Baseline and alternative scenarios of final energy consumption in Cyprus until 2020, 2030 and 2050

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Final Energy Demand Model Outline

Sectors:

- Industry (split to Cement industry & Other industry)
- Households
- Tertiary sector
- Agriculture
- Road passenger – road freight transport (currently inactive, using output of TREMOD)
- Air transport

Fuels: Gasoline, automotive diesel, LPG, gas/diesel oil, light fuel oil, heavy fuel oil, aviation fuel, electricity, coal, renewables (solar thermal, geothermal, hydrogen, biofuels, biomass)

Final Energy Demand Forecast – 1

Final energy demand = Demand for substitutable energy + non-substitutable electricity: $EN_{i,t} = E_{i,t} + ELCNS_{i,t}$

$$E_{i,t} = E_{i,t-1} \cdot \left(1 - eff_{i,t}\right) \cdot \left(\frac{A_{i,t}}{A_{i,t-1}}\right)^{a_i} \cdot \left(\frac{ap_{i,t}}{ap_{i,t-1}}\right)^{\beta_{1i}} \cdot \left(\frac{ap_{i,t-1}}{ap_{i,t-2}}\right)^{\beta_{2i}} \cdot \prod_{r=2}^{7} \left(\frac{ap_{i,t-r}}{ap_{i,t-r-1}}\right)^{\varphi\left(\frac{r}{n}\right) \cdot \gamma_i}$$

eff: exogenous energy efficiency improvements

A: exogenous activity variable – real GDP for air and freight transport, real private consumption for passenger transport, value added for industry, services & agriculture

α: income elasticities

β: price elasticities (short- and long-term)

ap: weighted average energy price per sector: $ap_{i,t} = \sum_j (W_{i,j,t-1} \cdot p_{j,t})$

φ(): polynomial distributed lag: $\varphi(r/n) = \frac{6(n+1-r).r}{n(n+1)(n+2)}$

Final Energy Demand Forecast – 2

Demand for non-substitutable electricity:

$$ELCNS_{i,t} = ELCNS_{i,t-1}.\left(1 - eff_{i,lc,t}\right).\left(\frac{A_{i,t}}{A_{i,t-1}}\right)^{\alpha e_1}.\left(\frac{p_{elc,t}}{p_{elc,t-1}}\right)^{\beta e_1}.\left(\frac{p_{elc,t-1}}{p_{elc,t-2}}\right)^{\beta e_2}$$

Notations are similar with those of variables & parameters of equation for $E_{i,t}$

Exogenous price of fuel *j* in year *t*: $p_{j,t} = p_{j,t-1} + ppa_j \cdot \left(p_{oil,t} - p_{oil,t-1}\right) + r_{j,t}$

p_{oil}: international crude oil price (Euros'2005/toe)

ppa: estimated parameter linking fluctuations in crude oil prices with those of national price of fuel *j*

r: exogenous adjustment to account for policy 'shocks' – e.g. changes to fuel taxes or introduction of carbon tax

ΕΕΡ

ΤΕΧΝΟΛΟΓΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΥΠΡΟΥ 2004

Final Energy Demand Forecast – 3

Final energy demand by sector and fuel, for equipment that survives from the previous year:

$$\overline{E_{ijt}} = E_{i,j,t-1} \cdot \left(1 - eff_{i,t}\right) \cdot \left(\frac{A_{i,t}}{A_{i,t-1}}\right)^{a_i} \cdot \left(\frac{ap_{i,j,t}}{ap_{i,j,t-1}}\right)^{\beta_{1i}} \cdot \left(\frac{ap_{i,j,t-1}}{ap_{i,j,t-2}}\right)^{\beta_{2i}} \cdot \prod_{r=2}^{7} \left(\frac{ap_{i,t-r}}{ap_{i,t-r-1}}\right)^{\varphi\left(\frac{r}{n}\right)\cdot\gamma_i} \cdot \frac{LF_{ij}-1}{LF_{ij}}$$

LF: lifetime of equipment using fuel/technology *j*

Demand for final energy coming from new equipment:

$NEW_{it} = E_{it} - \sum_j \overline{E_{ijt}}$; two cases are distinguished:

$NEW_{it} > 0 \; then \; E_{ijt} = \overline{E_{ijt}} + s_{ijt} . NEW_{it}$ $\qquad$ $NEW_{it} \leq 0 \; then \; E_{ijt} = E_{ijt-1} \cdot \frac{E_{it}}{E_{it-1}}$

s: share of fuel/technology *j* in new energy-using equipment

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Final Energy Demand Forecast – 4

Determination of fuel/technology share *s* by sector & year:

$$S_{ijt} = W_{ijt} \frac{\left(\frac{d_i e^{d_i LF_{it}}}{e^{d_i LF_{it-1}}} . CC_{ijt} + FC_{ijt} + (VC_{ijt} + \frac{p_j}{eff_{ijt}}) / CONV_{ijt} \right)^{\gamma_1}}{SUM_{it}}$$

with $$SUM_{it} = \sum_j w_{ijt} . \left[\frac{d_i e^{d_{iLF_{it}}}}{e^{d_i LF_{it-1}}} . CC_{ijt} + FC_{ijt} + (VC_{ijt} + \frac{p_j}{eff_{ijt}}) / CONV_{ijt} \right]^{\gamma_1}$$

CC, FC, VC: capital costs, fixed & variable O&M costs

d: discount rate

w: technology 'maturity factor'

eff: 'efficiency' factor depending on sector

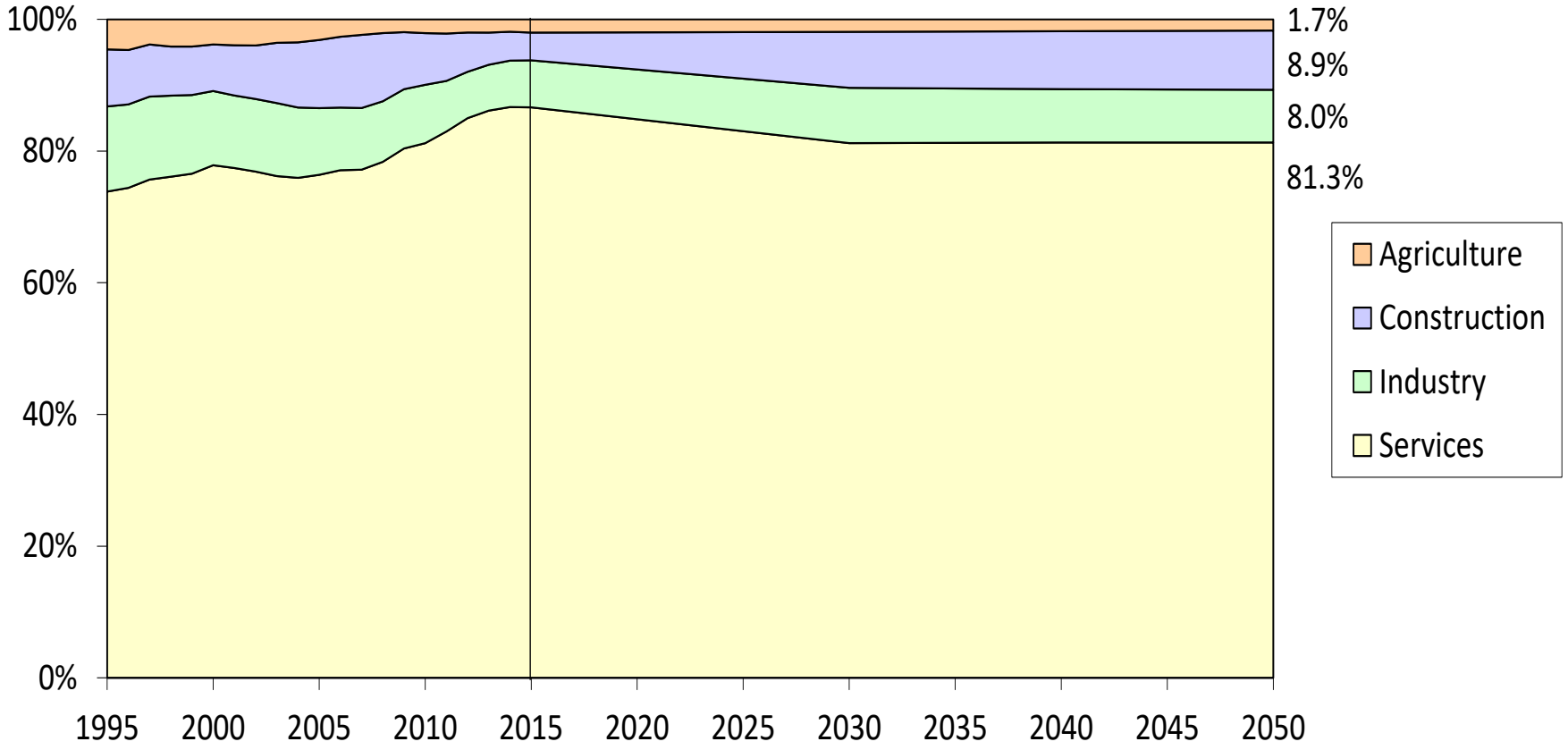
CONV: conversion factor depending on sector

Data Requirements for the Model – 1

- Macroeconomic data:
  - Past data from National Statistical Service (Cystat) – National Accounts as of October 2016
  - Future assumptions based on projections of Finance Ministry of Cyprus (as of November 2016)

	Actual values in 2015	*Forecast of real growth rates (average over each period)*			
	(m EUR)	*2016-2020*	*2020-2030*	*2030-2040*	*2040-2050*
GDP	15 355	2.8%	2.5%	2.3%	2.3%
Private consumption	10 376	2.1%	2.2%	2.3%	2.3%

Macroeconomic Assumptions for the Energy Forecast



Data Requirements for the Model – 2

- Fuel prices:
  - Past data up to 2014/15 from National Statistical Service (Cystat)
  - Future assumptions based on IEA medium forecast ('New Policies Scenario') from World Energy Outlook 2016 (Nov. 2016):
  - Crude oil price expected to reach $79 per barrel in 2020, $111 per barrel in 2030 and $124 per barrel in 2040 (at 2015 prices)
  - Future national fuel prices to evolve in line with crude oil price forecast – no 'policy shocks' in fuel taxation are assumed

Reference Scenario

- The Reference Scenario includes all relevant policies and measures that have already been implemented or are officially planned to be adopted by the government of Cyprus in the near future.
- The timeline of implementation of these measures is consistent with MECIT plans. More specifically:

Reference Scenario Measures

- Implementation of Energy Labelling Directive (2010/30/EC)
- Implementation of Energy Efficiency Directive (2012/27/EU):
  - Renovations and other measures of upgrading energy efficiency in buildings owned and used by the central government – up to 2020.
  - Energy efficiency requirements on purchasing by public bodies
  - Energy efficiency measures in street lighting
  - Obligation for energy audits for non-SMEs
  - Implementation of measures for the achievement of the obligatory target for energy savings at end use level by 2020, as set by article 7 of the Directive. No additional post-2020 measures are assumed.
  - Energy efficiency information and education measures.

