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Energy
REPUBLIC OF SOUTH AFRICA

DRAFT INTEGRATED ENERGY PLANNING REPORT



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DRAFT IEP REPORT MODELLING RESULTS

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 - DOE objectives and indicators
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 - System costs
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 - Primary energy mix

PURPOSE OF MODELLING



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In the context of the following policy options:

- Emissions limits
- Minimum renewable energy target
- Carbon pricing

Quantify indicators for DoE objectives:

- Energy requirements and technology investments
 - Energy security and security of supply
- System costs
 - Affordability - minimise energy costs
- Carbon dioxide emissions and water consumption
 - Environmentally friendly energy supply
- Energy mix
 - Diversity - energy security



PURPOSE OF MODELLING

| Case Study Objective | Base Case | Emissions Limited Cases | | RE Target | Carbon Tax | Low Oil Price | High Oil Price |
|-------------------------|--------------------------------------------------------------------------|-------------------------|----------------------------|----------------------------------|------------|-------------------------------------------------------|------------------------------------------|
| | | Peak Plateau Decline | PPD + No Nuclear | | | | |
| Energy and technology | Determine energy requirements and technology investments based on demand | | | | | | |
| Costs | Minimise and quantify | | | | | | |
| | | | | | | Externality costs of Carbon emissions included | Sensitivity analysis of crude oil prices |
| Emissions | Quantify | | | | | | |
| | | | Constrain emissions | | | | |
| Water | Quantify | | | | | | |
| Energy Mix | Quantify | | | | | | |
| | | | | Specify Minimum RE target | | | |



SUMMARY OF RESULTS

| Case Study Objective \ | Base Case | Emissions Limited Cases | | RE Target | Carbon Tax | Low Oil Price | High Oil Price |
|---------------------------------------------------------------|-----------|-------------------------|------------------|-----------|------------|---------------|----------------|
| | | Peak Plateau Decline | PPD + No Nuclear | | | | |
| Total discounted cost R bn (2010) | 2 484 | 2 701 | 2 705 | 2 570 | 2 644 | 1 779 | 2 977 |
| Additional cost from Base Case | | 8.8 % | 8.9 % | 3.5 % | 6.4 % | -28.4% | 19.9% |
| Total emissions (Mt) | 22 101 | 16 811 | 16 807 | 20 418 | 19833 | 22 393 | 22 425 |
| Average annual CO ₂ emissions (Mt/a) | 539 | 410 | 409 | 510 | 498 | 546 | 546 |
| Total Water (Mt) | 12 538 | 9 630 | 9 845 | 11 800 | 12 043 | 13 019 | 11 048 |
| Total Primary Energy (PJ) | 289 912 | 249 197 | 249 359 | 282 741 | 262 348 | 292 907 | 297 956 |
| Meets emissions limits for electricity & liquid fuels sectors | ✗ | ✓ | ✓ | ✗ | ✗ | ✗ | ✗ |
| Meets RE target | ✗ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ |



TRANSPORT AND REFINING

| Case Study Technology | Base Case | Emissions Limited Cases | | RE Target | Carbon Tax | Low Oil Price | High Oil Price |
|---------------------------|------------|-------------------------|------------------|------------|------------|---------------|---------------------------------------------------------|
| | | Peak Plateau Decline | PPD + No Nuclear | | | | |
| Electric vehicles | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Hybrid vehicles | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Petroleum product imports | High <2020 | High | High | High <2020 | High <2020 | Low | Medium |
| New refining capacity | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ |
| New CTL | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | ✓ |
| New GTL | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✓ |
| Notes | | | | | | | Assumes crude oil and natural gas prices are not linked |

