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WORKING DOCUMENT FOR THE ECODESIGN CONSULTATION FORUM ON INDUSTRIAL AND LABORATORY FURNACES AND OVENS (ENTR LOT 4), 16 MAY 2014

This Working Document is not a Draft Ecodesign Regulation for the product group "Industrial and Laboratory Furnaces and Ovens". Rather, it is a discussion note: (1) explaining the state of play; (2) introducing the proposed two main policy options under consideration, for different sub-sectors of the overall product group; (3) communicating the present draft modelled final energy savings associated with each policy option.

This discussion note outlines within the text various questions and issues for the Consultation Forum to consider. The Commission invites members of the Consultation Forum and observers to submit comments in writing in answer to the issues raised, or with regard to other general or specific observations on the policy options being considered. These written comments may be submitted before or subsequent to the Consultation Forum.

The Consultation Forum is also invited to contribute to the ongoing Impact Assessment study.

1. STATE OF PLAY

1.1 Background and Context

The Ecodesign Directive 2009/125/EC establishes the framework for the setting of ecodesign requirements for energy-related products. The first Working Plan of the Ecodesign Directive adopted on 21 October 2008 listed the product groups which were considered as a priority for implementing measures in 2009-2011, including 'industrial and laboratory furnaces and ovens'. A preparatory study for this product group was launched in January 2010. The final report of the study was published in September 2012, initially on the now-expired dedicated Project Webpage. The final report has now been uploaded to the European Commission's Ecodesign Library of Preparatory Study reports, part of the open access area of CIRCABC: https://circabc.europa.eu/w/browse/5cc4bea8-95d4-43e3-ab36-c859d0694217 .

The ENTR Lot 4 Ecodesign Preparatory Study report concluded that industrial and laboratory furnaces and ovens met the criteria of Article 15 (2) of the Ecodesign directive, i.e., that the overall product group presents a significant volume of sales on the market, has a significant environmental impact and energy consumption, and presents a significant potential for improvement. Given the high annual energy consumption of some of the large ovens and furnaces concerned, even small efficiency gains are of significance. The present estimated final energy consumption of all industrial

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and laboratory furnaces and ovens is c. 1 650 TWh/ year (around half of the overall EU industrial sectors' energy consumption).

Legislative Overlaps and Energy-saving Mismatches:

However, of crucial importance with regard to this product group is the issue stipulated by Article 15 (2)(c)(i) of the Ecodesign directive, namely that there should be an absence of other EU legislation to deal with the product group properly. There are already two directives in place which partly deal with the larger furnaces and ovens within the product group: the Industrial Emissions Directive ([IED] - Directive 2010/75/EU) – and associated sector-specific Best Available Techniques Reference documents (so-called BREFs) and their BAT conclusions; and the Emissions Trading System (ETS) (Directive 2003/87/EC, as amended), and associated legislation such as Decision 2011/278/EU governing rules on free allocation of emission allowances, and benchmarking of industry technologies and sectoral-based industrial installations' performances regarding Greenhouse Gas (GHG) emissions. The ETS is presently in its 2013-2020 3rd Trading Period, which will be followed in 2021-2028 by the 4th Trading Period, rules for which are already being made in 2014.

It is noteworthy that the product group, as presently defined, is extremely heterogeneous, and includes both standard, mass-produced smaller ("laboratory") furnace and oven products, up to multi-million Euro individually-designed large and very large furnaces and ovens. The large and very large (see Table 1 for size categories, as used in the ENTR Lot 4 Preparatory Study analyses) industrial furnaces and ovens are utilised in many sectors where the related activities and installations are subject to the above-mentioned IED and/ or the Emissions Trading Scheme [ETS]. These larger furnace and oven products, and related processes/ installations, use c. 1 435 TWh of energy per year (87%, mostly natural gas). Medium-sized industrial furnaces and ovens consume c. 211 TWh per year, and c. 4 TWh/ year is used by small/ laboratory furnaces and ovens.

Two of the questions which the contemplated Ecodesign measures regarding this product groups seek to address are: (i) whether mandatory energy-saving objectives and strategies could be put in place via a daughter regulation from the Ecodesign directive, for those (still quite large and with significant annual energy use, in some cases) ovens and furnaces ***outside the scope of the IED and the ETS***; and (ii) whether (the same as in (i)?) "Ecodesign-style" objectives and strategies should be incorporated into furnace and oven product design even for those furnaces and ovens ***within the scope of the IED and ETS***, in order to reduce their energy use more effectively, and associated Greenhouse Gas (GHG) emissions from direct fuel combustion, or intensive electricity use.

One Policy Option for the second (ii) group explores possibly considering adopting "Ecodesign-style" measures progressively *within sector-specific BREFs and BAT conclusions*, as part of the rolling system of IED update and implementation, and/ or noting such possibilities *within the ETS "benchmarking" system*. (It should be explicitly noted that from the remit of the Ecodesign Directive, and the formal role of the Ecodesign Consultation Forum, any recommendations regarding those furnaces and ovens in the IED/ ETS (ii) group will have to be considered elsewhere in the policy-making process of the European Commission, and associated bodies, such as the IPPC Bureau in Seville, and associated stakeholders, and likewise via established ETS consultations and mechanisms.)

Note regarding energy-saving and efficiency, and the IED/ ETS: The large and very large industrial furnaces and ovens are the largest consumers of energy. Article 9 of the IED states that the permit shall not include an emission limit value for direct emissions of greenhouse gas emissions from an ETS installation, unless necessary to ensure that no significant local pollution is caused. In addition, for ETS activities, Member States may **choose** not to impose energy efficiency requirements in respect of combustion units or other units emitting CO2 on the site. This explains why several BREFs and BAT conclusions contain provisions on energy efficiency and that there is a dedicated Energy Efficiency BREF. As the ETS carbon price is presently very low (c. €5 Euros per tonne [2013-14] of CO2 equivalent emitted), the expected financial inducement via the ETS to invest in new technologies is presently partly lacking. (NB This last statement also has to take into consideration, and be balanced, by Member States' individual energy-related policies, energy-related taxes, and other industrial financial inducements or costs imposed on operators, all or any of which may mean that a further financial inducement to reduce energy costs via the ETS may not be necessary to drive operators to seek more efficient processes).

Potential Energy Savings Available: Annual energy savings technically available for **all ovens and furnaces** (averaged over the 25 years between 2011 and 2035) are estimated to be c. 90 TWh/ year ("Best Available Technology" and also "Least Life Cycle Costs"), of which c. 8 TWh/ year (9%) are attributable to the small/ laboratory and medium furnaces and ovens.

Annex E gives a modelled breakdown of possible energy savings over the period 2011-2035 for all furnace and oven Base Cases, considering the several policy options and sub-options envisaged.

Business-to-Business Customised Products and Processes: The professional users of medium and large industrial ovens and furnaces in the end-user sectors decide on the type, and detailed specification requirements, of the oven or furnace being purchased, via its capacity to be able to manufacture sometimes very specialised end–products, which may comprise components or complete products.

The professional "business-to-business" oven and furnaces products described above are found in a variety of end-user (i.e., client) sectors, inter alia, iron and steel, ceramics, various glass sectors, other metals, petroleum refining, lime, etc. For many if not all activities, quality and time duration of completion of the derived product being manufactured is very important, for competitiveness.

Oven/ Furnaces Energy and Life Cycle Costs: For some of the largest furnaces and user sectors (e.g., primary steel, glass, cement) energy costs can amount to c.30% of total production costs (NB a different concept to the "Least Life Cycle Costs" approach of the Ecodesign directive "MEErP" methodology[1]). However, for some of the applications of medium-sized furnaces, e.g., heat treatment processes, energy costs can be less than 5% of total production costs.