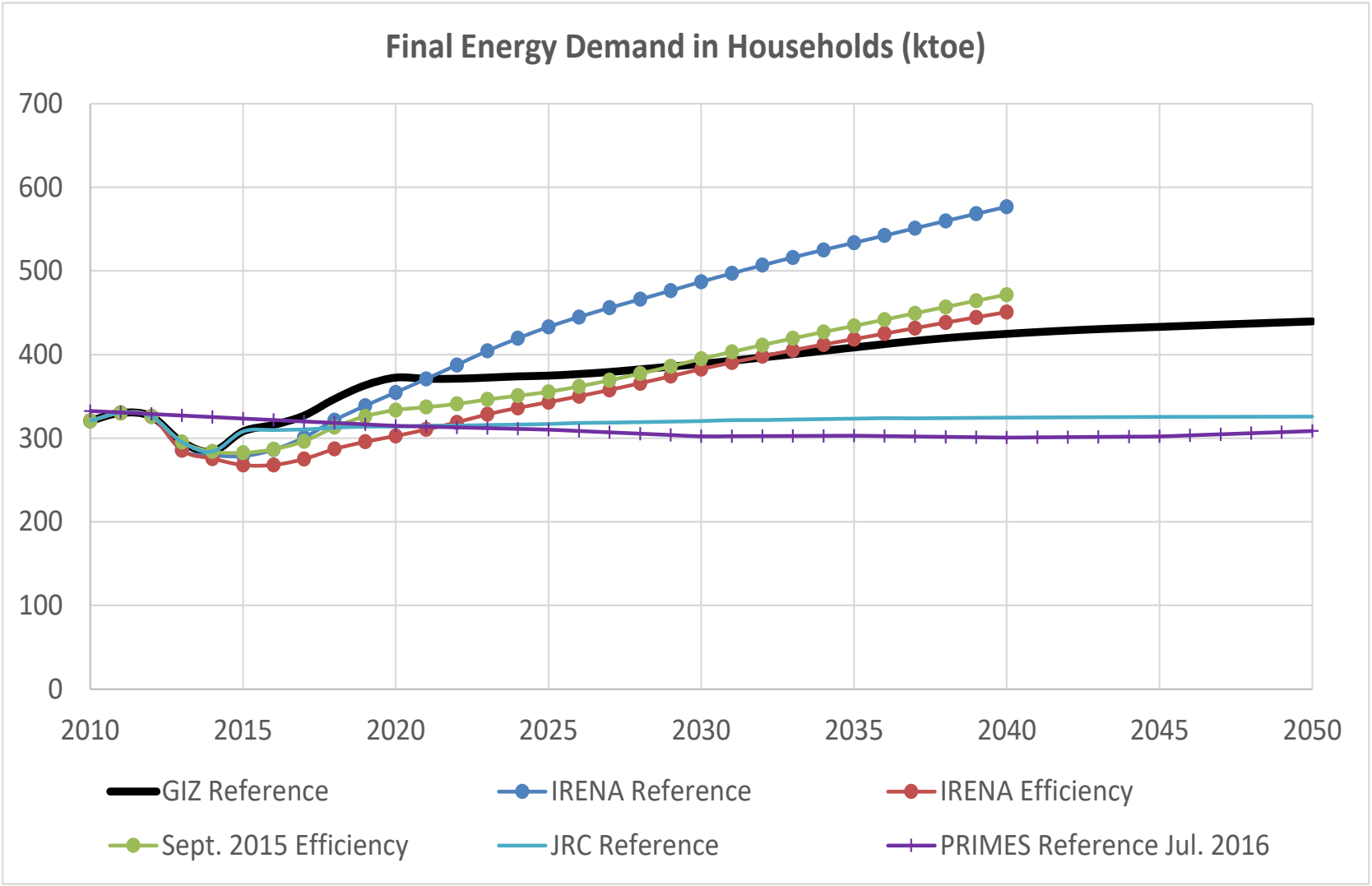
Reference Scenario Measures – 2

- Implementation of Energy Buildings Directive (2010/31/EC) and more specifically:
  - Regular inspections of central heating systems with boiler and air-conditioning systems in large buildings.
  - The implementation of new, more stringent minimum energy performance requirements by 2017 as an intermediate step towards NZEB.
  - Requirements in energy performance, operation, adjustment and control of technical building systems installed in existing buildings.
  - The requirement to issue energy performance certificates for sale and rent of buildings and apartments.

Reference Scenario Measures – 3

- Aggregate final electricity demand was calibrated to be in line with latest official electricity forecast for 2016-2025 that was prepared by the TSO and approved by the Cyprus Regulatory Authority for Energy in 2016.
- Energy-intensive investments implicitly taken into account
- Measures NOT considered:
  - Use of natural gas in power generation and in end uses
  - Electrical interconnection of Cyprus with other countries
  - Construction of a LNG terminal in Cyprus

Reference Scenario Results



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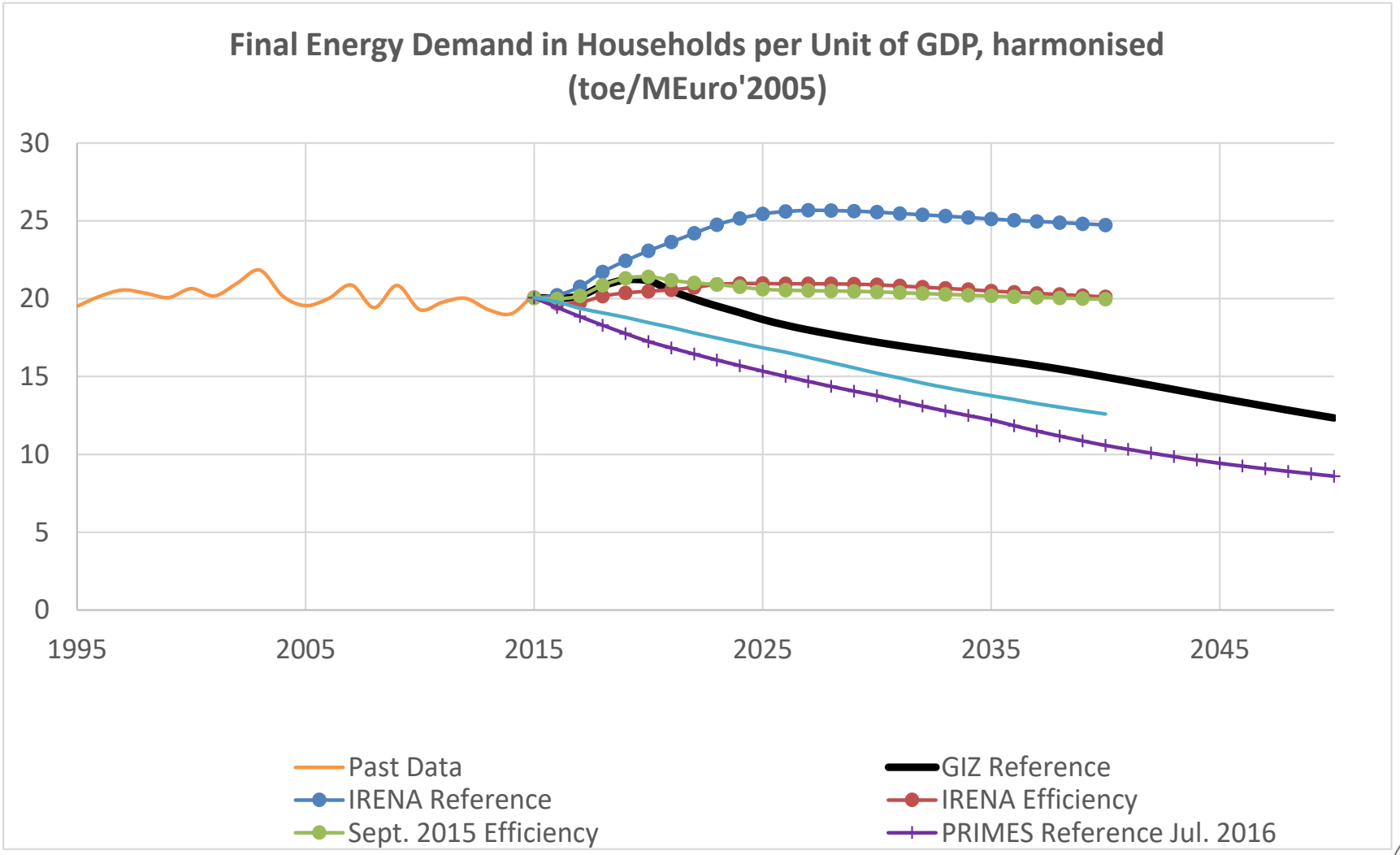

