South Africa's Energy Transition *in Context*

Tara Caetano

4th Annual STERG Research Symposium

14 July 2016

ERC

ENERGY RESEARCH CENTRE
University of Cape Town

"Solar power is on pace for the first time this year to contribute more new electricity to the grid than will any other form of energy—a feat driven more by economics than green mandates.

The cost of electricity from large-scale solar installations now is comparable to and sometimes cheaper than natural gas-fired power, even without incentives aimed at promoting environmentally friendly power, according to industry players and outside cost studies."

-IEA

ERC
ENERGY RESEARCH CENTRE
University of Cape Town

South Africa's transition?

- Electricity in South Africa
  - 90% generation from coal
  - large emitter of greenhouse gases, particularly CO_2 (± 80% of total)
  - Improving access instead of increasing capacity - constrained supply
  - Low real price - rising by over 300% over the last few years

- Integrated Resource Plan/Integrated Energy Plan
  - environmental sustainability
  - depleting low cost coal reserves
  - cost competitive alternatives

- Important element of growth strategy → growth, employment and welfare
  - Price impact
  - Investment
  - Other: e.g. ability to localise (how does this fit in with other policies)

- Water shortages?

Policy Options and Uncertainty

Policy Options

- CO_2 Price/tax level
- Commitment to a Nuclear Program
- Commitment to support a Gas Infrastructure program
- Commitment to support Renewables
- Open economy to electricity imports from the region (generated from hydro/gas)

Uncertainty

- Economic growth (and demand for electricity)
- CO_2 Price/tax level
- Global energy commodity prices
- Availability and cost of shale and other gas resource (still under exploration)
- Future cost reductions on RE
- Whether regional projects materialise

SATIM

- Inter-temporal bottom-up partial equilibrium optimisation model of South Africa's energy sector (Energy Research Centre)
  - SATIM: South African TIMES Model

- Optimisation problem
  - ***Minimize the sum of all discounted costs over the planning horizon subject to constraints and system parameters***
  - Costs include capital costs, operating costs and taxes (e.g. CO_2 tax)
  - Constraints: electricity demand, resource limits, reserve margin, policy targets
  - System Parameters: load curves, existing stock of power plants, new power plant options, fuel price and availability
  - Other: discount rate, taxes, etc.

- SATIM-el:
  - SATIM Calibrated and parameterised in line with Integrated Resource Planning Report (update 2013)
  - 20 time-slices, annual periods to 2050