Emissions limits remove new coal to liquids as an option viable

ELECTRICITY GENERATION



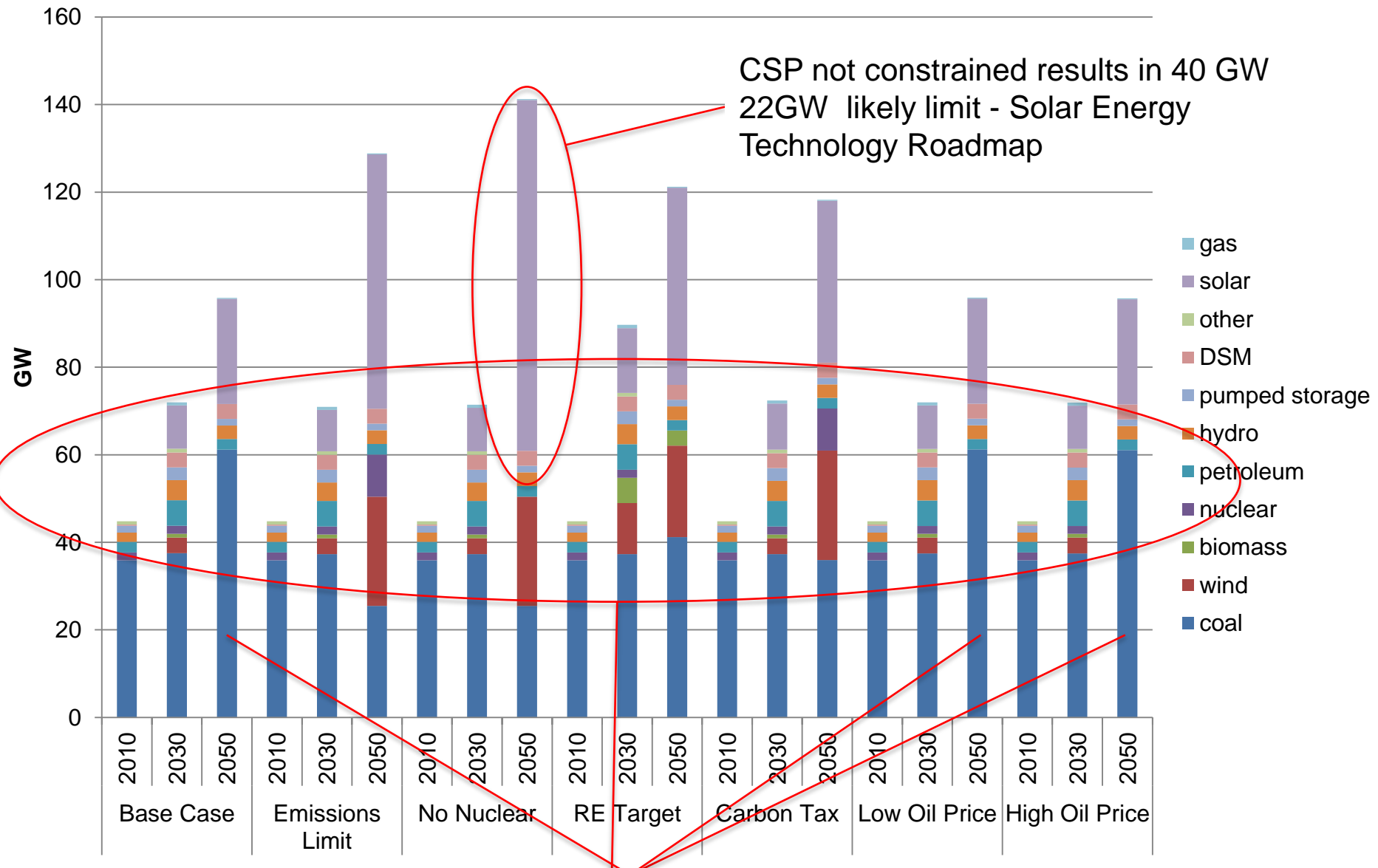
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| Case Study Share of energy mix into generation | Base Case | Emissions Limited Cases | | RE Target | Carbon Tax | Low Oil Price | High Oil Price | |
|------------------------------------------------------|-------------------|----------------------------|---------------------|-----------|------------|------------------|-------------------|-------|
| | | Peak Plateau Decline | PPD + No Nuclear | | | | | |
| 2010 | Coal | 95.6% | | | | | | |
| | Nuclear | 2.4% | | | | | | |
| | Hydro | 2.0% | | | | | | |
| | Solar | 0.0% | | | | | | |
| | Petroleum product | 0.0% | | | | | | |
| 2030 | Coal | 88.2% | 88.8% | 88.6% | 70.9% | 88.0% | 88.1% | 88.4% |
| | Hydro | 3.1% | 3.0% | 3.0% | 3.4% | 3.1% | 3.1% | 3.1% |
| | Solar | 2.7% | 2.8% | 2.9% | 4.6% | 2.9% | 2.7% | 2.8% |
| | Nuclear | 1.9% | 2.0% | 2.0% | 2.1% | 1.9% | 1.9% | 1.9% |
| | Biomass | 1.9% | 2.0% | 2.0% | 13.5% | 1.9% | 1.9% | 1.9% |
| | Petroleum product | 1.3% | 0.5% | 0.5% | 1.4% | 1.3% | 1.3% | 1.0% |
| | Wind | 0.9% | 1.0% | 1.0% | 4.0% | 0.9% | 0.9% | 0.9% |
| 2050 | Coal | 95.0% | 60.7% | 60.7% | 76.8% | 74.1% | 95.0% | 95.1% |
| | Solar | 3.6% | 20.1% | 29.4% | 11.1% | 9.4% | 3.6% | 3.6% |
| | Hydro | 1.0% | 1.6% | 1.6% | 1.2% | 1.4% | 1.0% | 1.0% |
| | Petroleum product | 0.3% | 0.4% | 0.4% | 0.4% | 0.4% | 0.3% | 0.2% |
| | Wind | 0.0% | 8.0% | 8.0% | 5.2% | 6.8% | 0.0% | 0.0% |
| | Biomass | 0.0% | 0.0% | 0.0% | 5.3% | 0.0% | 0.0% | 0.0% |
| | Nuclear | 0.0% | 9.2% | 0.0% | 0.0% | 7.9% | 0.0% | 0.0% |

RE target more effective in short term – more
Carbon tax more effective in long term
Emissions limits most effective in long term

Generation Capacity 2010, 2030, 2050



CSP not constrained results in 40 GW
22GW likely limit - Solar Energy
Technology Roadmap