[1] For the most up-to-date version and methodology considerations, please see: http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/methodology/index_en.htm

Table 1: Size Classifications of Furnaces & Ovens used for Base Case Assessment

Size range	Products included	Base Case approach
Laboratory	Ovens <750 litres Furnaces <120 litres *	Standard MEEUP EcoReport tool for a representative oven
Small and medium-sized industrial	Larger than laboratory and: Batch <10 tonnes capacity Continuous <20 tonnes / day	Products consist of standard and custom designs. As custom designs are unsuitable for base case assessment, MEEuP has been used for standard designs, but with estimated energy consumption
Large and very large industrial	Batch >10 tonnes capacity Continuous >20 tonnes / day	These are too complex for the standard approach. Therefore, two examples have been used to determine the most significant impacts, using real Bills of Materials (BOM) but weighted average energy consumption

*An alternative suggestion from CECOF (The European Committee of Industrial Furnace and Heating Equipment Associations) is that this maximum could be **250 litres** for laboratory furnaces.

Table 1 Explanatory Notes:

1. **Ovens are considered as operating at equal/ less than 450°C, and furnaces as greater than 450°C.** This is because ovens with maximum operating temperature of >450°C and less than 750°C are relatively uncommon.

2. Classification by furnace/ oven size can be misleading because it depends on the mass of product heated in the furnace or oven. A good illustrative example is a continuous wire heat treatment furnace. One size of furnace can treat 800kg/h of semi-conductor sawing wire (19t/day, thus “medium”) or up to 4 tonnes per hour of steel rope (48 t/day, thus “large”). To overcome this issue, product throughput per hour or per day should be treated as the maximum possible throughput, irrespective of the amount of material that is heated.

Market Failures: In all end-user sectors, a finding of the ENTR Lot 4 Preparatory Study was that the following financial and managerial considerations may hinder optimal design, with regard to energy efficiency of furnaces and ovens: (i) a lack of capital available for investment; (ii) a desire to limit the size of a company’s debt burden; and (iii) uncertainty over medium- to long-term future sales of products made, or types of product required by the market, made via the furnace/ oven. This may be exacerbated by corporate decision-makers who sometimes demand very short-term "payback" periods on new investments in thermal processing equipment, whilst at the same time not undertaking full Return on Investment (ROI) assessments. Such corporate investment behaviour/ strategies can be considered as a market failure.

A second source of market failure is the lack of reliable, standardised information on energy (and related environmental) performance of furnace and oven products. This prevents business customers from being able to adequately compare different manufacturers' furnace and oven products, with regard to universally-accepted measurement conditions for energy efficiency reinforced by standards. A third source of market failure is that, owing to the lack of transparent standardisation of energy efficiency measurement, business customers are more likely to choose well-known and proven technologies, rather than choosing to invest in novel technologies.

The above sources of market failure combined mean that innovation is not sufficiently encouraged, and neither is investment in proven, but still relatively new, technologies.

1.2 Impact Assessment Study

Regarding Industrial and Laboratory Furnaces and Ovens, the European Commission launched an Impact Assessment Study in November 2012 to support the preparation of its Impact Assessment, which is mandatory for all Commission proposals. One task of this study is also to reassess the findings and the product sub-groups of the preparatory study, and to consult on, and possibly revise, the indicated policy options via seeking additional information and feedback from stakeholders. The work is ongoing; the final report of the study will be delivered by August 2014.

The ongoing Impact Assessment Study comprises data taken from the ENTR Lot 4 Preparatory Study, which has been updated and consolidated, supplemented by additional data from stakeholders, and draft modelling exercises, which are discussed in the following sections. The interim results to date of the Impact Assessment study support the Policy Options being considered, as relevant to each of the seven main Base Cases into which the total product group has been divided (see Table 1).

Section 2 - at the outset - presents an overview guide of which Policy Options are relevant to which Base Cases.

Annex A provides further information on stocks, annual sales and sub-sectors within the overview product groupings and Base Cases. It is important to note the **high relative proportion of refurbishment of furnaces and ovens which takes place**, compared to sales of new products (reproduced as Table 4, below). ***This important frequent refurbishment characteristic is a principal reason why "ecodesign- style" implementing measures within the IED BREF sectoral framework are proposed*** as Policy Options in Section 2 of this Summary Working Document.

The refurbishment aspect is an important distinction, because implementing measures within the **Ecodesign Directive** have the restriction of only being able to cover **new products**, via being "placed on the market".

Annex E (separate document) presents the *draft* Impact Assessment final energy savings modelled between 2011 and 2035 for the various Policy Options considered.

1.3 Industrial and Laboratory Furnaces and Ovens - Base Cases Considered

Table 2 presents the 7 main Base Cases (BCs 1-7). There are in fact a total of 11 Base Cases, once the differences between electricity (suffix "a" in each Base Case) and gas-powered (suffix "b" in each Base Case) furnaces are taken into account. These base cases are unchanged from those considered in the 2012 ENTR Lot 4 Preparatory Study.

Table 2: Overall Oven/ Furnace Base Cases

Base Case reference	Base-Case description
BC1 (Lab)	Laboratory ovens and furnaces
BC2a (BO/e)	Medium size batch oven (electric)
BC2b (BO/g)	Medium size batch oven (gas)
BC3a (CF/e)	Batch chamber furnace (electric)
BC3b (CF/g)	Batch chamber furnace (gas)
BC4a (CO/e)	Continuous oven (electric)
BC4b (CO/g)	Continuous oven (gas)
BC5a (CBF/e)	Continuous belt furnace (electric)
BC5b (CBF/g)	Continuous belt furnace (gas)
BC6 (LF)	Large furnace (fossil fuel [gas] assumed)
BC7 (VLO)	Very large oven (fossil fuel [gas] assumed)

Table 3 shows estimated EU current stock and future sales data of furnaces and ovens, and average annual primary energy consumption per product unit, examined from a Base Case perspective. Table 4 (following) gives a summary of new sales compared to stocks, and annual refurbishments.

Table 1: Business as Usual (BaU) Scenario Input Data

Base-Case (BC)	Product life time (years)	Product purchase price (€)	Annual primary energy consumption (kWh/year)	Sales (units)	Stock (units)	Installation, repair and maintenance cost (€)	Source of energy
Laboratory ovens (BC1)	15	1 500	2 100	25 000	400 000	0	Electricity
Medium size batch oven (BC2)	25	20 000	200 000	8758	164 986	500	Electricity
	25	25 000	760 000	762	14 347	1 500	Natural gas
Batch chamber furnace (BC3)	25	30 000	230 400	856	16 118	800	Electricity
	25	35 000	875 520	74	1 402	2 100	Natural gas
Continuous oven (BC4)	25	20 000	200 000	6342	119 472	800	Electricity
	25	30 000	760 000	551	10 389	2 200	Natural gas

Base-Case (BC)	Product life time (years)	Product purchase price (€)	Annual primary energy consumption (kWh/year)	Sales (units)	Stock (units)	Installation, repair and maintenance cost (€)	Source of energy
Continuous "belt" furnace (BC5)	25	40 000	230 400	620	11 672	1 100	Electricity
	25	45 000	875 520	54	1 015	2 500	Natural gas
Large furnace (BC6)	35	4 000 000	98 337 600	348	11 196	110 000	Natural gas
Very Large oven (BC7)	35	2 000 000	15 408 000	66	3 050	22 000	Natural gas