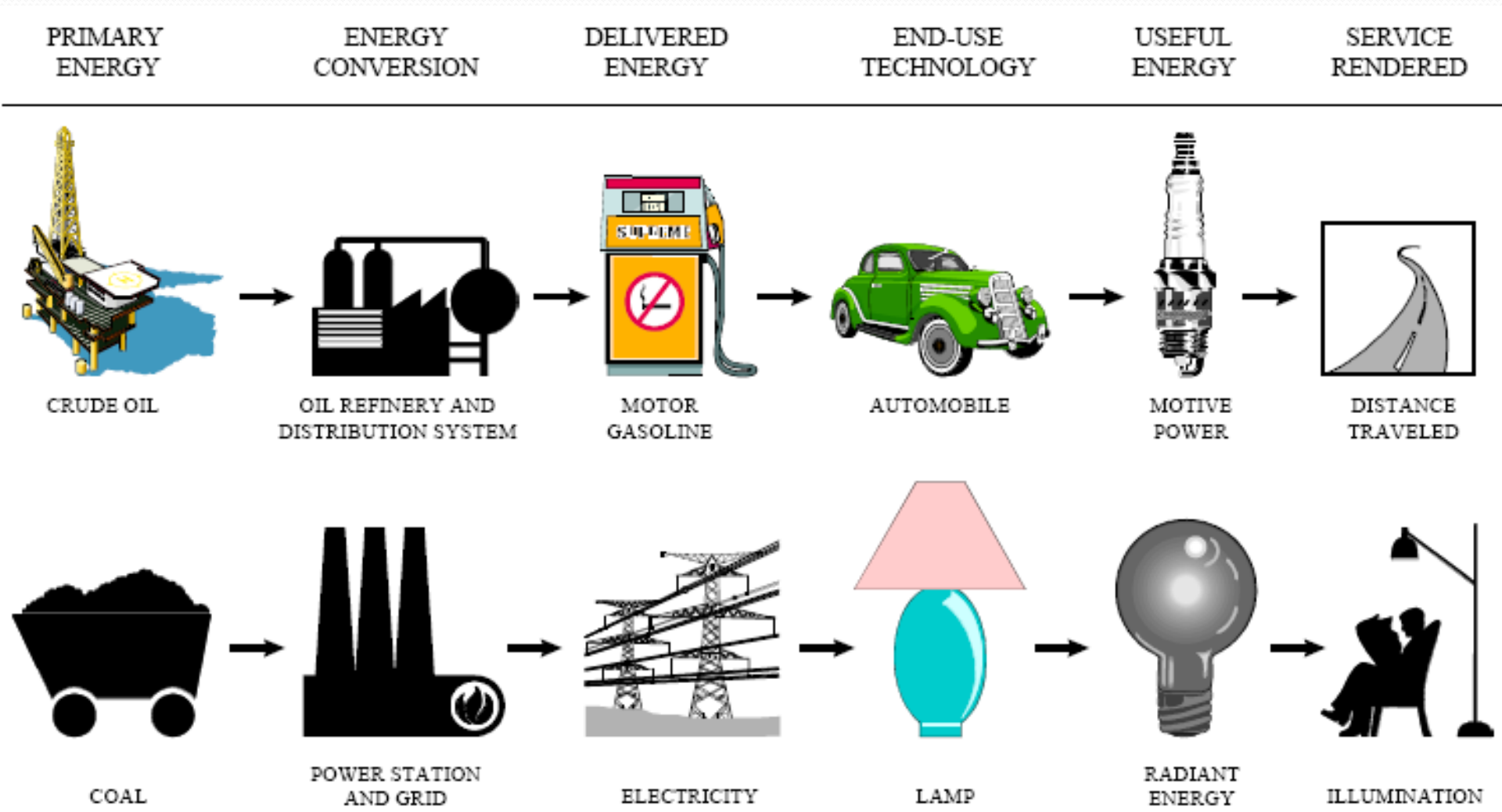


Figure 1.1. The energy flow.
Source: Scientific American (1990).

Motivation for Linked Energy-Economy-wide Models…

- Need tool that can measure the macro- and socio-economic impacts of Energy Policy
- Available tools:
  - Detailed bottom-up energy sector models
  - Economic models
- But existing models approaches are inadequate
  - **Economic Model (CGE type):** over-simplification of the energy system
  - **Optimization Energy System Models:** no/little economy and energy system feed-back
- We choose the linked iterative approach over full integration:
  - Full inter-temporal integration constrains the level of detail
  - Stakeholders like to see detail they can relate to