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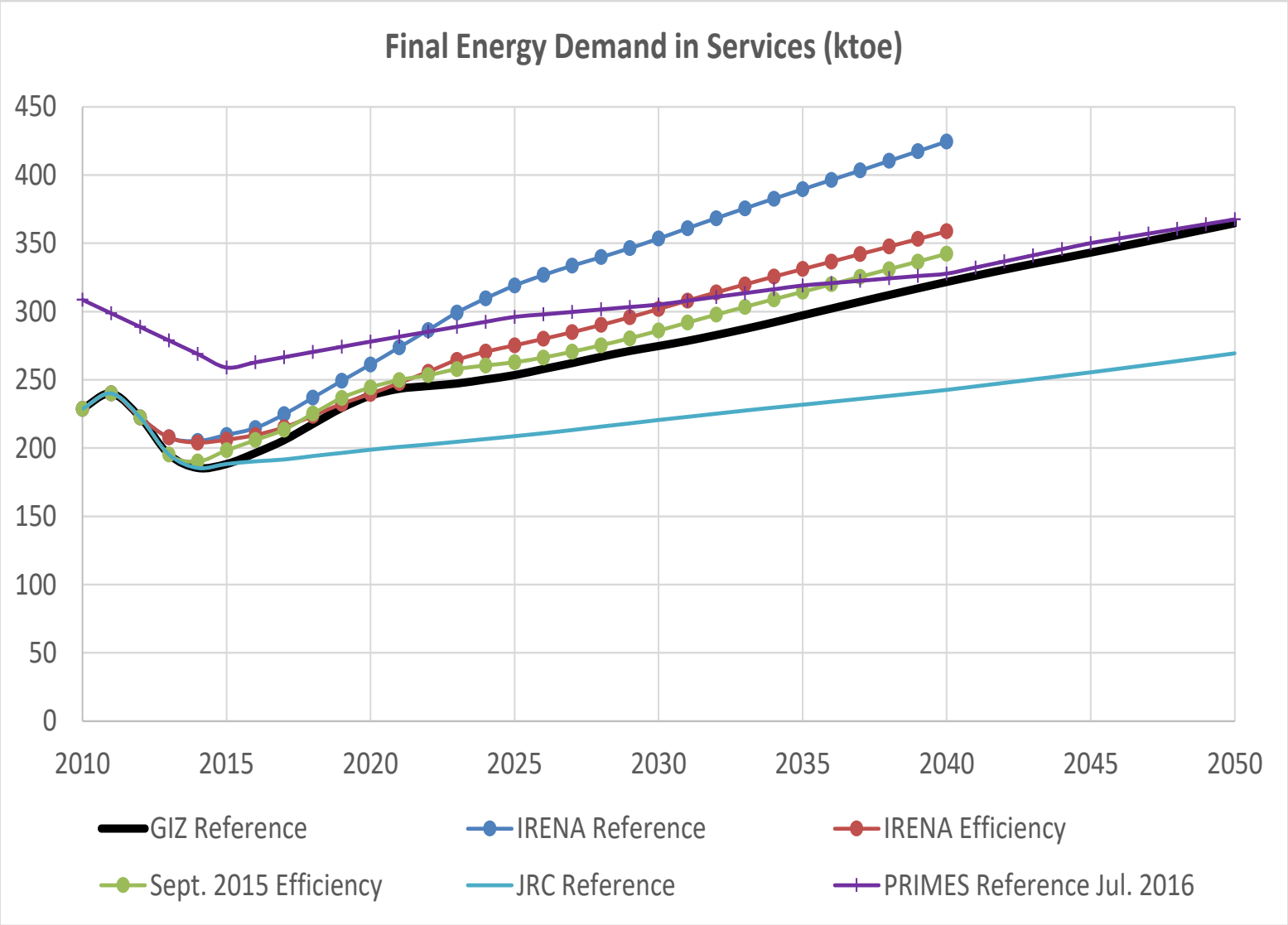

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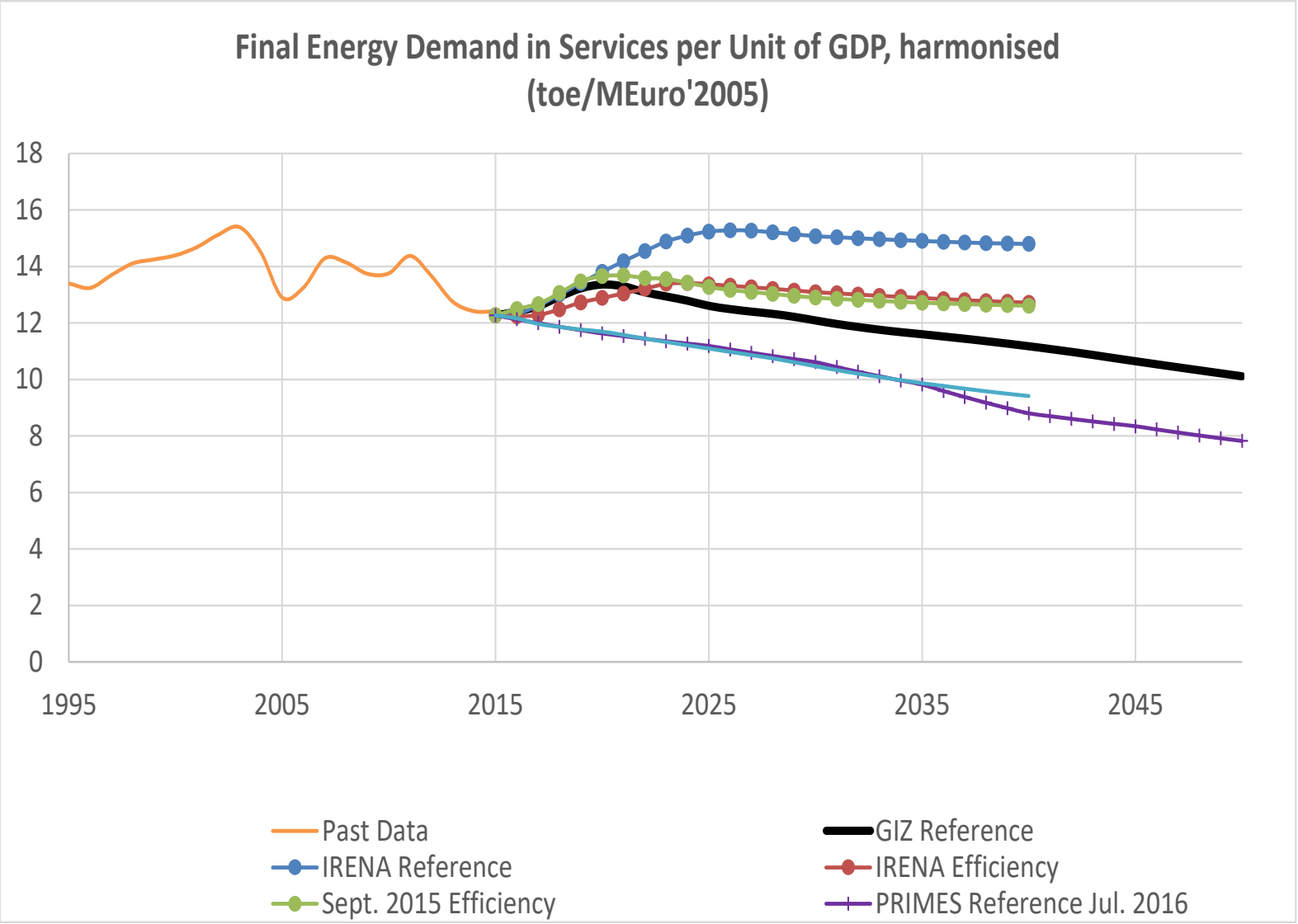

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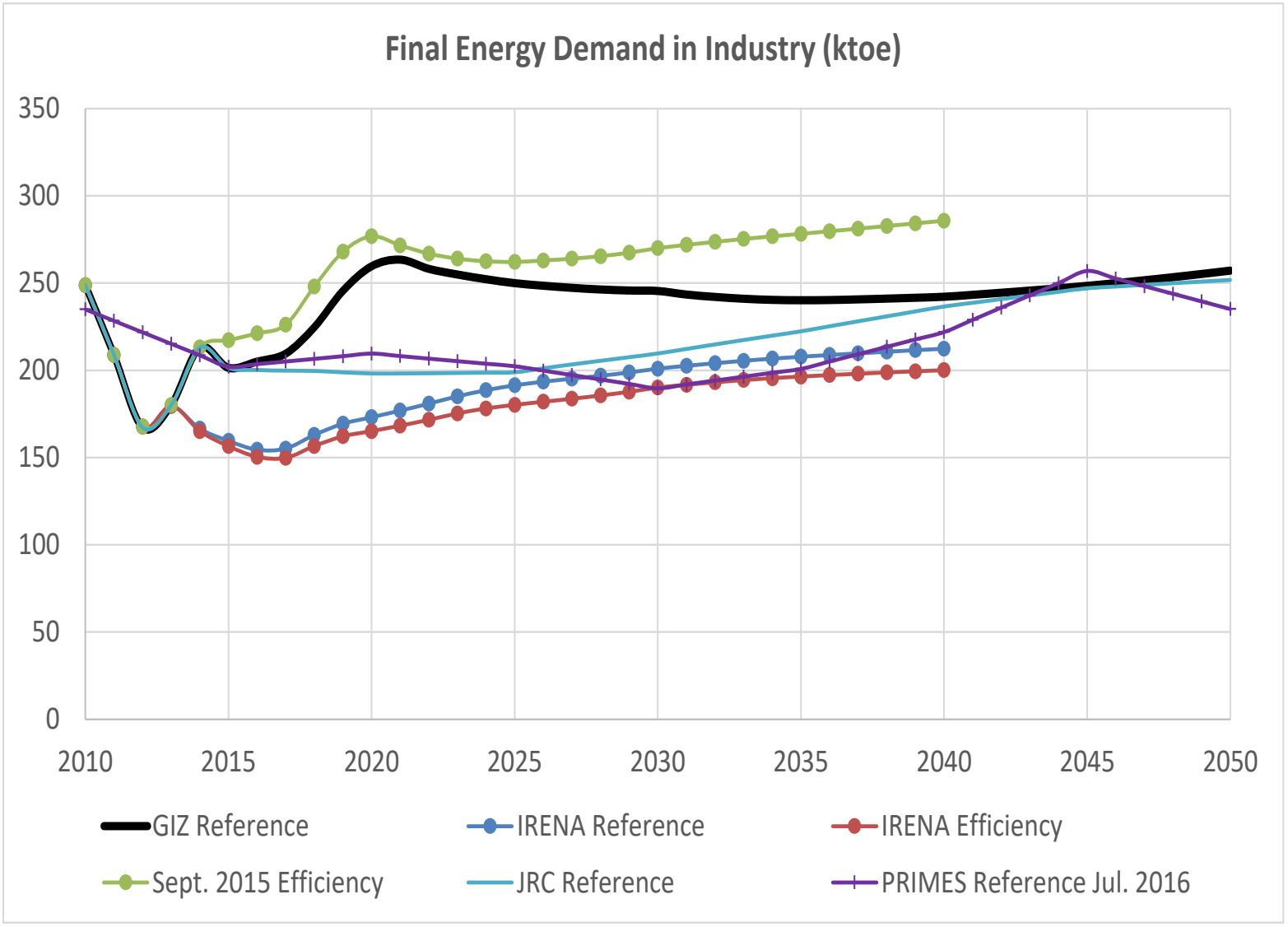