<u>Table 3 Notes</u>

1. The tariff for the energy sources (0.0913 €/kWh for electricity and 0.0272 €/kWh for natural gas) is assumed to be constant during the time horizon of the BaU scenario.
2. Stakeholders consulted during the Ecodesign ENTR Lot 4 Preparatory Study were unable to predict long-term trends in sales of industrial furnaces and ovens, owing to the uncertainties in the markets they serve, e.g., the gradual decrease in EU consumption of furnaces and ovens, in terms of value, according to Eurostat PRODCOM[2] statistics since 2000[3]. This is at least in part due to relocation of manufacturing to locations outside of the EU, in order for manufacturers to benefit from lower labour costs and for other cost and strategic reasons, and many other variables. Therefore, the assumptions made in the Ecodesign ENTR Lot 4 Preparatory Study assumed that future sales in the EU would have zero growth. The stability of the laboratory furnaces/ovens sector is a little more certain, and the largest laboratory oven manufacturer in the EU estimated a future growth of 0.67% per year. This last-mentioned figure was already used for the laboratory furnaces/ovens sub-group base-case calculations within the Ecodesign ENTR Lot 4 Preparatory Study.

Table 4: Estimated EU annual sales, stock levels and numbers refurbished of furnaces and ovens based on data from stakeholders, IPPC/ IED BREFs and other sources

Sector	Estimated EU annual sales	Estimated EU stock	Estimated numbers refurbished annually
Large industrial	c. 400	c.15 000	c.150
Small/ medium size industrial	18 000 (plus 50 000 batch bakery ovens)	340,000 (plus 500 000 batch bakery ovens)	10 000
Laboratory*	50 000	800 000	Uncommon

* Totals depend on whether incubators and laboratory instruments containing ovens are included.

<u>Annex B</u> provides further data on product lifetimes and energy consumption, for each of the furnace/ oven Base Cases.

[2] Production Communautaire, Statistics by product: http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction

[3] Ecodesign ENTR Lot 4 Preparatory Study: Task 2 – Economic and Market Analysis, ERA Technology and BIO IS, August 2013, Figure 6, p. 94.

1.4 Environmental Impacts

The ENTR Lot 4 Ecodesign Preparatory Study showed that energy consumption (and related emissions) in the use phase of industrial and laboratory furnaces and ovens has the most significant environmental impact, but that there are other factors as well.

Task 4 (Section 4.5) of the ENTR Lot 4 Preparatory Study provides an environmental impact assessment for each of the Base Cases considered. Typically, the use phase of the furnace/ oven dominates, being responsible for over 95% of Primary Energy and associated GHG, acidification and Volatile Organic Compounds emissions.

Although, as previously discussed, the actual Base Cases vary substantially, the type and proportions of the environmental impacts related the material acquisition phase, for the metals and other materials used to fabricate and assemble furnaces and ovens, are generally similar (at least as modelled utilising the streamlined Life Cycle Assessment MEEuP [forerunner of MEErP] tool). The materials acquisition phase is responsible for some 80% of the waste-related impacts (e.g., landfill), and emissions of Persistent Organic Pollutants (POPs), plus some 60% of releases of heavy metals to air and water, and 40% of the eutrophication impacts (all the above related to the production of stainless steel, a key component of the furnaces and ovens).

Note that those industrial plant which use furnaces and ovens, and which are subject to the Industrial Emissions Directive, will already have many other environmental impacts mitigated via the associated sectoral BREFs in the plant design or refurbishment phases, and will be subject to operating permits, with built-in periodic reviews, issued by relevant MS authorities. Depending on the Member States, many industrial plant smaller than the IED sectoral production thresholds may have permit requirements, and associated emissions restrictions. On a voluntary basis, also many of these industrial installations have a formal Environmental Management System in place, e.g., EMAS or ISO 14001.

The key environmental improvement aspects identified in the ENTR Preparatory Study, Task 4, Part B, were related to energy efficiency/ energy saving potentials (see Section 1.5 below).

1.5 Improvement Potential – Energy & Environmental Mitigation Approaches

Annex D reproduces the Task 5 summary findings on a sectoral basis, with regard to improvement potentials per types of process where the overall furnaces and ovens product group is used.

Annex E provides current draft energy data on potential improvements in the timeframe up to 2035, related to the policy options being examined.

Section 2 (Policy Options) also discusses the energy-related potential improvements that may be feasible.

1.6 Additional Aspects Regarding Existing and Draft EU Legislation, and Other Relevant Initiatives

1.6.1 Established Directives also Covering Furnaces and Ovens within a Process or Installation

In addition to the Industrial Emissions Directive (ex-IPPC) and the Emissions Trading System (ETS), previously mentioned in Section 1.1, the Energy Efficiency Directive 2012/27/EU ("EED") must also be considered[4]. Imminently (by 30 April 2014**)** and every three years thereafter, Member States will have to submit their National Energy Efficiency Action Plans (NEEAPs) for implementing the EED.

For the considerations of ENTR Lot 4 furnaces and ovens, it is anticipated that Member States' implementation of the EED may have a number of interactions with regard to the draft "Ecodesign" policy options proposed in Section 2 of this Summary Working Document. Policy Option 2, are obligations related to energy audits and maintenance (Article 8 of the EED).

The following Articles (and associated Guidelines, and potentially Member States' NEEAPs) may be relevant to the policy options (POs) – see Section 2 – regarding environmental and energy considerations for furnaces and ovens:

- Article 6 – Purchasing by public bodies (Policy Option 3)
- Article 7 – Energy efficiency obligations schemes (Policy Options 3 and 4)
- Article 8 – Energy audits and Energy Management Systems (all Policy Options)
- Article 14 – Promotion of efficiency in heating and cooling (including industrial heating and installations) – Policy Options 3 and 4, and consideration as to applicability in expediting/ funding (as necessary/ feasible) Policy Options 1 and 2.

To conclude, as the implementation of the EED is moving in parallel with the considerations of ENTR Lot 4, it is appropriate to examine how the EED may assist in ecodesign, or "ecodesign-style" options, particularly at sectoral or MS levels.

1.6.2 Draft EU Legislation – Medium Combustion Plants (MCP) Directive

The European Commission adopted on 18.12.2013 a Proposal for Medium Combustion Plant[5] (part of the Clean Air Policy Package). This Proposal covers combustion plant in the range 1MW – 50MW thermal input, with respect to the emissions of SO2, NOx and Particulate Matter.

Article 2(2) of the proposed Directive excludes a number of plants from its scope, amongst which are the following: "(a) combustion plants which are covered by Chapter III or Chapter IV of Directive 2010/75/EU; (b) energy related products which are covered by implementing measures adopted in accordance with Directive 2009/125/EC where those implementing acts are setting emission limit values for the pollutants listed in Annex II of this Directive; (c) combustion plants in which the

[4] For an overview of the EED, and the related Guidance Notes on the directive's implementation, see: http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

[5] Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013PC0919&from=EN

gaseus products of combustion are used for the direct heating, drying or any other treatment of objects or materials; and (d) post-combustion plants designed to purify the waste gases from industrial processes by combustion and which are not operated as independent combustion plants".

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1.6.3 Detailed Policy Areas with Important Potential Ramifications on Ecodesign Options being Considered

(i) European Harmonised Gas Quality[6]

Since 2011, the European Commission has been considering how to best harmonise the quality of European gas, in terms of its chemical and combustion properties. The emphasis of the proposed measures is to ensure security of supply of gas, via making on the one hand the permissible properties as wide as possible, whilst on the other hand ensuring safety and retaining the function of the domestic and industrial appliances using the gas.