DDPP Deep Decarbonisation Pathways Project

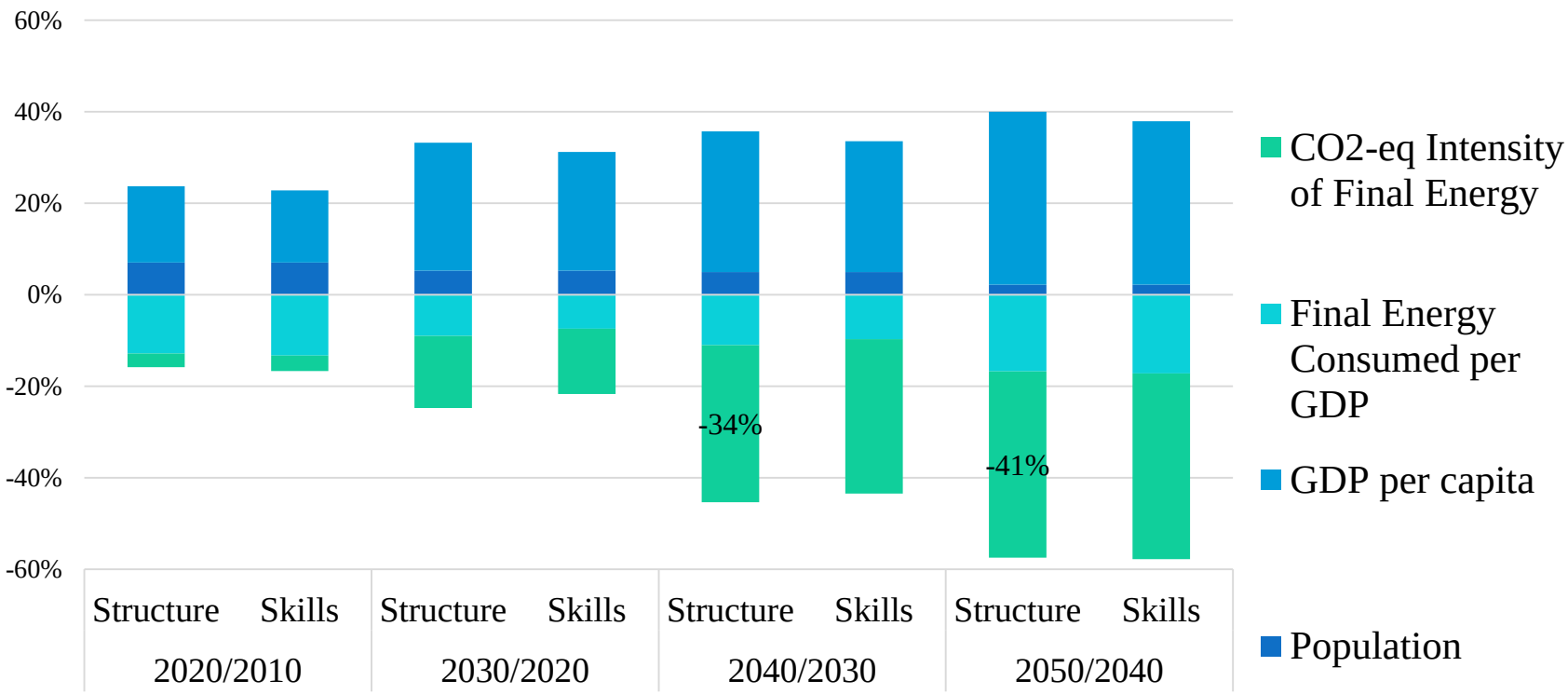
- Current domestic policy system – lock-in and path dependency
  - Not *enabling sufficient* development

- An equitable and low carbon economy (14GT constraint to 2050)
- Rethink the future
  - Similar drivers to NDP
  - How do we generate more inclusive growth?

- Two Economic pathways…
  - Economic Structure
    - Labour intensive and low carbon
  - High Skills
    - Optimistic view of the education system

An unemployment problem…

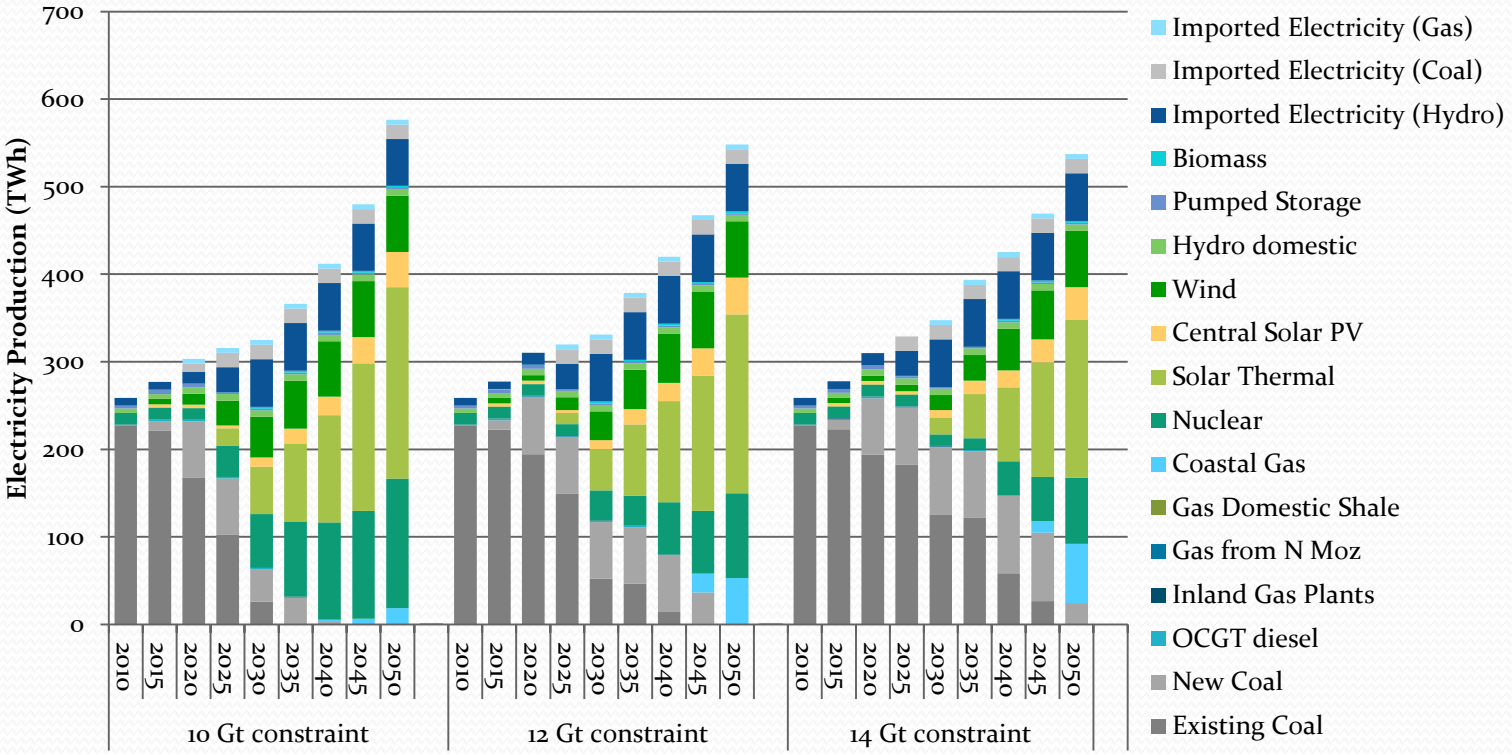
DDPP Deep Decarbonisation Pathways Project