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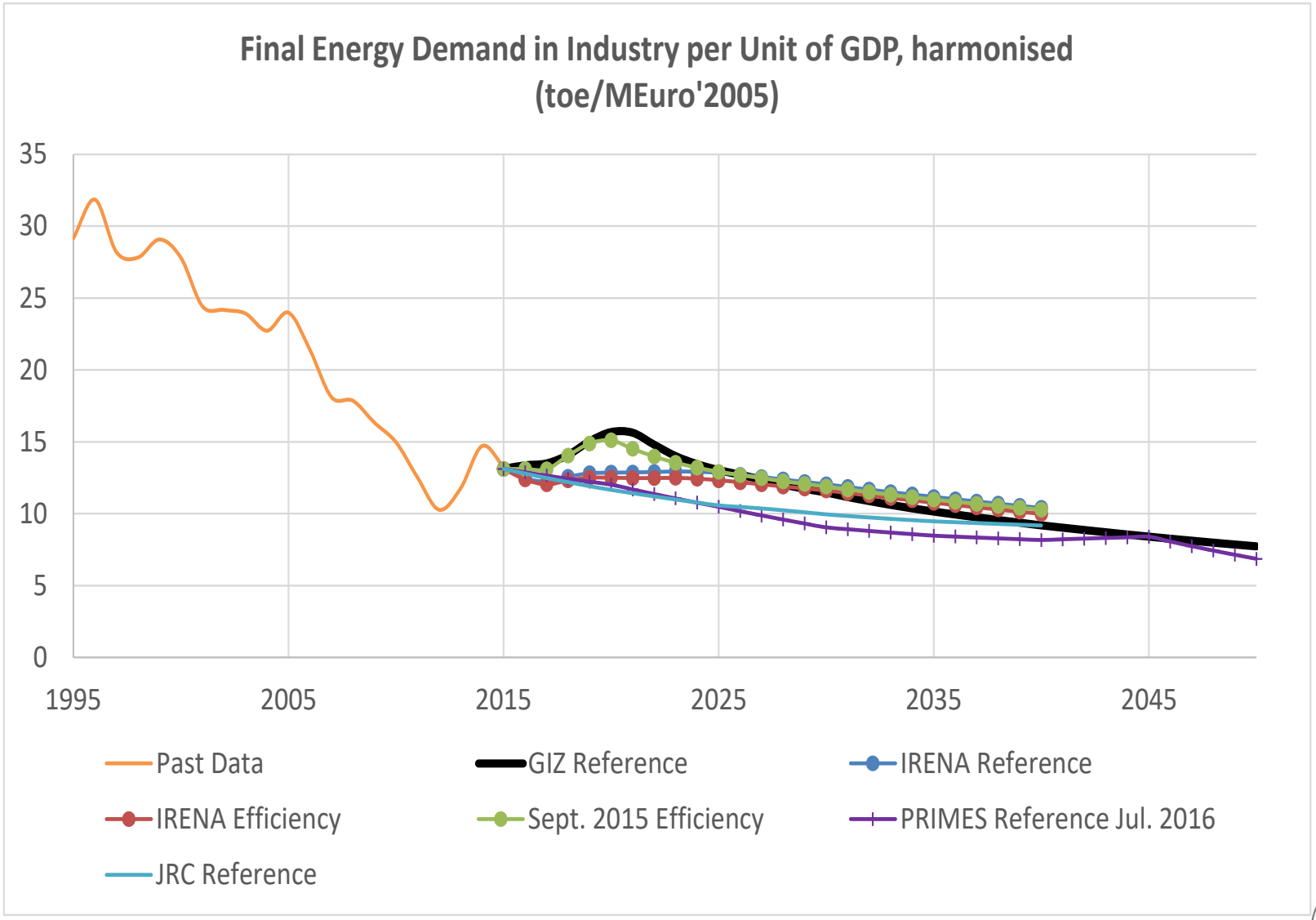

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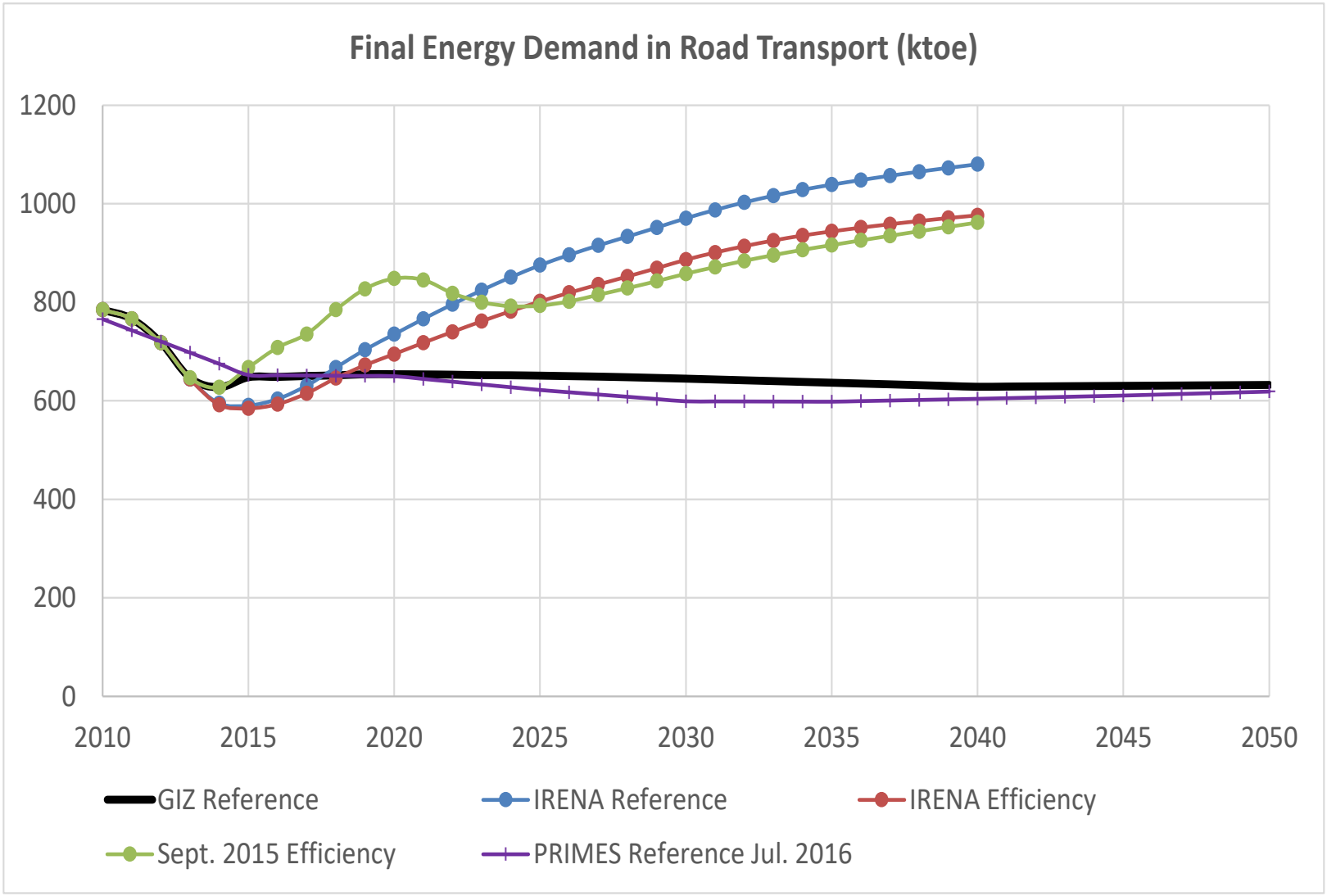

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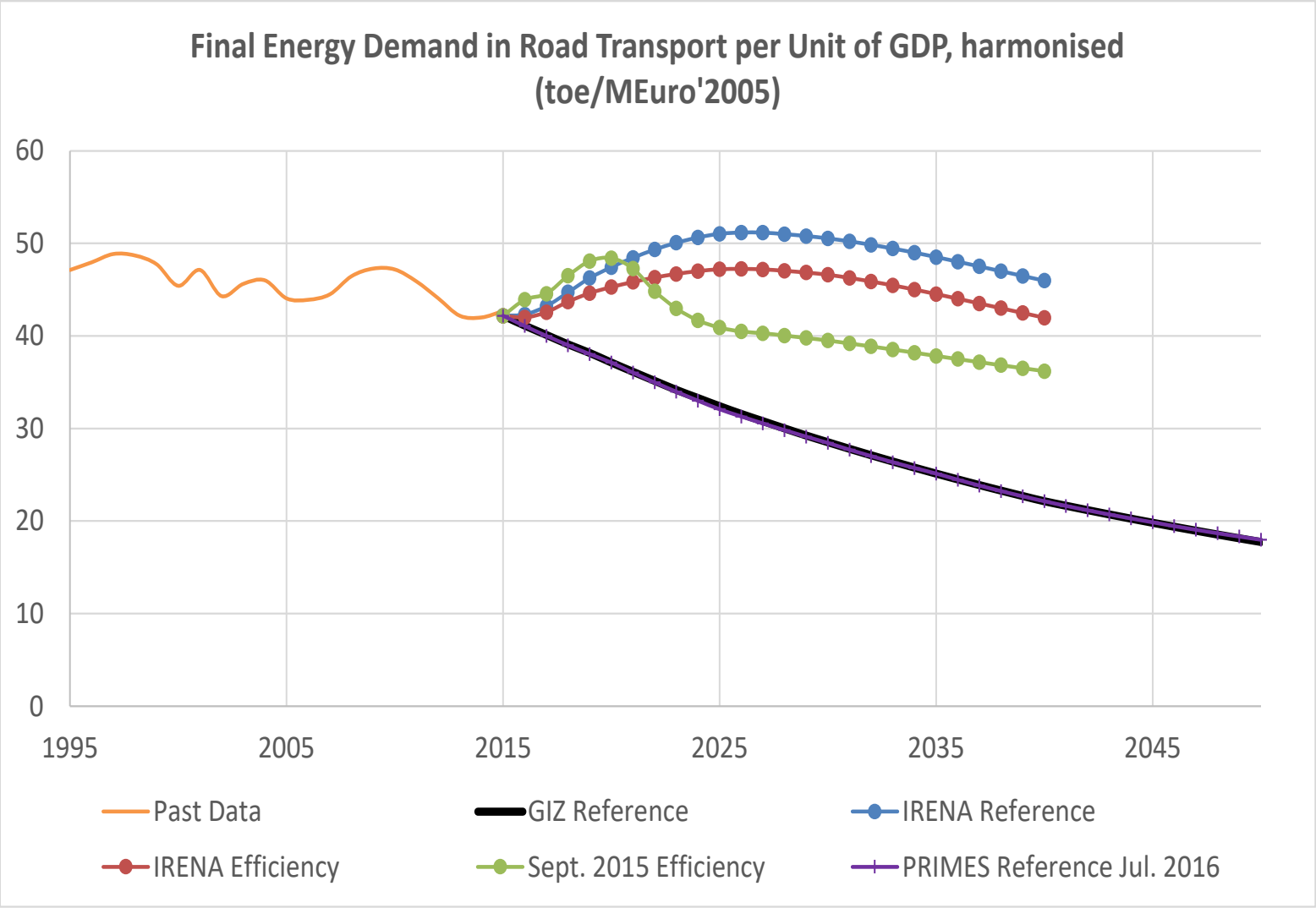

