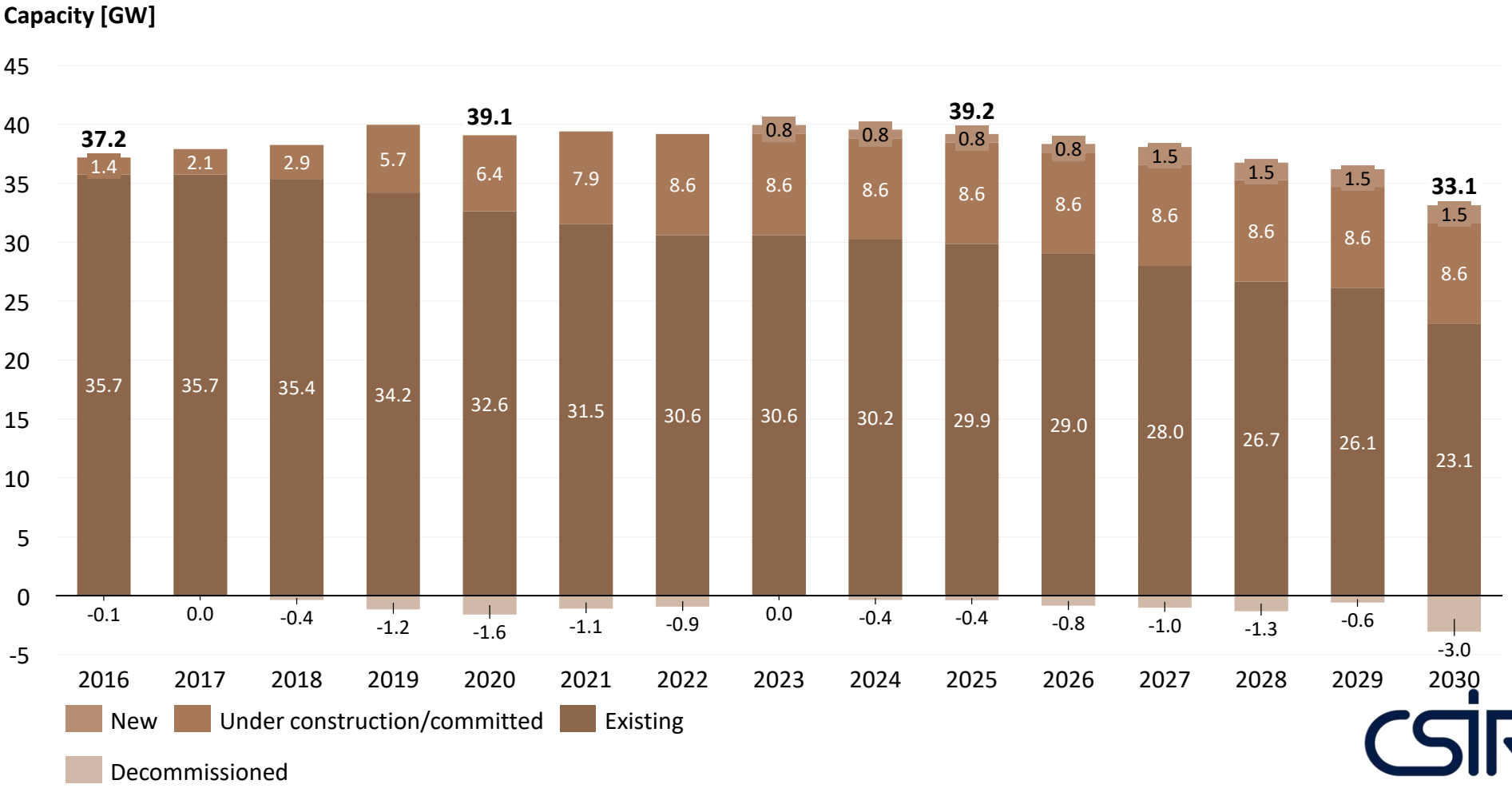
Notes: EAF - Energy Availability Factor
Sources: Eskom; CSIR Energy Centre analysis

Historical fleet EAF decline seems irreversable... expected EAF (IRP 2018) has also not materialised - is there risk of IRP 2019 expectd EAF not materialising?