: 2050 Base Case, Low Oil Price Case and
High Oil Price Case are similar – no
constraints or costs to emissions



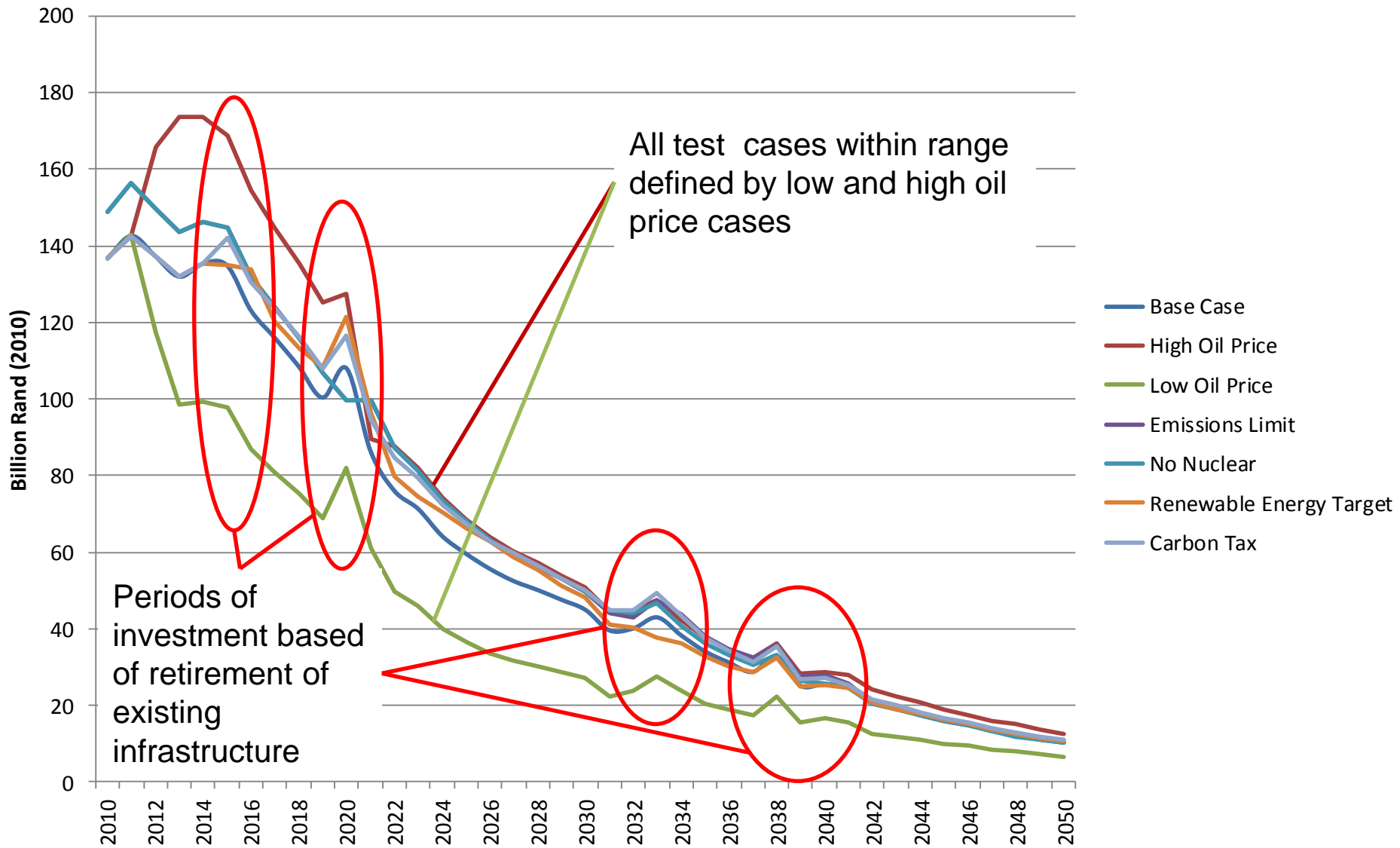
SYSTEM COSTS

| Component | Base Case | | Emissions Limit | | PPD No Nuclear | | RE Target | | Carbon Tax | | Low Oil Price | | High Oil Price | |
|----------------------------------------------|-------------|------|-----------------|------|----------------|------|-------------|------|-------------|------|---------------|------|----------------|------|
| | R'b 2010 | % | R'b 2010 | % | R'b 2010 | % | R'b 2010 | % | R'b 2010 | % | R'b 2010 | % | R'b 2010 | % |
| Total | 2484 | 100 | 2701 | 100 | 2705 | 100 | 2570 | 100 | 2644 | 100 | 1779 | 100 | 2977 | 100 |
| Imports | 1922 | 77.4 | 2187 | 81.0 | 2187 | 80.8 | 1922 | 74.8 | 1923 | 72.7 | 1209 | 68.0 | 2363 | 79.4 |
| Extraction/ Production | 208 | 8.4 | 188 | 7.0 | 188 | 7.0 | 187 | 7.3 | 197 | 7.4 | 207 | 11.6 | 207 | 7.0 |
| Electricity generation infrastructure | 189 | 7.6 | 199 | 7.4 | 203 | 7.5 | 297 | 11.5 | 310 | 11.7 | 189 | 10.6 | 189 | 6.3 |
| Liquid fuels production infrastructure | 129 | 5.2 | 92 | 3.4 | 92 | 3.4 | 129 | 5.0 | 179 | 6.8 | 138 | 7.8 | 183 | 6.2 |
| Storage, Transport and Distribution | 35 | 1.4 | 35 | 1.3 | 35 | 1.3 | 35 | 1.4 | 35 | 1.3 | 36 | 2.0 | 35 | 1.2 |