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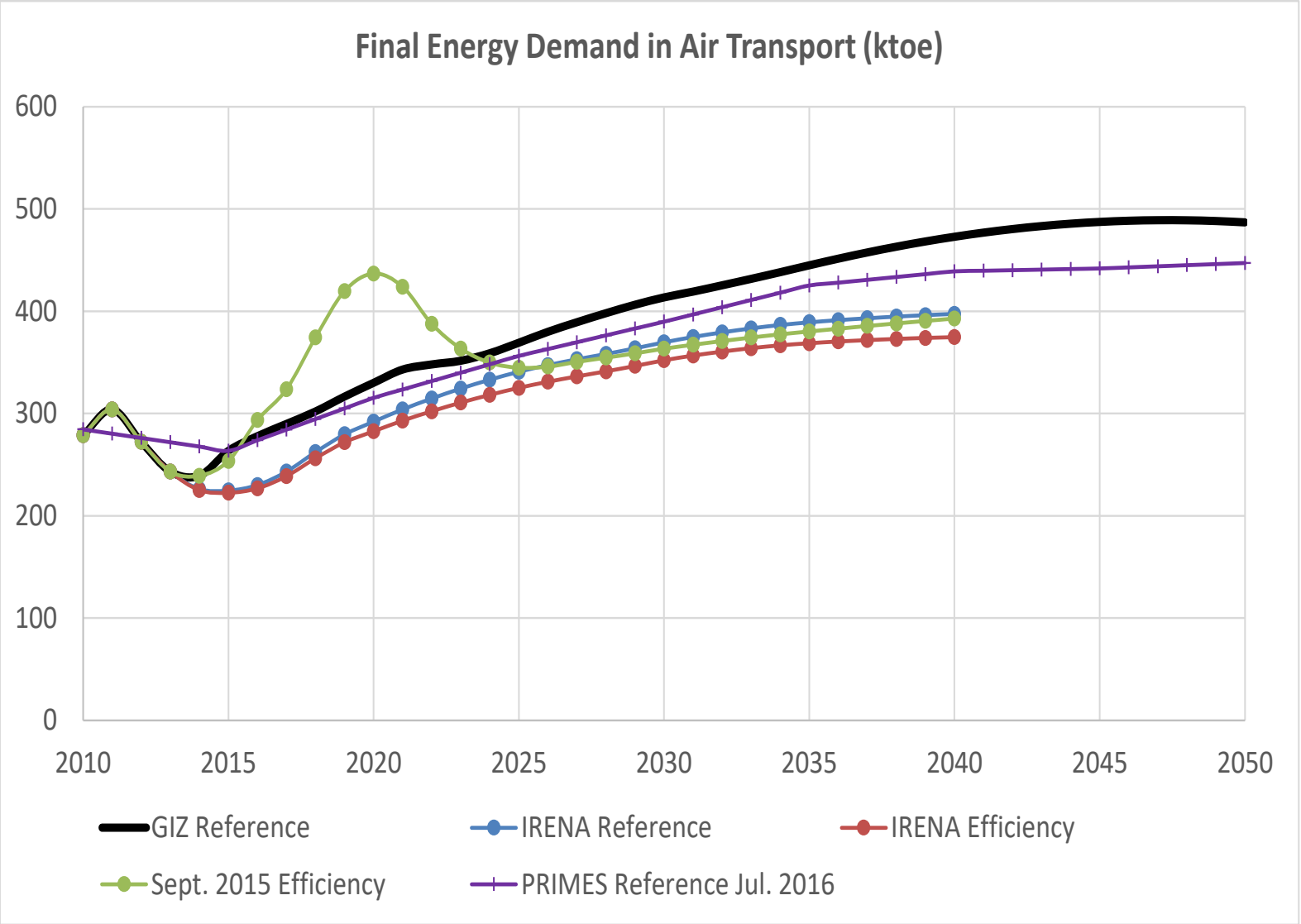

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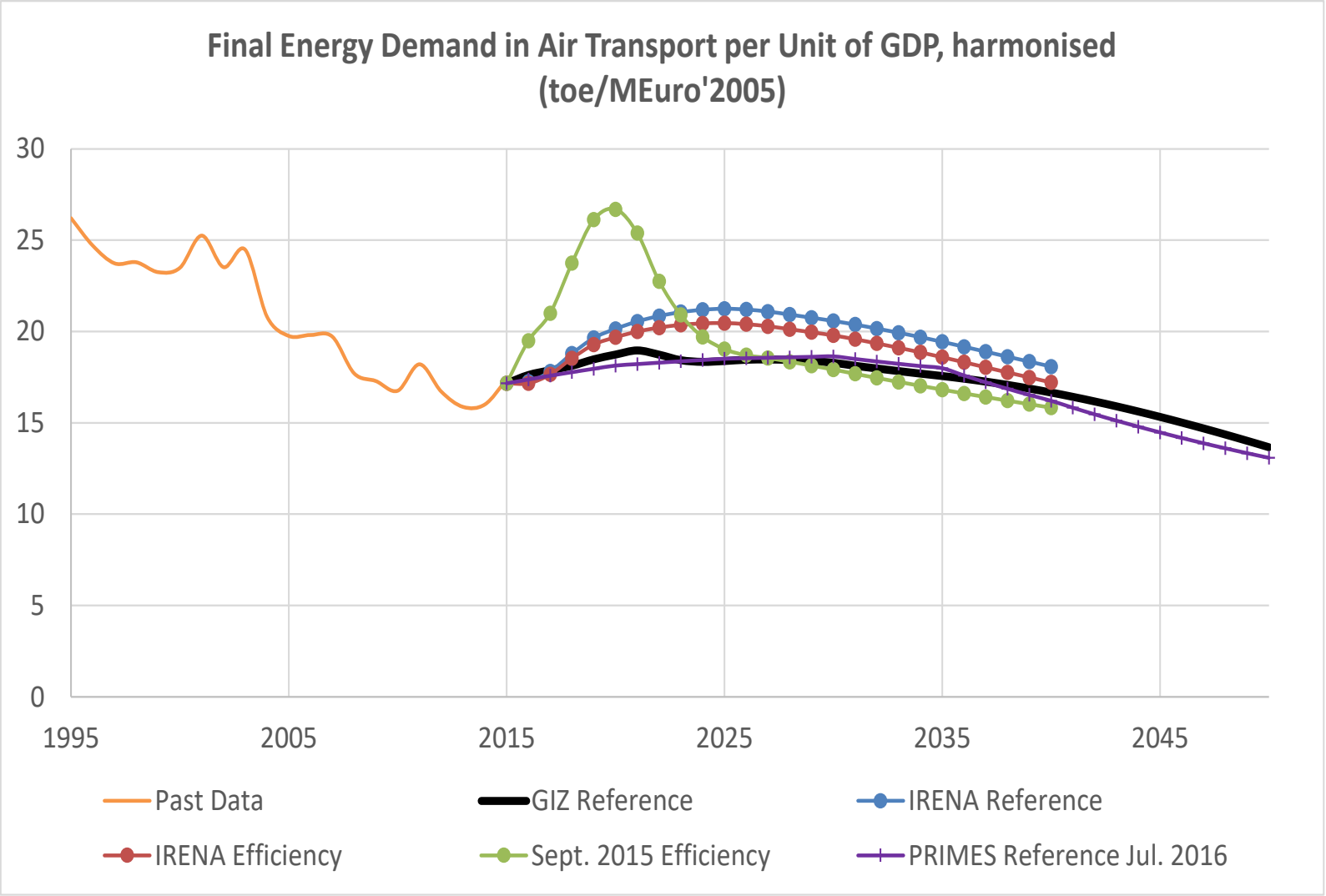

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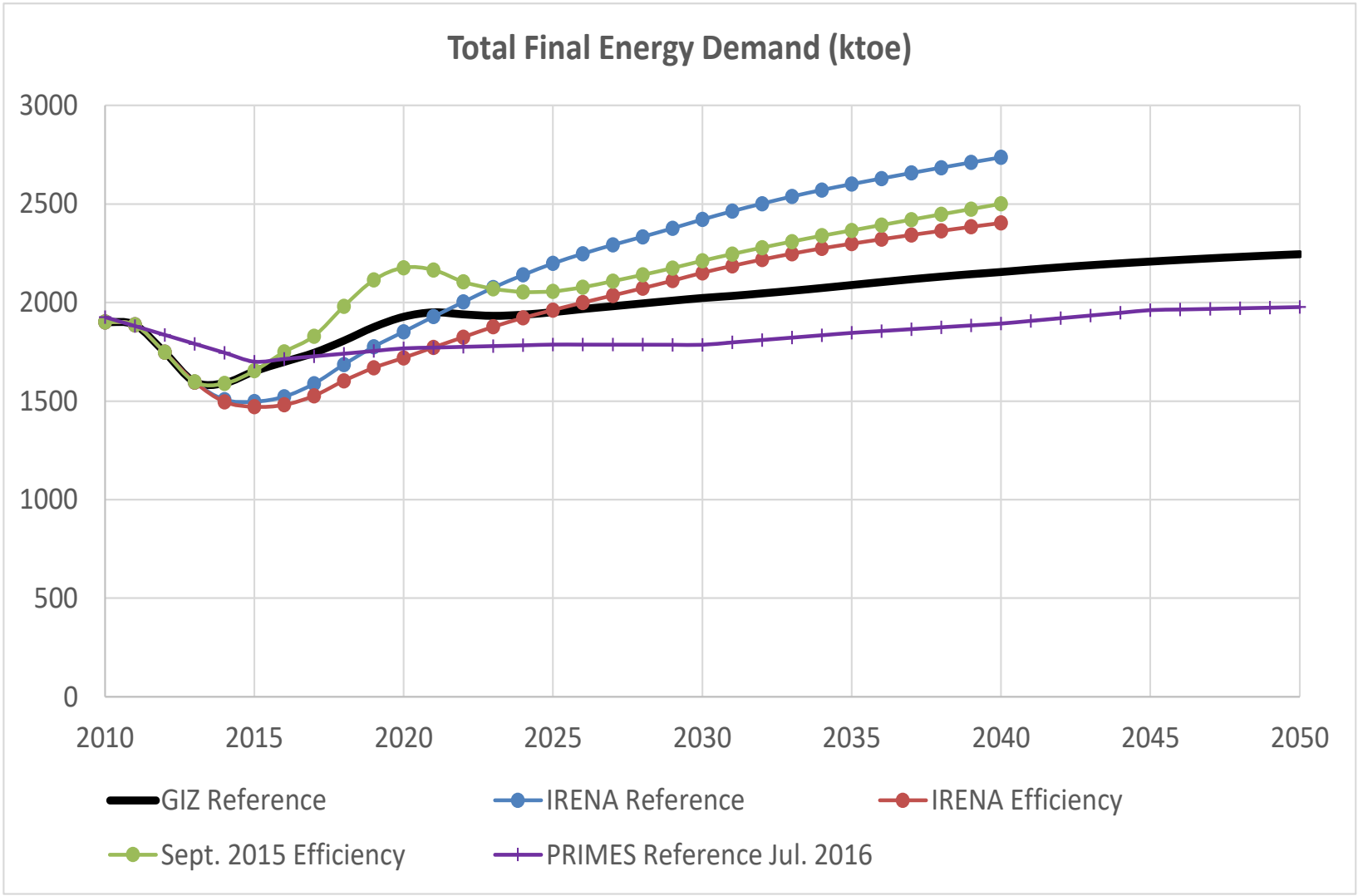