EAF – Energy Availability Factor
NOTE: 2019 EAF actual is YTD
Sources: IRP2019; Eskom; CSIR Energy Centre analysis

IRP 2019 coal fleet decommissioning of 12 GW by 2030 whilst Medupi/Kusile comes online and 1.5 GW of new coal is planned

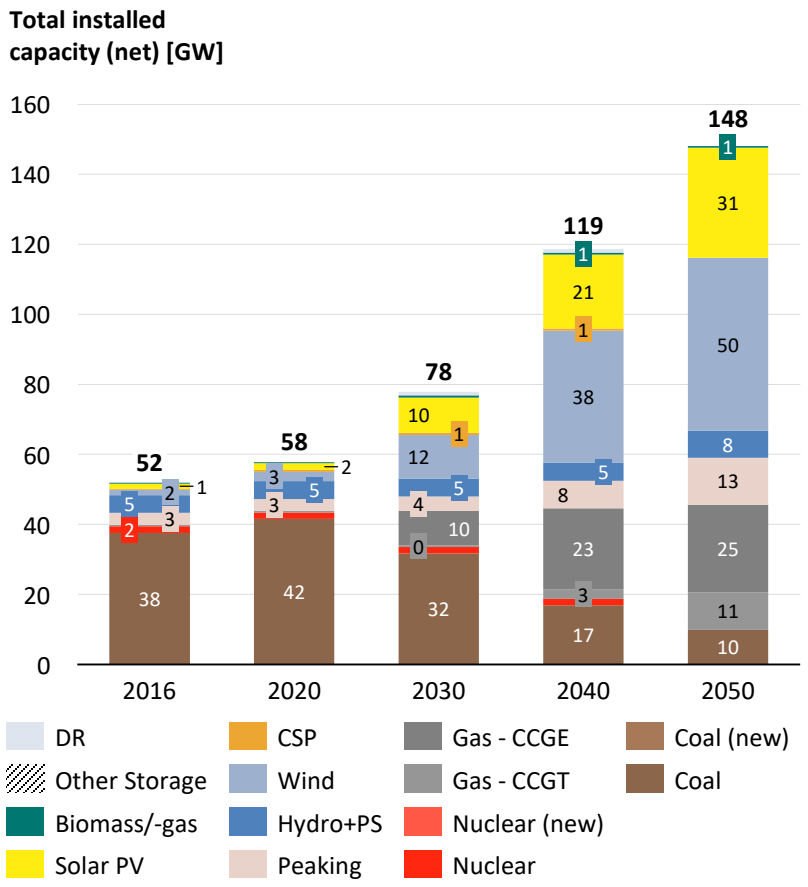


Draft IRP 2018 (IRP1) - Least-cost deploys considerable wind, solar PV and NG capacity to 2030 and beyond as the coal fleet decommissions