For some MS, the proposed draft permitted properties at EU level are tighter than their national requirements to date; however, for other MS, the draft permitted properties have broader limits than those to which they are accustomed.

These proposals affect the Ecodesign option regarding the air: gas ratio (the “Lambda” control value), which is further discussed in Section 2.1.6, below.

(ii) REACH – Potential Proposals regarding Hugh Temperature Insulation Wool[7]

High Temperature Insulation Wool (HTIW) of various types is an important material for insulating many furnaces, particularly owing to its low density, flexibility and very high efficiency at the high temperatures involved.

In 2011, some of the HTIW types (zirconia aluminosilicate refractory ceramic fibres and aluminosilicate refractory ceramic fibres) were placed on the Candidate List of the Substances of Very High Concern (SVHCs) of the REACH regulation (EC No. 1907/2006, as amended).

For some applications where low mass of furnace walls and related equipment is essential, alternatives to HTIW may be difficult to encounter, at affordable costs. The use of high performance, affordable insulation materials is important for the Ecodesign option regarding improved insulation, discussed in Section 2.1.5 below.

It is understood that discussions and potential actions with regard to the possible classification of some types of HTIW are currently ongoing between the relevant industry sectors and the European Commission. An account of the state-of-play should be given at the ENTR Lot 4 May 2014 Consultation Forum.

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[6] Further information available at: http://ec.europa.eu/energy/gas_electricity/gas/gas_quality_harmonisation_en.htm

[7] The position of the relevant EU industry association, ECFIA, is available at: http://www.ecfia.eu/has_reach.htm

2. POLICY OPTIONS UNDER CONSIDERATION FOR INDUSTRIAL AND LABORATORY FURNACES AND OVENS

In addition to the “No action”/ "Business As Usual" (BAU) scenario, four overall policy options (POs) were initially considered, as shown below. **Of these, only Policy Options 1 and 2 have been retained for further in-depth analysis within the ENTR Lot 4 Impact Assessment, and are discussed in this Summary Working Document. Further information with regard to Policy Options 1, 2, 3 and 4 will be uploaded to CIRCABC in due course.**

This does not mean that POs 3 and 4 are irrelevant, or do not have a role to play in improving the energetic and environmental impacts of industrial and laboratory furnaces and ovens. However, POs 3 and 4 essentially go beyond the remit of what may be achieved via Ecodesign, or “Ecodesign-style” measures at a European level, and therefore may be pursued via other policy initiatives, or at Member State (MS) level, as part of MS’ implementation of other directives or initiatives (e.g., via the Energy Efficiency Directive and related National Plans, or national sectoral initiatives).

- **Policy Option 1 (PO 1):** Draft proposals for Ecodesign Implementing Measures relevant for Lot 4 furnaces and ovens, subdivided according to Base Case;
- **Policy Option 2 (PO 2):** Regulating Lot 4 furnaces and ovens through the Industrial Emissions Directive (IED) sectoral BAT conclusions (higher chance of being more effective, through sectoral customisation) or the Horizontal Energy Efficiency BAT conclusions, via the same "ecodesign-style" provisions. This option would enhance IED by providing clearer energy consumption targets, but should not conflict with ETS and its “benchmarking” system;
- **Policy Option 3 (PO 3):** Support to increase energy efficiency of Lot 4 furnaces and ovens via Government/ public authority measures;
- **Policy Option 4 (PO 4):** Voluntary Initiative(s) by Lot 4 furnaces and ovens end-user sectors.

2.1 PO-1: Summary Description of Proposed Mandatory Ecodesign Regulation Requirements

2.1.1 Scope and Coverage: Overview of Draft Ecodesign Measures Proposed – Policy Option 1

The ecodesign implementing measures presented in this section are primarily based on the recommendations made in the Ecodesign ENTR Lot 4 Preparatory Study. In summary, the ecodesign policy options comprise the following five ecodesign strategies:

ALL Base Cases (BCs 1- 7)

- Provision of energy consumption information to end-users

BC 1 only

- Laboratory Furnaces and Ovens: possible Energy Efficiency Index, or Voluntary Agreement (details of these options are in their infancy, and at the beginning of discussions)

BCs 2 – 7 (actual options available depend on whether fired by natural gas/ fuel oil or electricity): NB none of these options is directly applicable to BC1

- Heat recovery and reuse (all direct gas-fired Base Cases)
- Improved insulation (electricity-fired and direct gas-fired Base Cases)
- Optimised fuel/ air ratio (all direct gas-fired Base Cases)

With respect to the provision of energy consumption information, this is addressed in embryo in Section 2.1.2; Section 2.1.3 discusses the initial potential policy/ industry interventions for **BC1, Laboratory Furnaces and Ovens.**

Regarding the **Base Case 2-7 options**, it should be noted that there is to some extent a mutual relationship between the parameters, i.e., they partly interact, and are not mutually exclusive. Therefore, the effects of these technology interventions are not directly additive in a simple manner. These three parameters are based on existing Japanese legislation, namely the Japanese Energy Act (2006), the key elements of which are summarised in Annex C, with regard to industrial furnaces and ovens.

During direct-fired processes, some of the excess unused heat is released with the flue gases, creating the opportunity to recover and reuse this heat within the system (either within the immediate furnace, or elsewhere within the industrial process/ facility). Also, since the fuel to air ratio is a fundamental variable of combustion, it also can be modified and controlled, thus reducing the amount of fuel used to achieve the desired temperature inside the furnace or oven. On the other hand, maintaining the inside temperature and avoiding heat loss by using appropriate insulation materials can also make furnaces/ ovens more efficient, minimising the energy consumption and reducing GHG. The improved insulation ecodesign option is suitable for electrical heating as well as direct fossil fuel combustion, whereas heat recovery and fuel/ air ratio control are applicable only to direct fossil fuel combustion processes.

The scope of an ecodesign measure could cover a wide range of furnaces and ovens. However, since there are many different applications for furnaces and ovens and user requirements, some of the furnaces and ovens will have to be excluded from the scope of any ecodesign measures.

2.1.2 Provision of Energy Consumption Information to End-Users

For larger industrial furnaces and ovens, it is commonplace for both the design and the patterns of envisaged use – including provision of energy consumption estimates and subsequent "in-use" provision of energy consumption information - to be discussed during the tendering contract, and the customised design phase of the apparatus concerned, and then at the initial "commissioning" phase of the furnace/ oven going on-stream.

However, for furnaces and ovens within BC1, and some of the smaller "standard catalogue" apparatus within BCs2-5, standardised energy consumption information would be very useful for end-users to access.

The type, feasibility of, and format of information provision is in the initial stages of discussion with the Impact Assessment consultants and with stakeholders.

The Consultation Forum is invited to provide input regarding this aspect, as appropriate.

2.1.3 Possible Energy Efficiency Index, or Voluntary Agreement (BC1)

The ENTR Lot 4 Preparatory Study compiled the following list of difficulties and constraints to potential ecodesign measures for BC1 Laboratory furnaces and ovens.

During both the ENTR Lot 4 Preparatory Study, and again during the Impact Assessment study, possible expressions of interest at formulating ecodesign measures, possibly along the lines of a "typical" B2C ecodesign Lot Energy Efficiency Index, or via a Voluntary Agreement by BC1 oven and furnace manufacturers.

However, to date, no concrete proposals have been formulated. The EU total magnitude of the annual energy savings is estimated to be possibly c. 1.5 TWh Primary Energy savings per year by 2035 (38% savings on the BaU scenario), i.e., 0.6 TWh Final Energy savings per year by 2035 (see Annex E modelling).