GHG emissions per capita: 7,7 → 3,9 tons per capita (RBS 1,5 tons/cap)

Potential stranding of power sector assets in South Africa

- *"Is this the beginning of the end for coal?"*



Potential stranding of power sector assets in South Africa

- **Socio-economic consequences** of stranding assets in South Africa are likely to be substantial - even with an assumed export demand
- If coal remains in **structural decline**, the *spatial impacts* will be significant
- An **unwillingness to strand assets** is likely to lead to South Africa overshooting our global fair share
- **Stranding of assets** may be necessary in a carbon-constrained world. And stranded assets result in higher electricity prices. Building new coal plants will only add to this risk
- Higher electricity prices –
  - Slower growth in or the shutdown of energy-intensive sectors overall
  - These users moving off grid

  → **Disaster?**
- This could be an **opportunity** for structural change; South Africa could be **competitive** in a low carbon world

Water-Energy Project

- Funded by the World Bank
- Can water constrain our energy future?
- Develop the SATIM-Water model
  - Matching energy producing regions with water resource areas (WMAs)
  - Able to tackle key policy questions:
    - Is solar capacity expansion water constrained?
    - How does accounting for the cost of water impact shale gas production?

Insights

- There are a number of uncertainties surrounding South Africa's energy transition – not just *energy*
- The interplay between energy, development, and the environment is complex – tools?
- Solar investments are no longer driven by green mandates, but are *economically competitive*
- Key growth and development opportunities for South Africa
- Could be costly if we continue on a centralized/coal-heavy path
- *Q: What role can CSP play in this transition, given our context?*

Thank you!