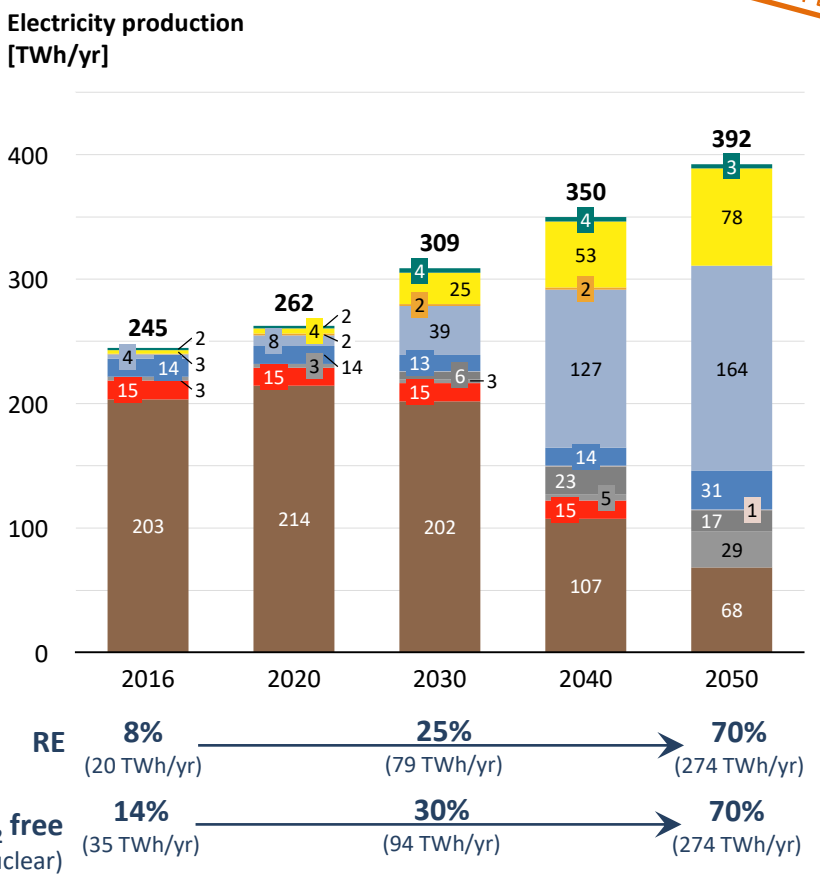
Installed capacity and electricity supplied from 2016 to 2050 as planned in the Draft IRP 2018

IRP 2018
IRP1
(least-cost)
(from DoE)

Installed capacity



Energy mix



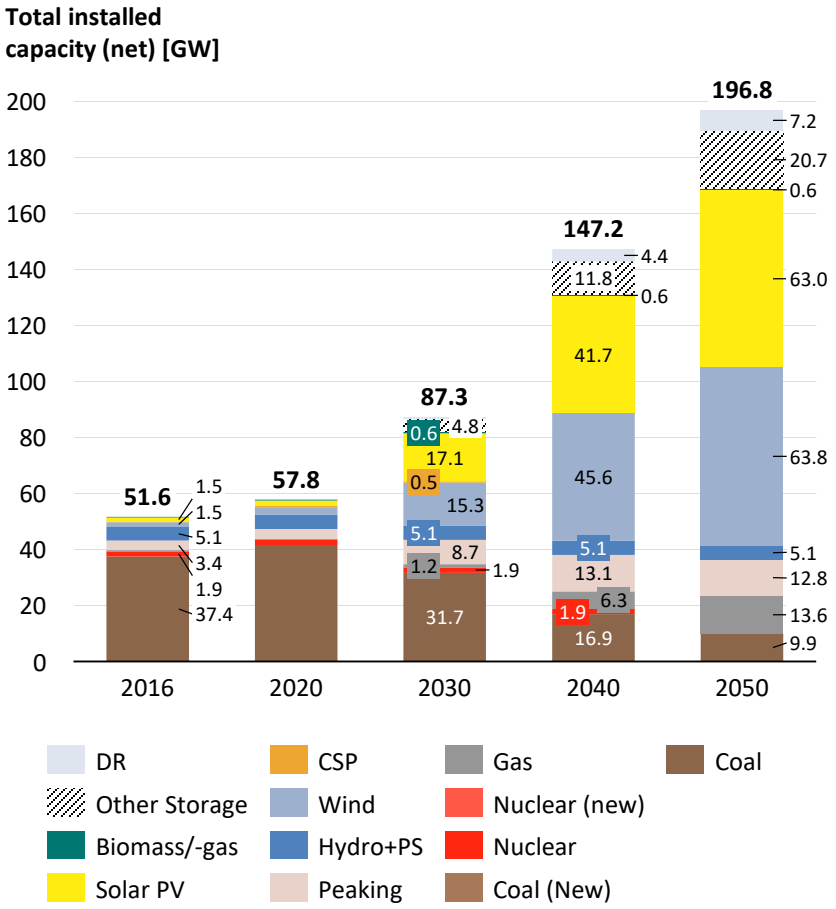
Sources: Draft IRP 2018. CSIR Energy Centre analysis