NB Further information on BC1 improvement potential is given in the ENTR Lot 4 Preparatory Study Appendices, Table 21.

ENTR Lot 4 Preparatory Study - BC1 List of Technical Constraints:

Heat loss through insulation – the size of ovens and furnaces is limited, and so it is not possible to significantly increase the thickness of insulation. Ovens and furnaces are often used in fairly small rooms where it is not possible to use larger equipment. The use of lower thermal conductivity materials will give only limited improvement, especially for high temperature furnaces, because the best materials are unsuitable at very high temperature. If the thermal mass of the insulation is large and the thermal conductivity is low, the rate of heat loss will be slow and the temperature will drop slowly when heating is stopped. This is a problem where the user wants to cool parts quickly to remove them before placing more parts into a cool furnace. Very efficient insulation may not affect fast heating rates if the heat source is inside the chamber and so heats the parts directly, but it will severely delay cooling which will hinder throughput and productivity. Where furnaces are used for fairly short tests, increasing insulation thermal mass has the undesired effect of increasing energy consumption (ENTR Lot 4 Preparatory Study, Task 6).

Heat recovery – adding heat recovery equipment to a small laboratory oven or furnace would significantly increase the size, which may not be acceptable to users due to space constraints. Heat recovery equipment would significantly increase the product price, which could make EU test laboratories uneconomic compared to non-EU competitors

Process control – most BC1 products already have accurate temperature controllers, but only a few ovens and furnaces have timers that switch off when tests are complete. Timers have the potential to reduce energy consumption but rely on users to use them. Manufacturers' experience is that timers are not popular with users of ovens (more common with furnaces), and are rarely used.

Lack of information on energy consumption– It is very uncommon for there to be information available on the energy consumption of laboratory ovens and furnaces, for potential customers to make a purchase decision. Responses to the first study questionnaire showed that this was a common reason why energy efficiency was not considered in purchase decisions. A few manufacturers test their products, and some of this data is in this report. However, they all use in-house tests, as no European Standard test method exists to date[8].

Size – laboratories are often quite small and so the space available for ovens and furnaces is quite limited. Where noxious emissions occur from processes, the ovens and furnaces may be used inside fume cupboards, which are very limited in space. Therefore it is not always possible to use a sufficient thickness of insulation to minimise heat losses without actively cooling the insulation surface, which – in turn - causes a high heat loss rate. For example, to attain a 50°C external temperature for a 1200°C furnace, the necessary 500mm thickness of insulation would double the width and height of a small furnace to a size where it would not be usable in some laboratory locations. Another constraint with very thick insulation is the very long cooling time, which could seriously delay any work which requires commencing with a cold furnace.

The Consultation Forum is invited to give its feedback on the possible nature of any ecodesign measures which might be feasible for BC1, and whether the significance of the impacts of BC1 merits ecodesign legislation. (Voluntary Agreement actions in any case might be pursued, depending on industry views, and stakeholder reactions.)

[8] Tentatively, CEN/ TC 186 has agreed in principle to undertake this task, in common with the work associated for the three draft proposed Ecodesign options described in Sections 2.1.4, 2.1.5 and 2.1.6. (to be confirmed by the TC).

2.1.4 Heat Recovery and Reuse - Potential Ecodesign Measures

The suggested mandatory Ecodesign Implementing Measures concerning heat recovery are based on a tiered approach. The draft ecodesign requirements comprise measures suggested by CECOF, values based on current average performance parameters, and values based on BAT performance parameters (this information was collected from stakeholders via questionnaires and direct consultation, during the ENTR Lot 4 Preparatory Study). The draft ecodesign requirements are presented in Table 5. Mandatory heat recovery proposed obligations are listed, with guidance values only in brackets (indicative flue gas temperatures).

Table 5: Heat Recovery: Potential Draft Ecodesign Mandatory Requirements

Process temperature/ size	Minimum amount of heat recovery*		
	1st Tier (from 2016 onwards)	2nd Tier (from 2019 onwards)	3rd Tier (from 2025 onwards)
≥1 000°C large	Heat recovery minimum 40%	≥40% recovered & reused (Flue gas ≤500°C measured at 3% O_2).	≥55% recovered & reused (Flue gas ≤300°C measured at 3% O_2).
≥1 000°C medium	No initial requirement	≥30% recovered & reused (Flue gas ≤550°C measured at 3% O_2).	≥40% recovered & reused (Flue gas ≤400°C measured at 3% O_2).
<1 000°C large	Flue gas ≤600°C measured at 3% O_2.	≥35% recovered & reused (Flue gas ≤500°C measured at 3% O_2).	≥50% recovered & reused (Flue gas ≤350°C measured at 3% O_2).
<1 000°C medium	No initial requirement	≥25% recovered & reused (Flue gas ≤500°C measured at 3% O_2).	≥35% recovered & reused (Flue gas ≤350°C measured at 3% O_2).

[1] Note that in Tiers 2 and 3, the percentage of heat recovery/ reuse is mandatory, but the indicated temperatures in parentheses are indicative (as in the Japanese Energy Act).

[2] The EU furnace manufacturers' industry association CECOF has reservations concerning the 3rd Tier proposals, regarding whether such values are attainable, or indeed are optimal.

* Temperatures quoted can be calculated values equivalent to flue gas containing 3% oxygen. In practice, any oxygen content is permitted but will need to be measured to calculate the equivalent temperature that would exist with 3% oxygen.

a) Explanation regarding what constitutes "heat recovery and reuse":

Heat recovery can be achieved by at least four methods, and each of these methods will reduce energy consumption. Some of these methods are unsuitable for some processes, due to technical constraints. Heat recovery may be estimated from the temperature of the flue gas (calculated, for consistency, at 3% oxygen) but this will not give an accurate heat recovery percentage. In Japan, the percentage heat recovery is determined using the equations described in Annex C, p4 (reproduced from the ENTR Lot 4 Preparatory Study Task 1), and is quoted as a percentage of the energy in combustion gases as they leave the main combustion chamber. (The Japanese legislation uses combustion gas temperature only as an *indication* of heat recovery, and this approach is also adopted here.)

- **Use of recuperative/ regenerative burners:** The use of such burners is claimed to reduce energy consumption by between c.20% and over 50%, depending on the complexity of design, and flue gas temperature. The percentage heat recoverable depends on combustion gas temperature and size of regenerators or recuperators (essentially types of heat exchanger). Recuperators can recover 20%–50% of heat, whereas regenerators can save up to 85% of heat, although the maximum value is process-dependent.

- **Use of heat exchangers** to recover heat from combustion gases, or from hot contaminated gases, to make clean, dry hot air that can be used as hot air for burners, as secondary hot air entering ovens, or used elsewhere. Heat exchangers can recover over 50% of combustion gas heat if no other heat recovery method is additionally used. The percentage heat recoverable depends on combustion gas temperature, and on the size and design of heat exchanger.

- **Pre-heating feedstock** (usually within continuous furnace processes, but can also be used separately for batch processes). The percentage of heat re-used depends on the process temperature, and percentage of input heat adsorbed by the product. Pre-heating is commonly used, for example in continuous ceramics kilns and continuous metal reheating furnaces.

- **Recovery of heat from hot product**, which is used - for example - with cement kilns, to recover heat from hot clinker, and in brick kilns as a result of rapidly cooling hot bricks (which produces air at up to 500°C, which can be used for hot air burners and in drying ovens).

b) Measurement of Heat Recovery:

There are several ways that “heat recovery” can be measured/ defined as an ecodesign option:

- The difference in temperature between combustion gases leaving the main furnace chamber and the entrance to the flue/ chimney.