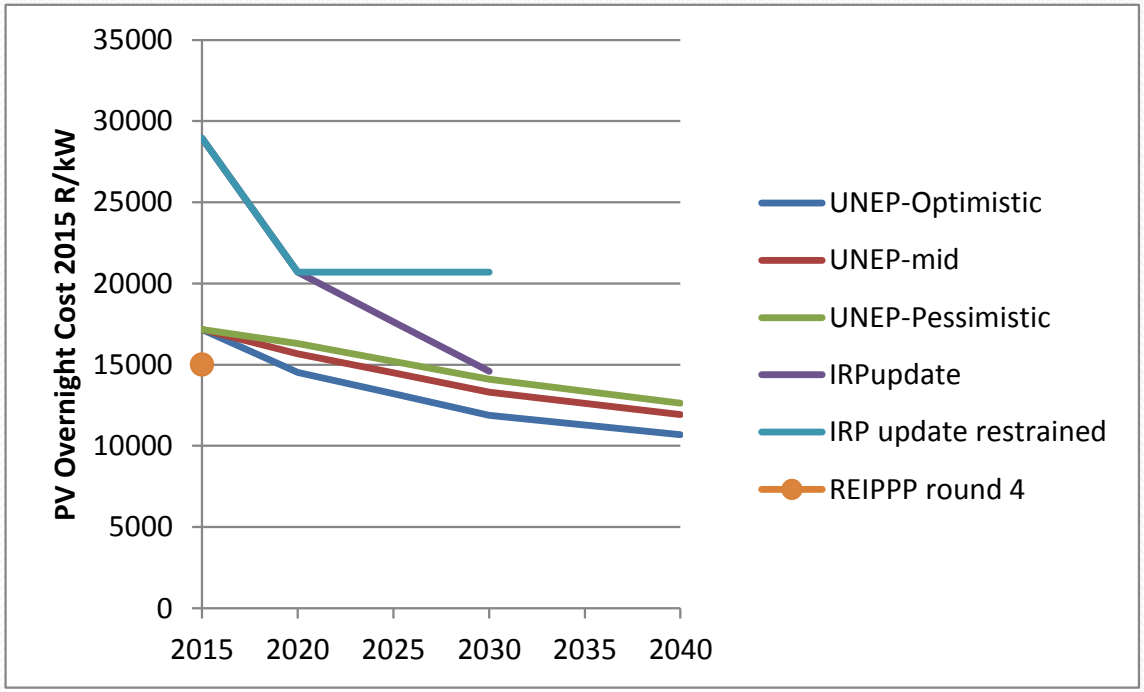
tara.caetano@uct.ac.za

**Reports/information available on our website www.erc.uct.ac.za*

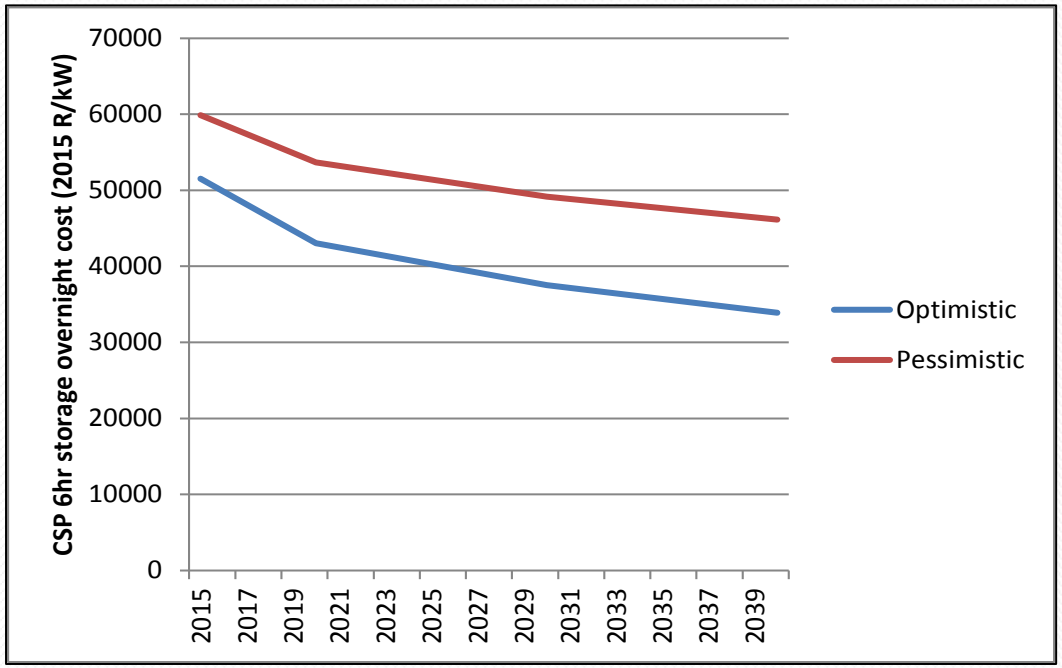
ERC

ENERGY RESEARCH CENTRE
University of Cape Town

Centralised PV

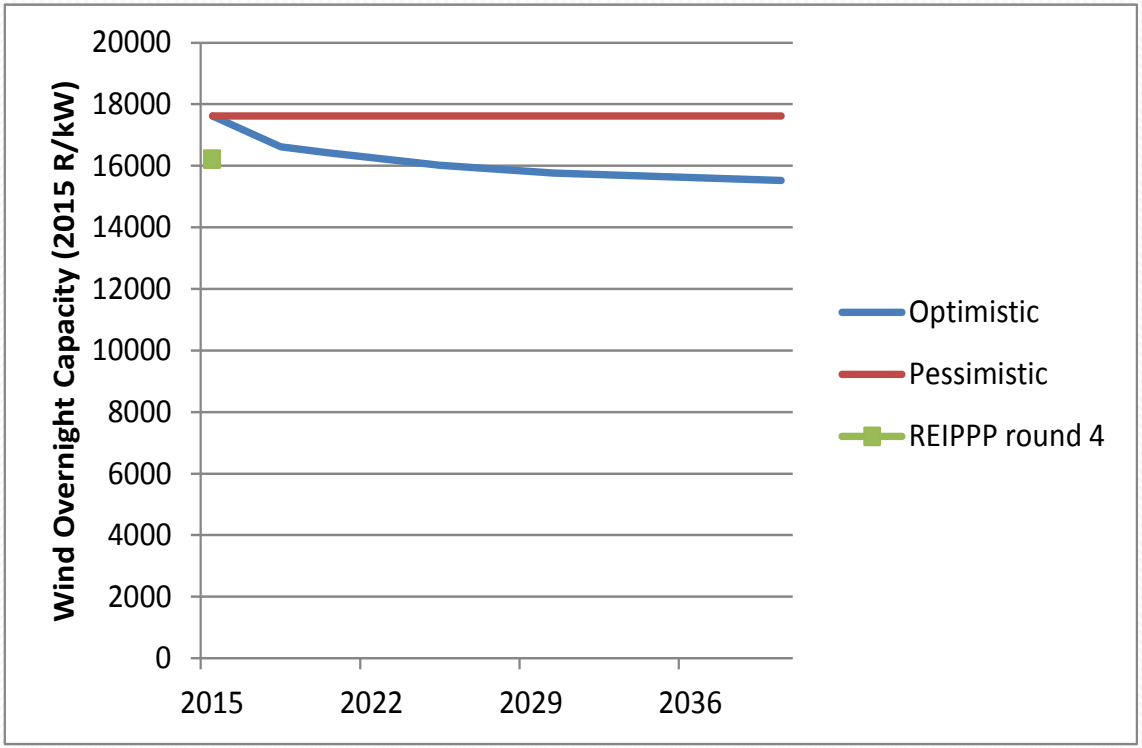


CSP



Storage Hrs	Cost Ratio
3	0.84
6	1.00
9	1.15
12	1.31
14	1.41

Wind


Wind Overnight Capacity (2015 R/kW)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
2015
2022
2029
2036
Optimistic
Pessimistic
REIPPP round 4

Empl[illegible]ions

	Coal	Nuclear	Hydro	PV	CSP	Wind	Waste	Gas	Diesel
Base Year 2007									
Electricity Supply (GWh)	229 571	11 317	5 845	213	319	32	204	1	86
Gross Operating Surplus[1] (R mil)	55 749	2 480	1 369	140	103	8	76	0	16
Total Employment (people)	33 014	2 071	2 063	64	96	7	56	0	12
High Skilled (people)	15 054	795	990	32	48	3	26	0	6
Assumptions2									
Build cost (Rmil/GWh)	17 785	26 575	9 464	37 225	37 425	14 445	9 464	4 868	4 868
Levelized Cost[3] of Plant (Rmil/GWh)	0,40	0,74	0,13	1,43	1,42	0,70	0,54	0,96	2,25
O&M (jobs/GWh)	0,14	0,18	0,35	0,30	0,30	0,22	0,27	0,14	0,14
Construction/Installation (Job years/MW)	10,40	10,80	19,40	52,30	10,80	4,50	6,90	6,20	6,20
Manufacturing (Job years/MW)	1,50	1,20	0,90	16,80	7,20	22,50	0,80	0,07	0,07
Imported Content (%)	35 %	35 %	35 %	70 %	50 %	70 %	50 %	35 %	35 %
Value4 (R/GWh)	6 225	9 301	3 312	26 058	18 713	10 112	4 732	1 704	1 704
Fuel (Rmil/GWh)	0,08	0,07	0,00	0,00	0,00	0,00	0,00	0,60	2,39