Additional costs due to greater imports due to no mining of coal for CTL

Additional costs due in part to carbon tax

Discounted costs





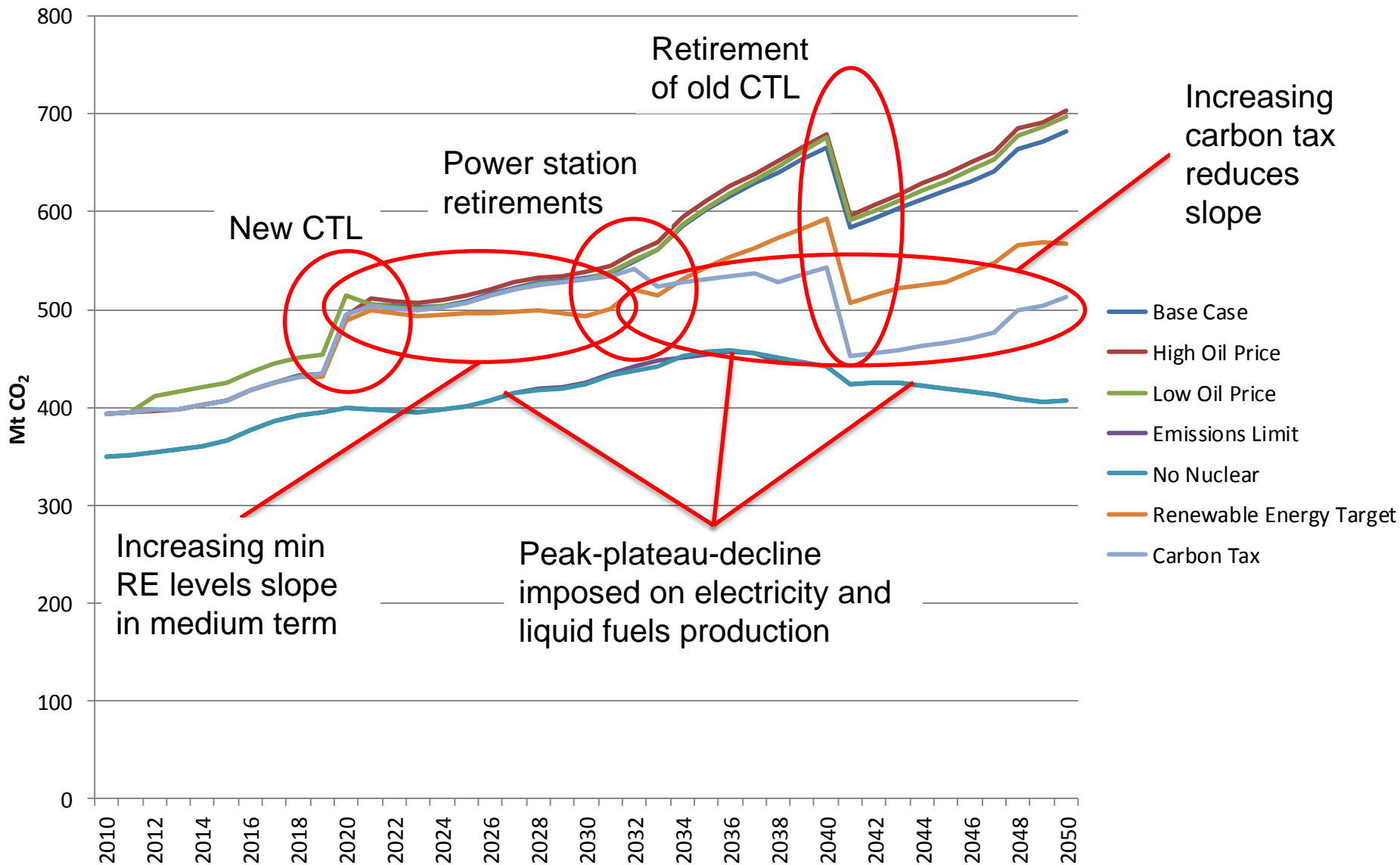
EMISSIONS

| | Base Case | Emissions Limit | PPD No Nuclear | RE Target | Carbon Tax | Low Oil Price | High Oil Price |
|-------------------------------------------------------------------|-----------|-----------------|----------------|-----------|------------|---------------|----------------|
| Total Discounted Cost | 2 484 | 2 701 | 2 705 | 2 570 | 2 644 | 1 779 | 2 977 |
| Difference in cost from Base Case (Rb) | | 218 | 222 | 87 | 160 | -705 | 494 |
| Difference in cost from Base Case (%) | | 8.8% | 8.9% | 3.5% | 6.4% | -28.4% | 19.9% |
| Model Period Emissions 2010-2050 (Mt) | 22 101 | 16 811 | 16 808 | 20 419 | 19 833 | 22 393 | 22 425 |
| Difference in emissions from Base Case (Mt) | | -5 290 | -5 293 | -1 682 | -2 268 | 292 | 324 |
| Average cost difference per tCO ₂ from Base Case (R/t) | | 41 | 42 | 52 | 71 | 2 411 | |