- The difference in heat energy before and after heat exchangers (recuperators, regenerators, etc). This difference may not be the same as heat recovered and reused, as there are usually losses between heat exchanger output and where recovered heat is used (c.5% – 10%).

- Total of all re-used heat, compared to total input heat. This would include heat recovered from hot product, which is suitable for processes where moderately fast cooling is needed, and forced air cooling is used (e.g., bricks, cement clinker, etc.). This would also include heat recovered by pre-heaters, when these can be used. This definition is different to the one used in the Japanese Energy Act (which only includes heat recovered from combustion gases). However, this broader definition to include heat recovery from hot product is beneficial where this is technically possible, and has therefore been included in draft proposals.

c) Limitations and Exceptions to the Heat Recovery Ecodesign Requirements:

To reach each Tier, the ecodesign option may require additional equipment unless the level is already being achieved, but the cost of this additional equipment, as a percentage of the original furnace price, will vary considerably. This is partly due to the very wide variation in processes that use furnaces and the technical constraints that exist. Heat can be recovered by a variety of methods, each of which has technical limitations that are process-dependent. Table 6 shows that these **limitations** may include the following:

Table 6: Limitations to Heat Recovery Ecodesign Mandatory Requirements

Method	Limitations
Heat exchangers for combustion gases	Corrosion if gases contain corrosive substances, for example those emitted from brick clays
External recuperators	% heat recovered depends on size and complexity. These affect price so that a higher percent heat recovery is financially viable for large furnaces than for small furnaces
Regenerators	Will become blocked if combustion gases contain dust or particulates
Self-regenerative and self-recuperative burners	Some are designed for smaller furnaces but minimum power rating is 150kW, so not suitable for very small designs
Pre-heating incoming materials	Suitable only for continuous processes. Uncommon for batch processes.
Heat recovery from hot product	Some products are used hot and others need slow controlled cooling so heat cannot be recovered

In addition, there is the ***general limitation that there must be a use for any recovered heat*** (see below).

d) Formal Exceptions to the Heat Recovery Ecodesign Mandatory Requirements

- Where oxy-fuel burners are used: Such burners are already very efficient, and are at least as good as the best regenerative burner systems.
- Processes where slow cooling of vapours is needed, such as zinc oxide production using rotary furnaces (the melting of zinc metal to generate zinc vapour, which subsequently oxidises to zinc oxide vapour, which is then cooled at a controlled rate, which is essential to control the product's particle size).

- Where ovens use recovered heat as the main heat source at the installation concerned, such as brick drying ovens which use recovered heat from the brick kiln, which is usually situated in close proximity. Hot bricks are cooled with cold air to produce air at 500°C, and this hot air is used elsewhere in brick installations, including in drying ovens. Cooling hot bricks to produce hot air is one method of recovering heat that would otherwise be wasted, and some brick drying ovens need no other sources of heat.
- With regard to the general exception where there no use for the recovered heat, the drafting of the final ecodesign measure related to heat recovery and reuse could utilise a presumption of its applicability, similar to that used in the Ecodesign Standby regulation, but in this case submitted on a site by site, case by case basis (rather than necessarily a product by product basis). That is, the user of the furnace or oven must prove via a technical and economic submission to the appropriate authorities that the plant/ installation and its end products are not suitable for the use of recovered energy technologies, or that the installation cannot be reasonably and economically adapted to facilitate the use of recovered energy.

The Consultation Forum is invited to comment on the Heat Recovery Mandatory Ecodesign proposals, with regard to the ambition, the technical concepts, the feasibility and the timing and number of Tiers. (For example, should a technical review be included to check on BAT between the draft proposals for Tier 2 and Tier 3?)

2.1.5 Minimum Insulation Performance - Potential Ecodesign Measures

Table 7 illustrates potential draft ecodesign mandatory requirements for improved insulation, based on a suggested ambient temperature of 20°C with calm air. Note that at present no standard exists to specify the measurement conditions, and that this would need to be developed[9].

Mandatory minimum insulation requirements are suitable for electricity-fired furnaces and ovens as well as fossil fuel fired ovens and furnaces.

Table 7: Improved Insulation Mandatory Ecodesign Requirements

Furnace/ Oven Base Case	Requirement (W/m²) away from "hot-spots"
BC1	No requirement
BC2 Batch ovens	< 300
BC3 Continuous oven	< 300
BC4 Batch furnace	< 500
BC5 Continuous furnace	< 400
BC6 Large furnace (operating temperature >1000°C)	< 500
BC6 Large furnace (operating temperature 450°C – 1000°C)	< 400
BC7 Large oven (operating temperature <450°C)	< 200

In the above table, ovens are designated as having maximum temperature of $\leq$450°C. Furnaces comprise equipment designed to have maximum temperatures of >450°C. External wall surface temperatures away from hot-spots may be approximated to the following equivalent wall heat losses, expressed in W/m^2 (at 20°C ambient and in calm air):[10]

Ovens:	40°C	200W/m^2.
	50°C	300W/m^2.
Furnaces:	60°C	400W/m^2.
	70°C	500W/m^2.

[9] Tentatively, CEN/ TC 186 has agreed in principle to undertake this task, in common with the work associated for the three draft proposed Ecodesign options described in Sections 2.1.4, 2.1.5 and 2.1.6 (to be confirmed by the TC).

[10] Ecodesign ENTR Lot 4 Preparatory Study: Task 6 – Improvement Potential, ERA Technology and BIO IS, August 2013, p. 332.

Notes:

The aspects of "calm air" and a 20°C ambient temperature are important to take into account owing to the relationship between surface heat loss and the heat transfer coefficient, α, units $W/(m^2.K)$.

Surface heat loss ≈ α (Temperature (K) $_{surface\ wall}$ – Temperature (K) $_{ambient}$)

For calm air (also known as "free convection"), α = 10 $W/(m^2.K)$

Therefore, at an ambient temperature of 20°C (293 K) and surface wall temperature of 40°C (313 K),

Surface heat loss in calm air ≈ 10 $W/(m^2.K)$. (313 K – 293 K) = 200 W/m^2 (hence the "ovens" at 40°C figure above being 200 W/m^2).

The heat transfer coefficient, α, may have a much higher value in conditions of turbulent flow, or where air is being convected or forced, via a blower, etc (e.g., at the base of an actively cooled furnace).

NB Add in other point raised recently by CECOF

Need to add in here the exceptions, and any explanations needed (hopefully all given in Task 6, in detail).

Exceptions to Insulation Mandatory Ecodesign Requirements

Several technical reasons impede or prevent better insulation being used to the mandatory set levels of Table 7, including:

- Short batch processes, which consume less energy if the insulation has a small thermal mass. If thicker insulation were to be used, this would increase energy consumption (see ENT R Lot 4 Preparatory Study, Task 5, pp312-315, and Task 6).

- Processes which are very exothermic, such as steel production in a blast furnace, and copper smelting from sulphide ores. It is important that the produced heat is removed, otherwise the insulation could become so hot that it would melt (and hence increased insulation is redundant).

- Glass melting, and metal smelting processes, which involve very corrosive substances which would adversely affect most types of insulation material. In these cases, special chemically-resistant materials are used for insulation purposes, which have inferior thermal insulation properties to other more commonly-used higher performing insulation types. Unfortunately, this is an unavoidable technical trade-off.