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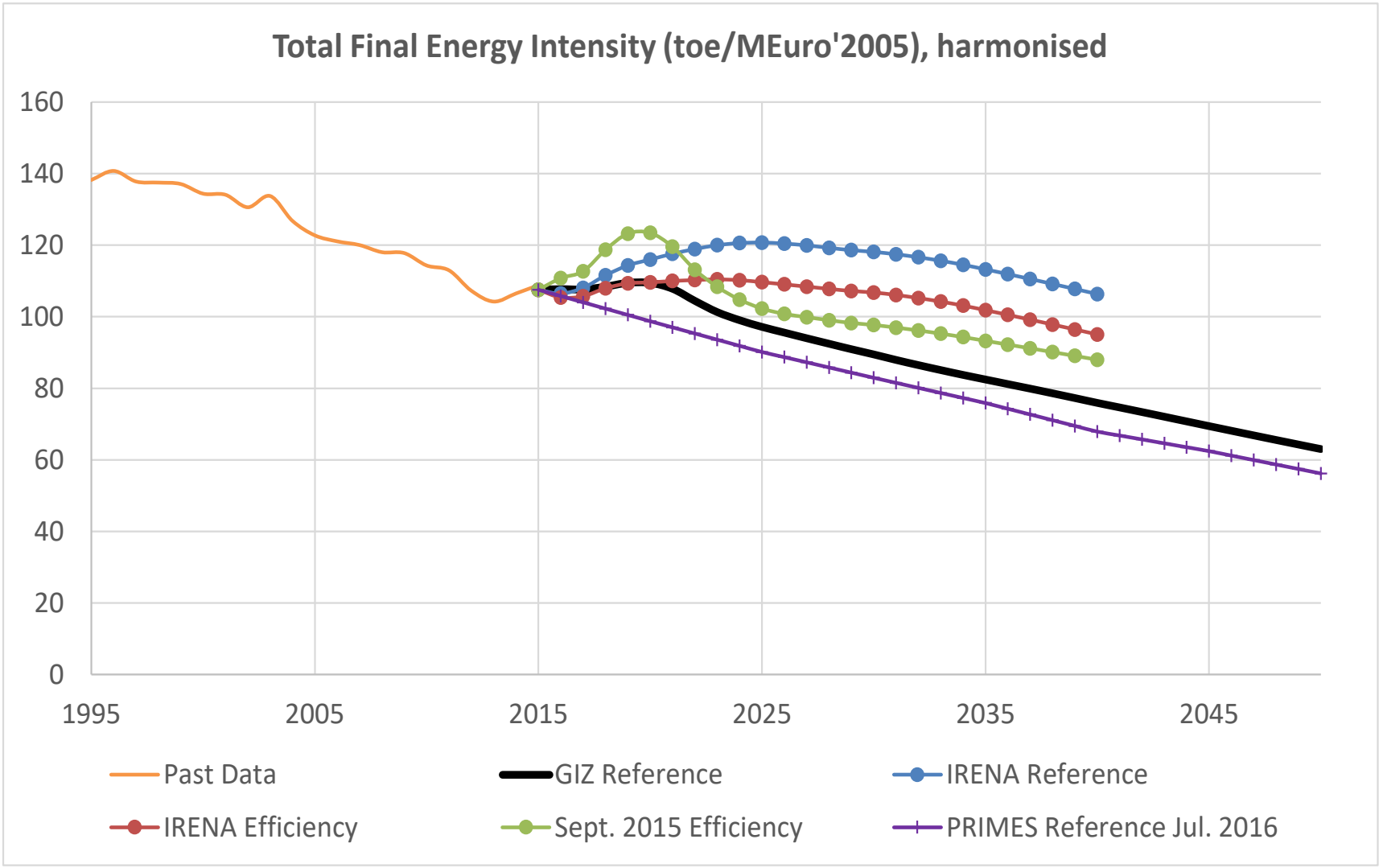
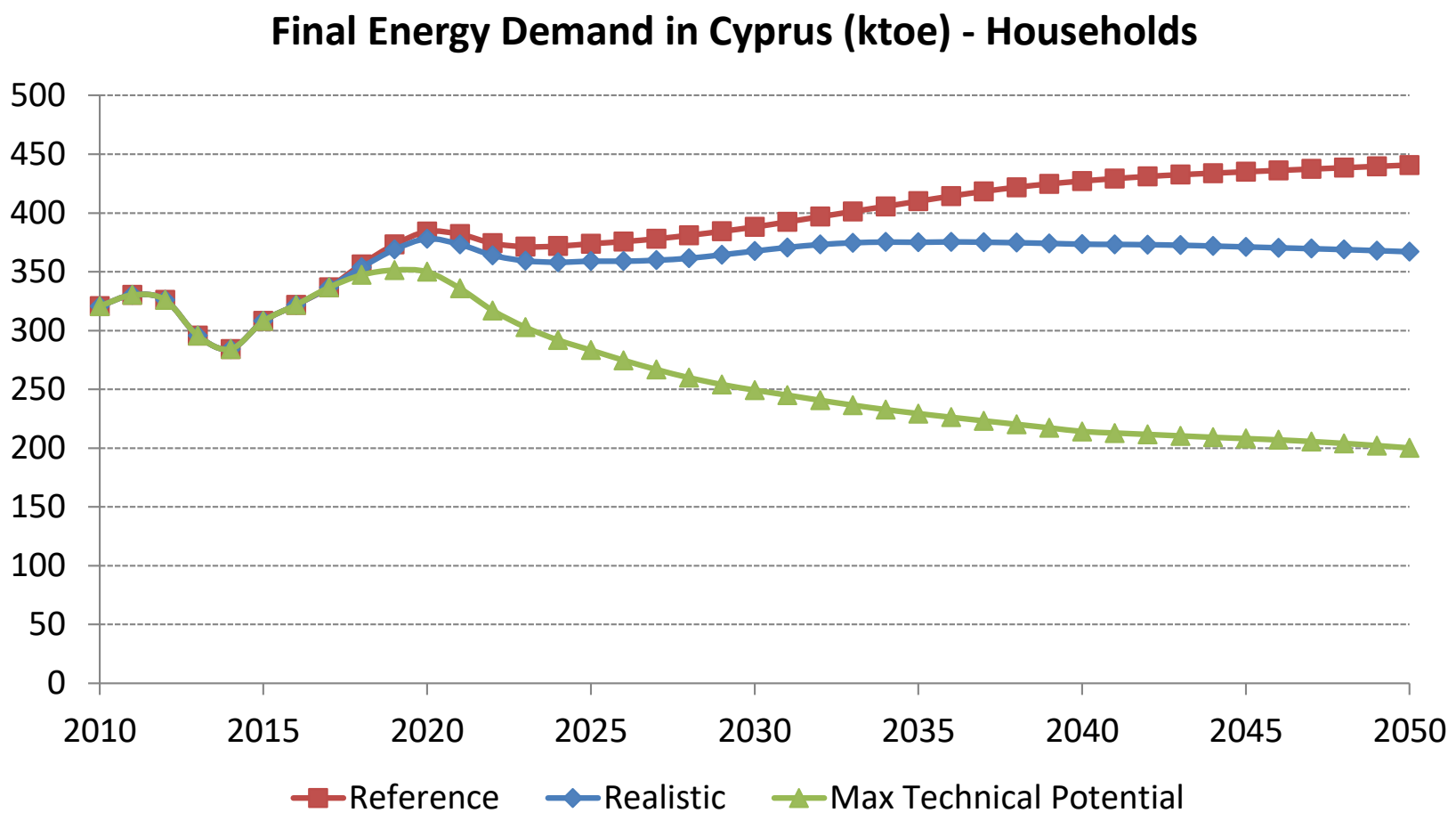


Alternative Scenarios

Based on the theoretical and economically viable energy efficiency potential identified in our study for each sector, two additional scenarios were developed:

- Maximum Technical Potential Scenario
  (assuming 90-95% implementation of theoretical potential up to 2040 and further improvements afterwards)
- Realistic Scenario
  (assuming achievement of economically viable potential by 2030/2040 depending on the sector, and further modest improvements afterwards)