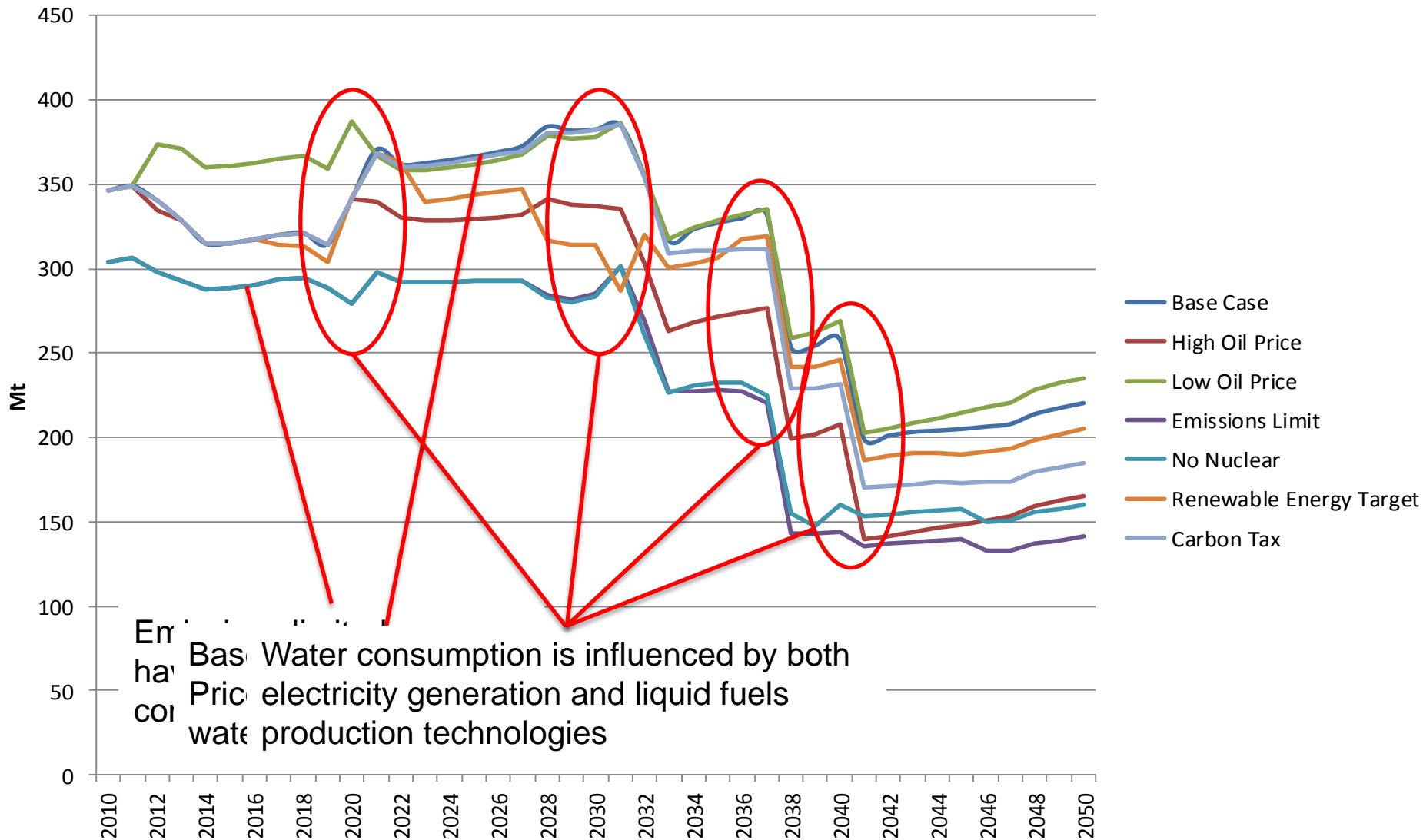
Carbon Tax Case - prices all carbon including final consumption