A risk-adjusted scenario with further storage and VRE cost reductions incl. DSR results in increased new wind, solar PV, storage and less NG

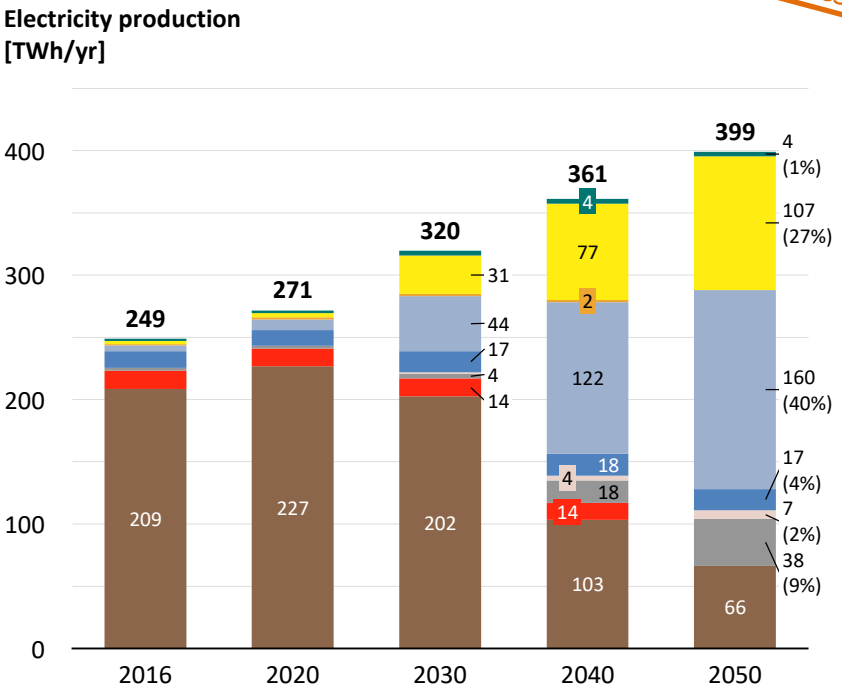
Installed capacity and electricity supplied from 2016 to 2050 for IRP1 with storage, DSR and higher RE cost reductions

Risk-adjusted scenario, 2018 (from CSIR)

Installed capacity



Energy mix



Demand: Median

First new-builds:

PV (2027)	*6.5 GW*
Wind (2027)	*2.1 GW*
OCGT (2024)	*1.9 GW*
Storage (2027)	*1.1 GW*