Scenario Comparisons



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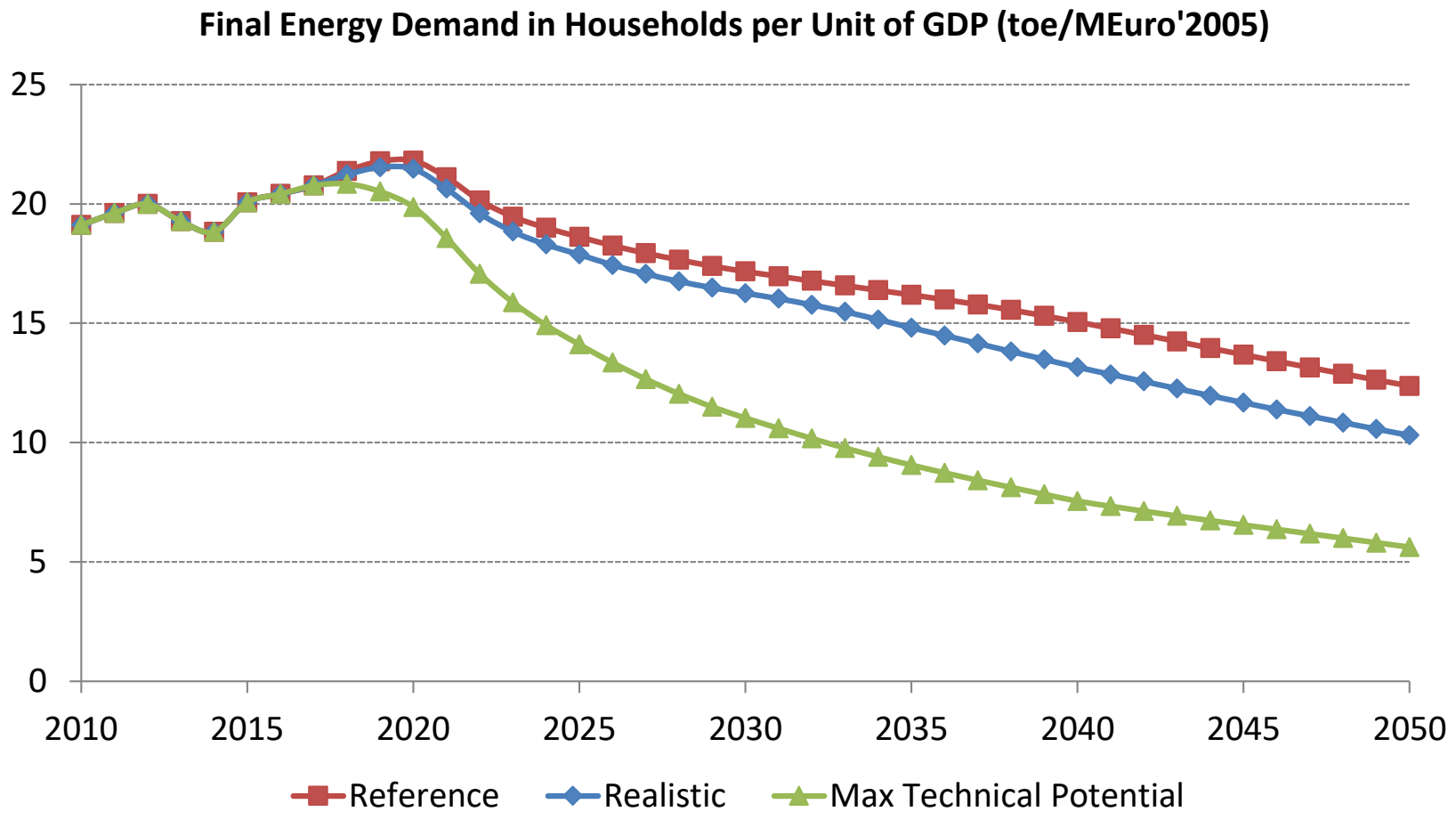

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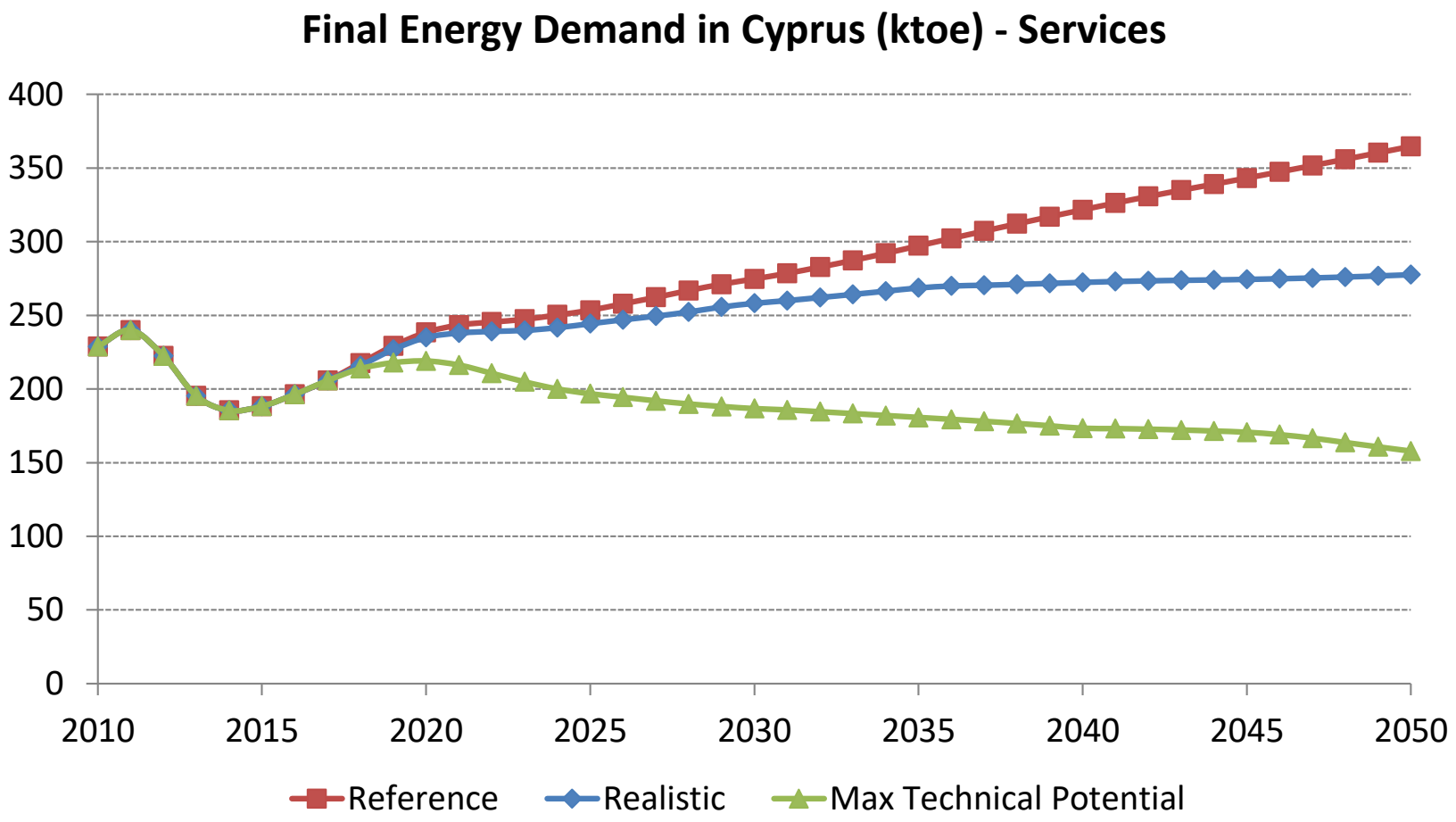

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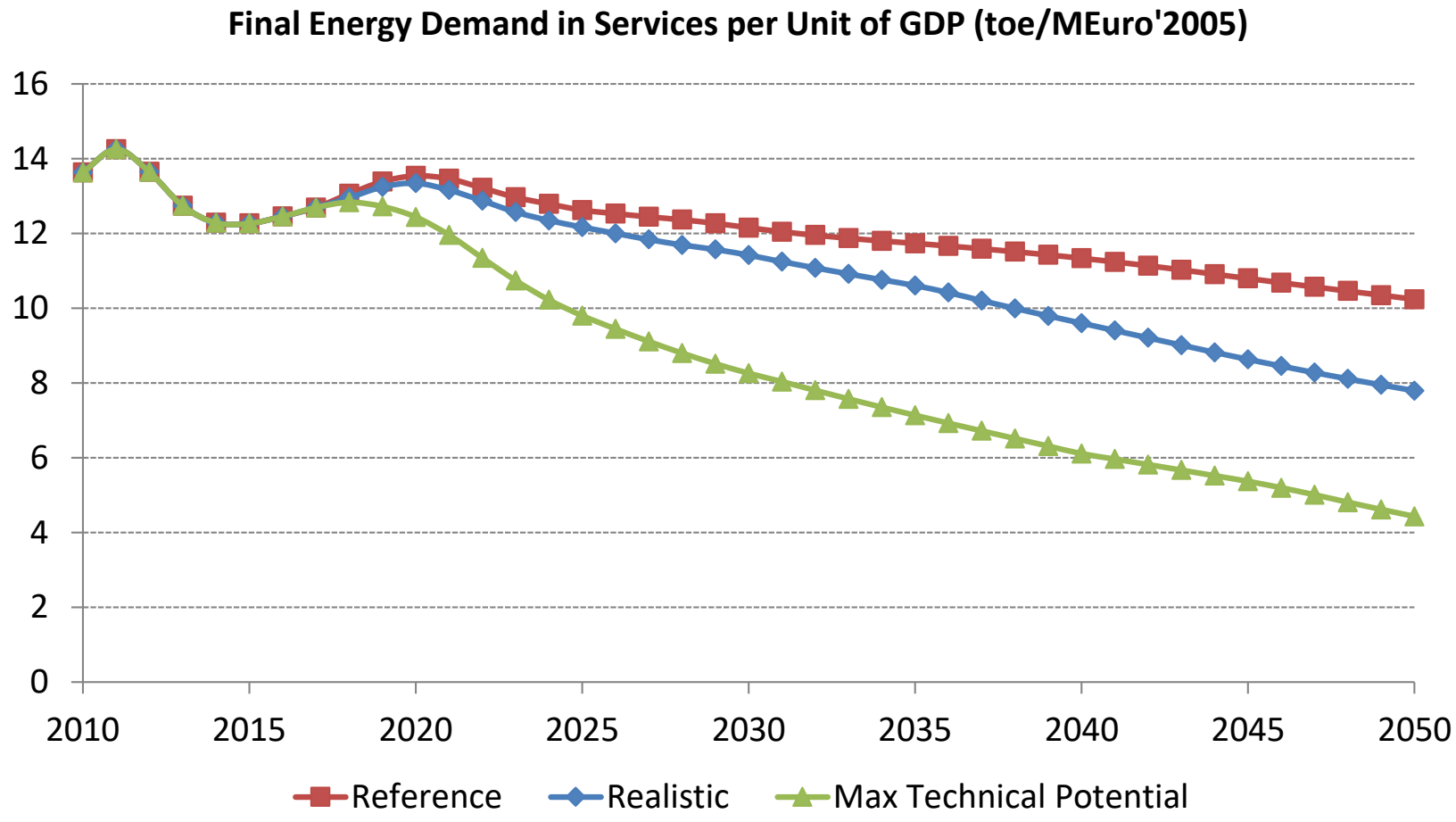