- Where extremely high temperatures are generated, with corrosive fluxes, e.g., in electric arc furnaces. In these operations it is necessary to water-cool the insulation, to prevent it from melting or being attacked by the fluxes that are used, or the slags that are produced. Therefore, again, resistant, lower-performing, "sub-optimal" insulation materials have to be used in this technically necessary trade-off.

Some other example types of process have specific design requirements that limit the choice of insulation, with the result that the most effective insulation cannot be used. These processes include:

- **Blast furnaces and cement kilns** – both are used for at least 20 years and have steel outer shells. It is essential that condensation does not occur, as the corrosive process gases will dissolve in liquid water and will cause rapid corrosion. The outer surface therefore has to be maintained at temperatures above the dew-point, which is >100°C (irrespective of O2 concentration) and an actual temperature of 200°C is typically used (which would be a higher value when calculated at 3%O_2).

- **Induction melting furnaces** – The thickness of the insulation needs to be a compromise between the need to allow radio frequency (RF) energy to pass through the insulation into the furnace and to prevent heat losses out of the furnace. If the insulation is too thick, RF energy is lost before it reaches the process material.

Recommendation from the above considerations:

Similar to the approach to exceptions discussed with regard to the Heat Recovery and Reuse Ecodesign Mandatory Implementing Measure, the drafting of the final ecodesign measure related to insulation could utilise a presumption of its applicability (again analogous to the Ecodesign Standby regulation), unless the user is able to prove otherwise via detailed technical evidence submitted to the relevant authorities, on a site by site, case by case basis (rather than necessarily a product by product basis). That is, the user of the furnace or oven must prove via a technical and economic submission that the plant/ installation and its end products are not suitable for the use of enhanced insulation, or that the installation cannot be reasonably and economically adapted to incorporate insulation with the properties specified in Table 7.

The Consultation Forum is invited to comment on the Insulation Mandatory Ecodesign proposals, with regard to the ambition, the feasibility and the exceptions.

2.1.6 Minimum Air to Gas Ratio Value ("Lambda") for Optimum Combustion – Draft Proposed Ecodesign Measures

The proposed draft Ecodesign mandatory requirements for a maximum air/ fuel ratio have been based on data provided by stakeholders during the Ecodesign ENTR Lot 4 Preparatory Study. A lower lambda value (actual mass ratio of air/fuel/ Stoichiometric mass ratio of air/fuel) is desirable, because minimising the "excess air" reduces fuel consumption, i.e., by approaching as far as possible the "ideal" stoichiometric air/ fuel mixture for combustion. The draft ecodesign mandatory requirements are suggested below, on the basis of two tiers, in Table 8.

NB This measure **only** applies to ***indirect-fired fossil fuels ovens and furnaces***, and is most effective at higher temperatures.

Table 8: Draft Mandatory Ecodesign Requirements: Optimised Air: Fuel Lambda Value

Fuel	Maximum λ value	
	1st Tier (from 2016 onwards)	2nd Tier (from 2019 onwards)
Natural gas	1.25	1.15
LPG	1.25	1.15
Fuel oil	TBD	TBD

Note:

The energy savings from optimised fuel/air ratio are realised based on values proposed for λ ((actual mass ratio of air/fuel)/ (Stoichiometric mass ratio of air/fuel)). TBD = to be determined (for fuel oils).

Exceptions:

1. This measure does not apply to any of the Base Cases comprising electric furnaces and ovens.
2. This measure does not apply to direct-fired ovens and furnaces.
3. The measure does not apply where specific atmosphere conditions are needed. Some processes require a reducing atmosphere, with, e.g., 0.95: 1 ratio. On the contrary, some processes are designed to oxidise metal surfaces, and so higher proportions of air are required.

Explanation/ discussion re. λ Values:

This ecodesign requirement is applicable only to higher temperature processes and indirect furnaces and ovens. This is because there is no benefit in accurate air: gas ratio control if the burner gases require to be mixed with cold air to control oven/ furnace temperatures, as is the case in the ceramics sector for "biscuit" ovens. Average values found in the ENTR Lot 4 Preparatory Study from stakeholders were in the range 1.4:1 to 1.1:1. BAT values were in the range 1.05:1 to 1.15:1 for natural gas as fuel (1.25:1 using LPG as fuel). As burner design is less dependent on process, it is reasonable to assume that if one manufacturer can achieve 1.05:1, then this is possible for all, although it may be costly.

Note that the 1.05:1 value was for cement kilns which are unusual, in that they usually utilise only one very large burner. Therefore, it is much easier to control the air/ fuel ratio in this simpler case, than in the more frequent case of furnaces which utilise many burners.

The air: gas ratio control ecodesign option is unsuitable for direct-fired ovens because the combustion gases must be diluted with air to achieve the required process temperature. Cold air has to be mixed with combustion gases to achieve the desired temperature; therefore, limiting excess burner air is not feasible.

Although a number of stakeholders submitting information during the ENTR Lot 4 Preparatory Study a reduction of the λ value from 1.2 to 1.1 reduced energy consumption only by the order of 1%, this is in contrast to two publications[11] which state that the theoretical energy saving for a furnace operating at 1100°C from going from using 20% excess air (λ= 1.2: 1) to a stoichiometric combustion ratio (λ= 1: 1) would be c. 18% less fuel needed. Based on the research publications cited, the ENTR Lot 4 consultants have estimated that a reduction of the λ value from 1.2 (20% excess air) to 1.1 (10% excess air) could save approximately 9% fuel, which is considerable, where feasible, and if this value is realistic.

The Consultation Forum is invited to comment on the Air: Gas/ Fuel "λ" Ratio Mandatory Ecodesign proposals, with regard to the ambition, timing and feasibility and the exceptions, also taking into account the ongoing Gas Harmonisation discussions outlined in Section 2.1.7.

2.1.7 Gas Quality Harmonisation in the EU, and Ongoing Potential Ramifications for Close Control of Lambda Values

The optimum gas air ratio is often controlled such that fuel is fully burned, no carbon monoxide is formed, and a minimum of excess air is present. There are heat treatment processes for metals where a reducing atmosphere is essential to prevent surface oxidation, and so less air is used to ensure that some carbon monoxide is produced. There is, as a result, less heat energy generated from a given quantity of burning gas (thus producing carbon monoxide) than from full combustion (which produces carbon dioxide).

The quantities in terms of mass or volume of fossil fuel and air required by a burner depend on the fuel composition. As long as the fuel composition remains constant, limiting excess air is relatively straightforward. Where oil or Liquid Petroleum Gas, LPG (a mixture of propane and butane) are supplied in tanks, no fuel composition change will occur until the next batch of fuel is used.

However, the use of piped natural gas is quite common in the EU for industrial furnaces and ovens, but its composition is variable. Natural gas contains mostly methane but also ethane, propane and

[11] A Best Practices Process Heating Technical Brief - Waste Heat Reduction and Recovery for Improving Furnace Efficiency, Productivity and Emissions Performance, U.S. Department of Energy. 2004. The second publication refers to the DoE's Energy Efficiency handbook which states that a 1% decrease in excess air saves 1% of fuel.

other hydrocarbon constituents depending on its source. North Sea gas consists of mostly methane, whereas liquid natural gas from the Middle East has a higher ethane content. The hydrocarbon composition affects the amount of oxygen for stoichiometric combustion, and so to prevent the formation of hazardous carbon monoxide, a higher excess air content is used in case the composition changes. Gas supplies in the EU are linked via a grid, and the gas supplied at any location depends on the sources of gas being used - and the demand throughout the EU - and so composition changes can occur unpredictably. To avoid excessive changes, EU Member States limit the composition change by imposing maximum and minimum Wobbe Index values.