Emissions limited cases - applied to electricity and liquid fuels production

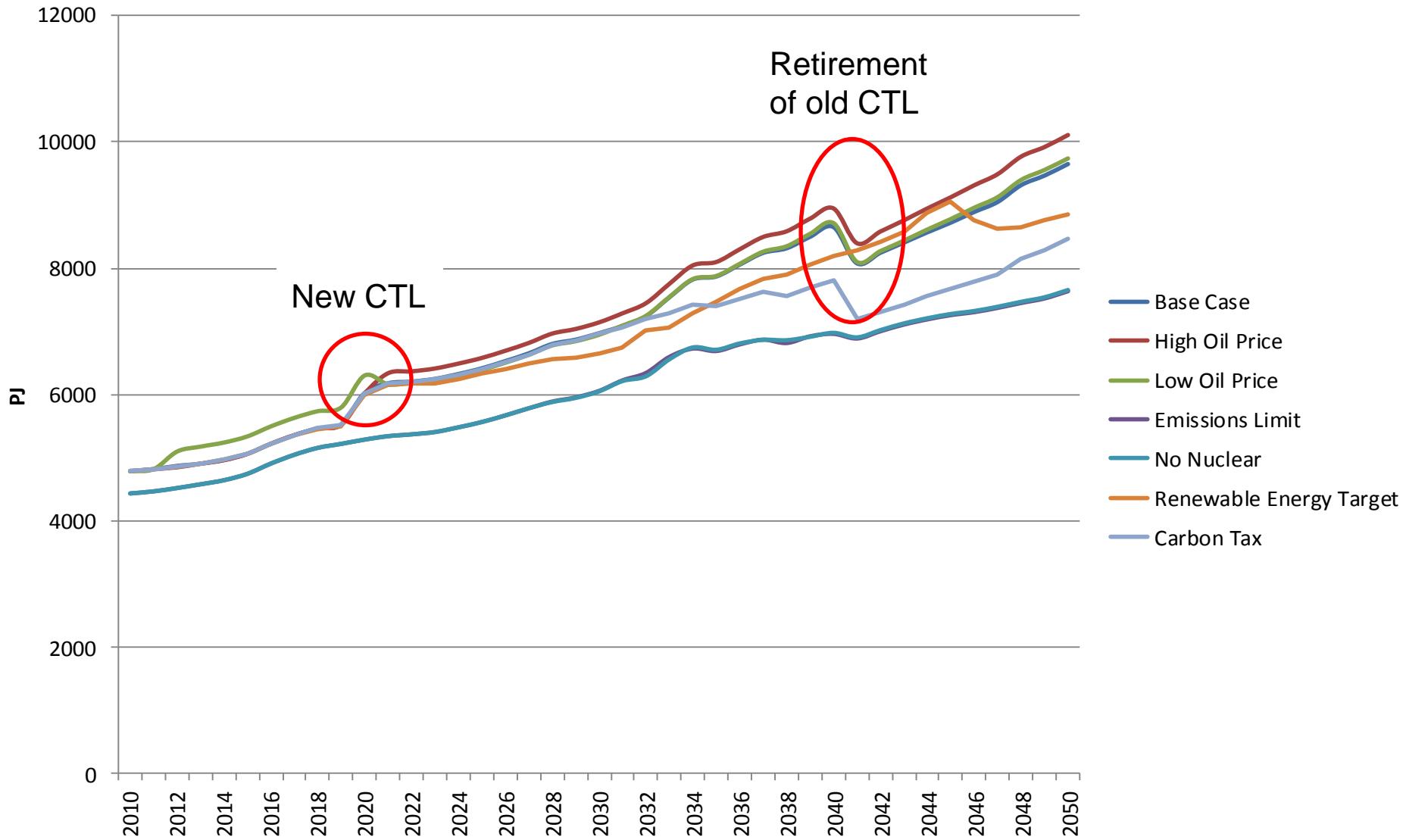
CO₂ Emissions for Test Cases