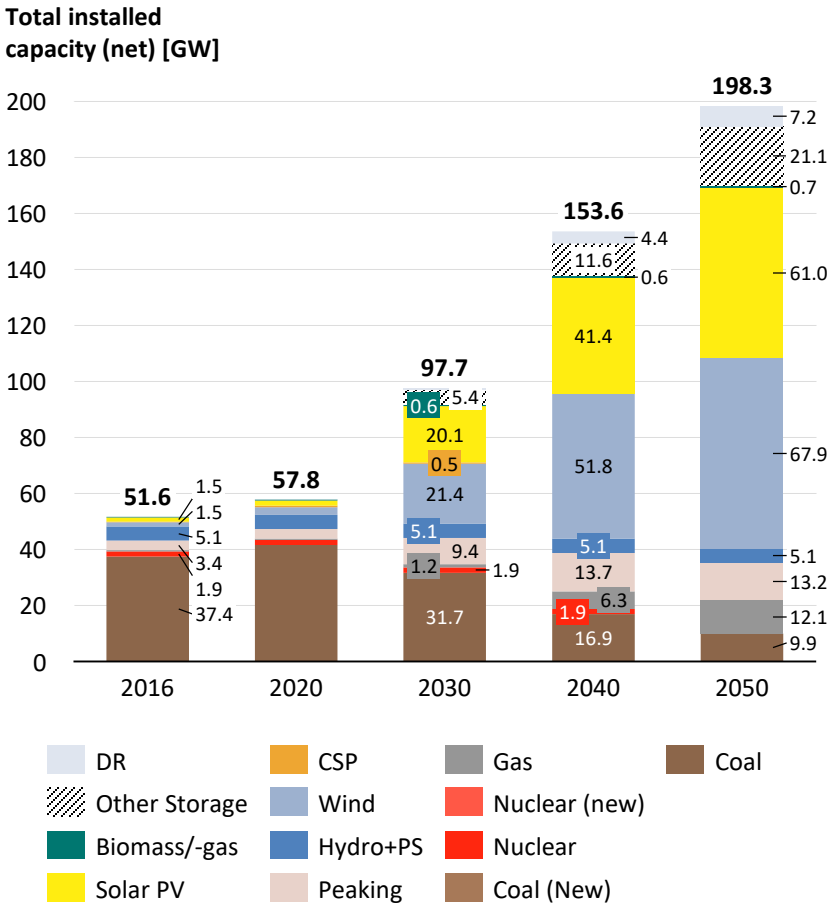
Sources: Draft IRP 2018. CSIR Energy Centre analysis

Risk-adjusted scenario with Low EAF requires earlier new-build around 2023 too and increased absolute levels of new-build by 2030

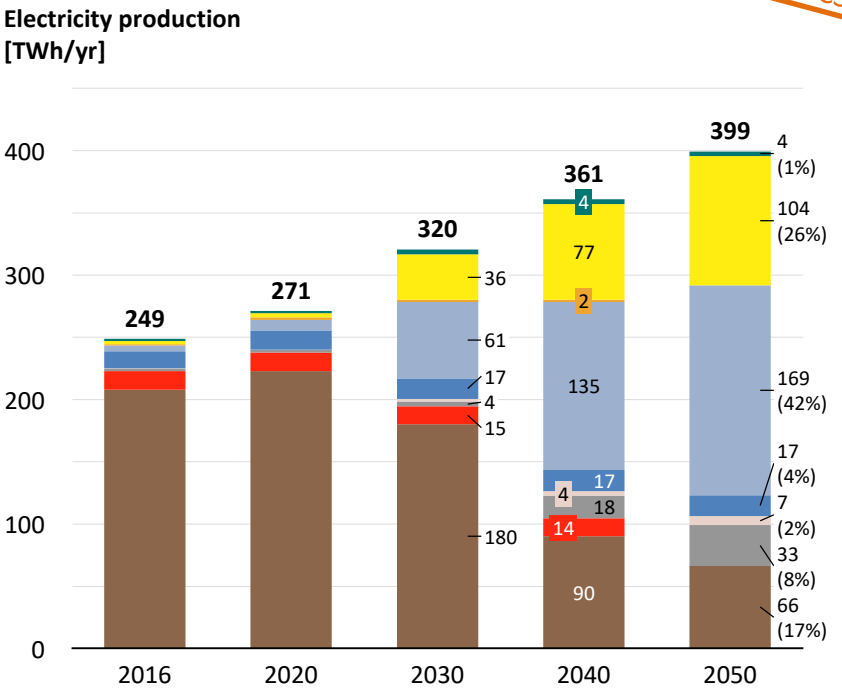
Installed capacity and electricity supplied from 2016 to 2050 for Risk-adjusted scenario with low coal fleet EAF

Risk-adjusted scenario - Low EAF, 2018 (from CSIR)

Installed capacity



Energy mix



Demand: Median

First new-builds:

PV (2023)	*0.4 GW*
Wind (2023)	*0.2 GW*
OCGT (2023)	*1.9 GW*

Sources: CSIR Energy Centre analysis