Owing to an envisaged increasing variation in the source and exact composition of the EU's natural gas supplies (e.g., increasing supplies of LNG entering the EU grid, from a variety of supplier countries, and with differing chemical constituents), the European Commission is consulting on formulating an EU-wide range of permitted gas entering EU pipelines, based on prescribed values of the Wobbe Index[12]. Note that this Wobbe Index permitted range is aimed to be as large as feasibly possible, **to guarantee security of supply** (i.e., rather than to minimise energy consumption, as in Ecodesign λ control implementing measure).

The Wobbe Index is a measure of calorific value in MJ/m^3, although the actual values depend on temperature and pressure. The proposed Wobbe Index range is 47 – 54 MJ/m^3, which represents a range of 15%, and this variation in the Wobbe Index of piped natural gas composition is equivalent to the difference between 100% methane and (80% methane + 20% ethane).

This change in gas composition requires a 13% increase in the amount of oxygen, in order to maintain stoichiometry. Therefore, for example, if 5% excess oxygen is used with 100% methane and the gas composition changed to 80% methane + 20% ethane, there would be insufficient oxygen for full combustion, unless the air flow to the burner were to be increased. Furnace operators need to adjust the gas and oxygen flow rates to provide the correct energy input to the furnace, as well as to minimise excess air. This requires adjustments to flow rates when natural gas composition changes. This is relatively straightforward if combustion gas analysers are fitted with furnaces that have only a small number of burners. The analysers can have alarms to warn operators if there are changes outside preset limits giving a warning that adjustment is needed. However, some designs of large furnace have a large number of burners; for example, a tunnel brick kiln may have 300 or more burners. Manual adjustment of these burners to compensate for gas composition changes is practically impossible, as gas composition changes occur without warning. It is therefore necessary for the user of the furnace to utilise a higher excess air content than the optimum ratio for energy efficiency, to avoid carbon monoxide formation when composition changes occur. A higher excess air content is also used with small ovens and kilns, where the gas consumption is relatively low (thus implying that a combustion gas analyser would have too long a payback period, and is therefore not used).

There is a technical solution for large multi-burner furnaces. The gas supply can be monitored with a Wobbe Index analyser. There are two types of Wobbe Index analyser: one measures calorific value,

[12] Further information available at: http://ec.europa.eu/energy/gas_electricity/gas/gas_quality_harmonisation_en.htm

and the second type is a gas chromatograph, which monitors composition (however, both analysers require c.20 minutes to function, and therefore seem to preclude the control of, or response to, rapid gas composition changes). The gas analysis data can be used with computer control to automatically adjust gas flow rates to each burner, but this is expensive because one flow controller is needed for each burner. The best precision is achieved with mass flow controllers which for high gas flow rates can be c. €4000 each. This means that to compensate for variations in gas composition there would be a cost of c.25% of the original furnace price, which would entail a payback time of 10 years[13]. Volume flow controllers are cheaper than mass flow controllers, but flow control is more complex, as it must compensate for temperature and pressure, which also constantly fluctuate. A 10 year return on investment (ROI) would be unacceptable, and so higher excess air concentrations than are technically achievable have to be used, if the gas supply Wobbe Index is not constant.

2.1.8 Overview of the Three Ecodesign Options and their Ambition for BCs 2-7

These savings would be achieved using three eco-design options in three tiers, as follows:

Ecodesign options	Tier 1 (from 2014 onwards)	Tier 2 (from 2018 onwards)	Tier 3 (from 2024 onwards)
Heat recovery: Fossil Fuel fired only	For BC6 and BC7 only – energy saving and cost is half of total difference between BaU and BAT	For all industrial (BCs 2-7), energy saving and cost is half of total difference between BaU and BAT	BAT
Insulation (BCs 2-7): both Electric and Fossil Fuel Fired	Same as BaU	BAT	BAT
Gas/ air (BCs 2-7): Fossil Fuel fired only	For BC2 – BC7, energy saving and cost is half of total difference between BaU and BAT	BAT	BAT

Note: The energy saving potential of laboratory ovens (BC 1) was only assessed for the LLCC and BAT scenarios.

2.1.9 Indicative Summary of the Potential Energy-Saving Ecodesign Measures on a Sectoral Basis – Estimations from the ENTR Lot 4 Preparatory Study for BCs 2-7

Annex D gives estimates (from the ENTR Lot 4 Preparatory Study, Task 5) for possible energy saving potential values, on a sectoral and sub-sectoral basis.

[13] 300 mass flow controllers at €4000 each, plus gas chromatograph (€20,000) plus computer controller etc.

2.2 PO-2: Summary Description of Proposed "Ecodesign-Style" Requirements within IED BREFs

Policy Option 2 basically consists of the same three most important sub-options within Policy Option 1 (Heat Recovery and Reuse; Minimum Insulation; and Air: Gas/ Fuel "λ" Ratio Control), but to implemented within the remit of the sectoral IED BAT conclusions (or possibly the Horizontal Energy Efficiency BAT conclusions).

As the sector-specific BAT conclusions can customise the requirements on a relevant basis for each sector and sub-sector, it is likely that – if possible – the use of the Ecodesign-style technical options outlined within Sections 2.1.5-2.1.8 of this Summary Working Document may be more optimally used within sectoral BAT conclusions, on a rolling basis, as they are revised.

Annex E compares the PO-2 implementation with that of PO-1, utilising in each case the same main three Ecodesign strategies of Heat Recovery and Reuse; Minimum Insulation; and Air: Gas/ Fuel "λ" Ratio Control.

It should be noted that in the three variations of PO-2 ("Optimistic", "Pragmatic" and "Pessimistic" IED BAT adoption), the BAT comprises the most advanced Tier of each ecodesign option, as appropriate.

Further information on PO-2 proposals will be uploaded onto CIRCABC, from the draft Impact Assessment, as it becomes available.

2.3 POLICY OPTIONS 3 & 4

As described in the introduction to Section 2, Policy Options 3 and 4 have not been further pursued within the draft Impact Assessment study, for detailed analysis.

For reference, they comprise the following potential proposals:

- **Policy Option 3 (PO 3):** Support to increase energy efficiency of Lot 4 furnaces and ovens via Government/ public authority measures;

- **Policy Option 4 (PO 4):** Voluntary Initiative(s) by Lot 4 furnaces and ovens end-user sectors.

Additional information on Policy Options 3 and 4 will be uploaded to CIRCABC, to explain the envisaged remit of the policy options, and why they have been discarded from further analysis.

3. DRAFT IMPACT ASSESSMENT FINDINGS – PRIMARY ENERGY (ELECTRICITY-POWERED FURNACES AND OVENS) AND FINAL ENERGY (NATURAL GAS, FUEL OIL, COAL AND COKE) SAVINGS BY INDUSTRIAL AND LABORATORY FURNACE BASE CASE[14]

[14] Please note that these are draft energy consumption modelling considerations from the ongoing Impact Assessment.

Annex E presents the draft modelling of Primary and Final Energy consumption and savings, which has been undertaken analysing the appropriate Policy Options and sub-options available for each Base Case.

It should be noted that wider economic and other factors have yet to be incorporated into the Impact Assessment Policy Options modelling and comparisons; hence, solely the relative Primary and Final Energy consumption figures are included.

Members of the Consultation Forum are invited to comment on the relevant advantages of the various Policy Options per Base Case, and policy options overall within the product group of "Industrial and Laboratory Furnaces and Ovens". The Consultation Forum is also invited to contribute to the Impact Assessment study.