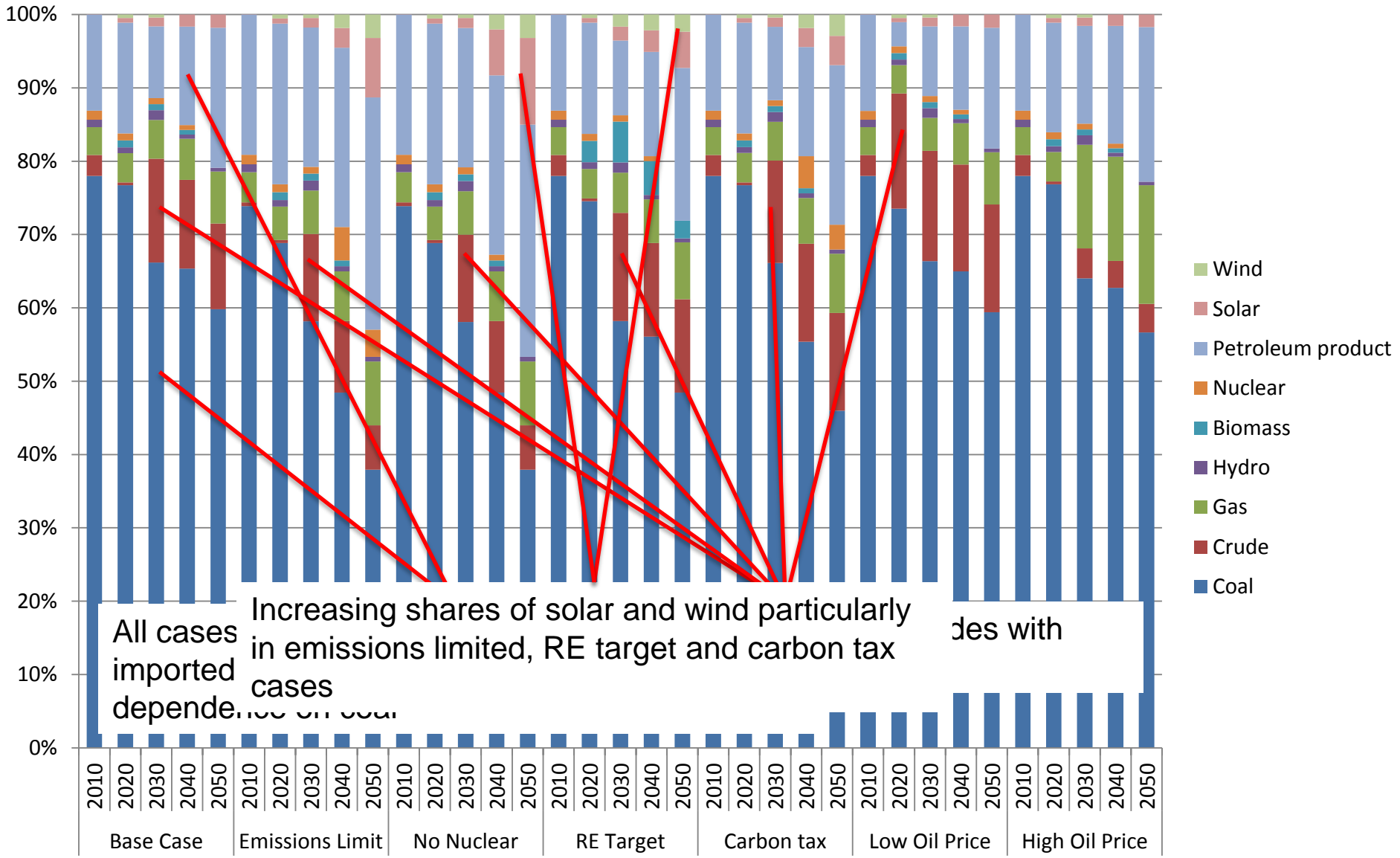
Water use for Test Cases



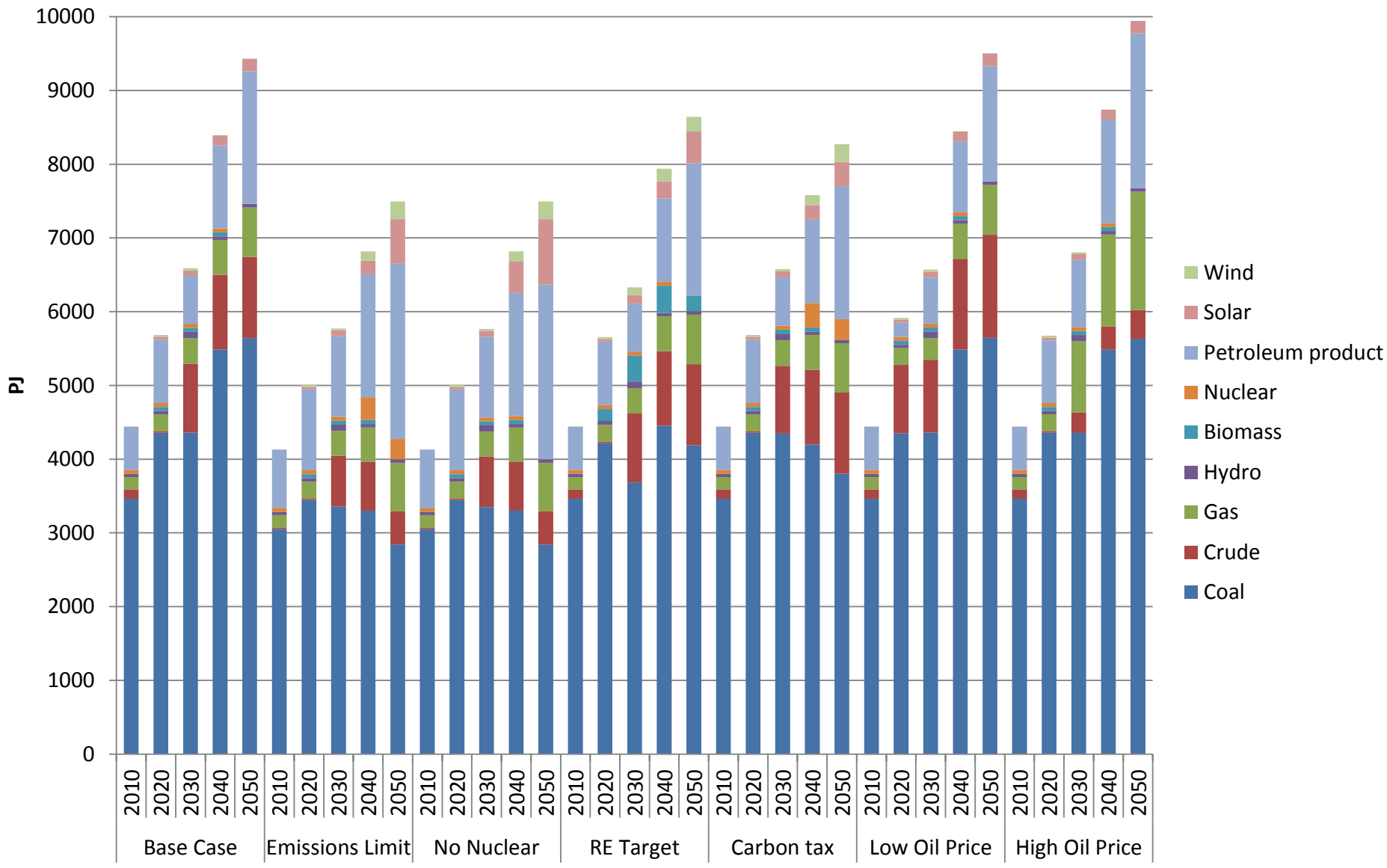
Primary Energy Use



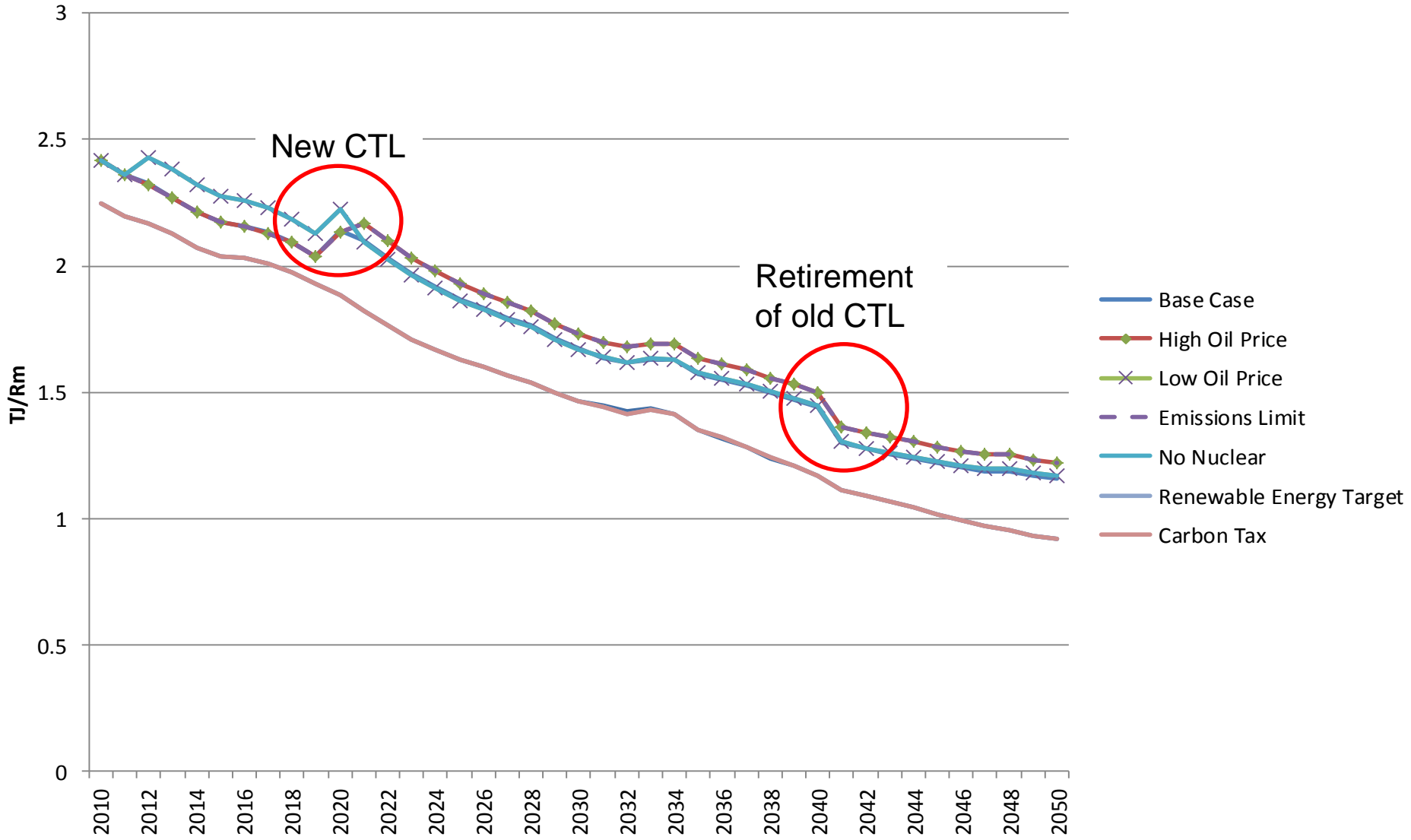
Primary Energy Use



Primary Energy Use



Energy Intensities for Test Cases





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