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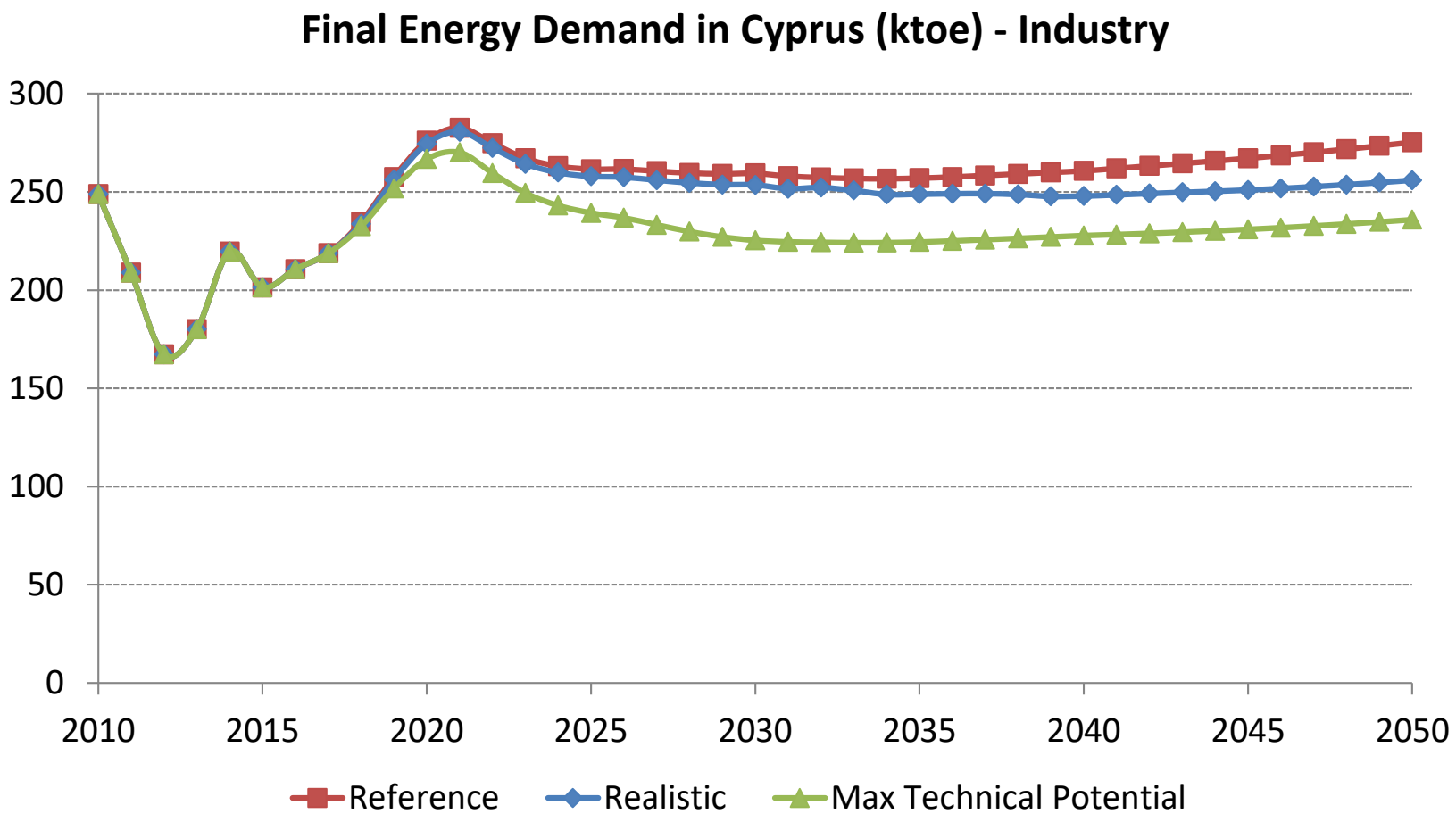

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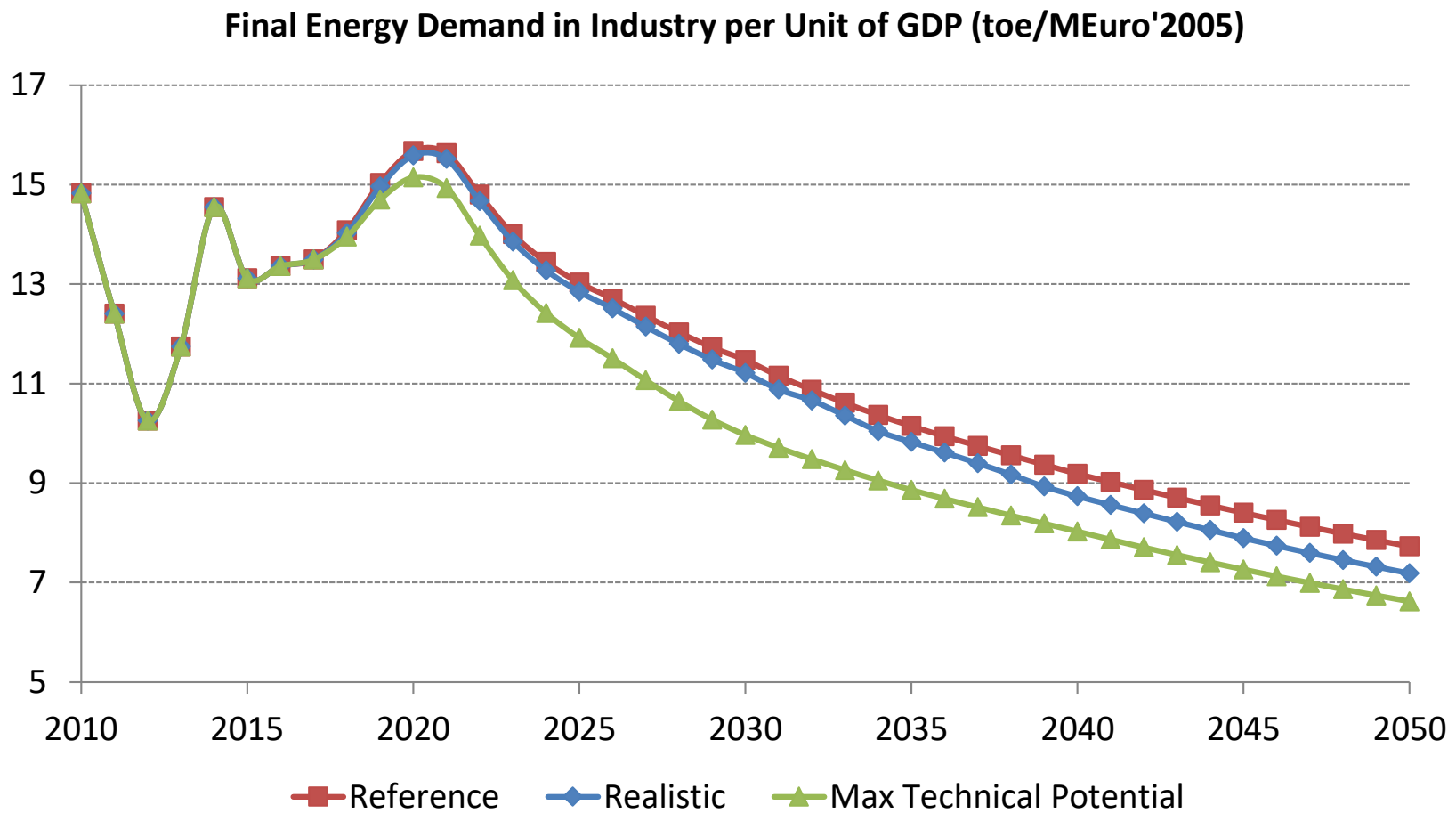

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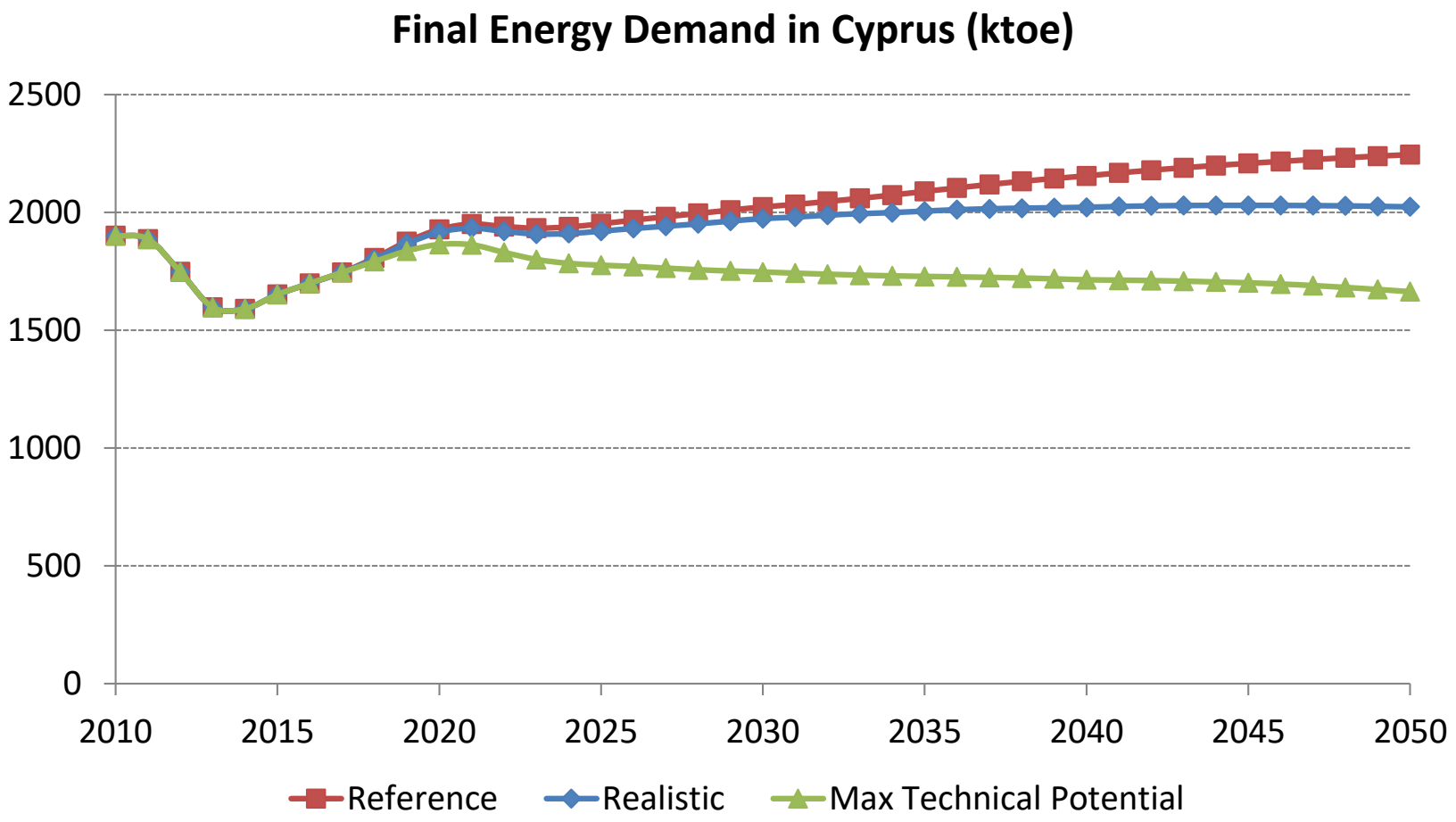

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