ANNEX C – JAPANESE LEGISLATION ON RATIONAL USE OF ENERGY (UTILISED AS INSPIRATION FOR FURNACE AND OVEN PROPOSED DRAFT ECODESIGN PARAMETERS) – excerpt from ENTR Lot 4 Preparatory Study, Task 1

The Japanese Energy Act[1] - Law Concerning the Rational Use of Energy (enforced in April 2006) (in generally, called "Energy Conservation Law"). This imposes mandatory standards on air ratio of burners, external surface temperatures of furnaces and re-use of heat energy from hot gases. Subsidies and low interest loans are provided to encourage energy efficiency improvements. Audits by energy conservation experts are provided to eligible manufacturers. Users of furnaces and ovens are obliged to measure and record the performance of heat exchangers and the performance of their furnaces and this is reported to the authorities. The standards specify:

Maximum external temperatures - are specified for furnaces rated at ≥500°C; ambient temperature is assumed to be 20°C. Limiting the outer surface temperature limits heat losses through insulation.

Table 1. Maximum outer surface temperature as specified by the Japanese Energy Act

Item	Furnace temperature (°C)	Furnace wall outer surface temperature (°C)		
		Ceiling	Side wall	Bottom in contact with open air
Standard	1,300 or more	140	120	180
	1,100-1,300	125	110	145
	900-1,100	110	95	120
	Less than 900	90	80	100
Target	1,300 or more	120	110	160
	1,100-1,300	110	100	135
	900-1,100	100	90	110
	Less than 900	80	70	90

These are maximum temperatures and actual wall temperatures will vary, because areas around doors, for example, will be hotter than other areas. The outer wall burn threshold temperature of industrial furnaces in the EU is specified by EU standard EN ISO 13732-1, which is a voluntary safety standard. Maximum outer surface temperatures are specified for surfaces that can be touched by workers; this means that much higher temperatures could be used at inaccessible locations, or those protected by barriers.

The Japan Energy Act excludes certain types of furnace from the surface temperature obligations:

- Small furnaces with consumption equivalent to <20 l/h crude oil

[1] http://www.asiaeec-col.eccj.or.jp/databook/2009e/index.html

- Furnaces requiring forced cooling systems, such as glass melting furnaces, blast furnaces and electric arc furnaces (forced cooling will include water cooling, such as with electric arc furnaces and air cooling such as with glass melting furnaces)

- Rotary kilns, such as cement clinker kilns and rotary metal melting and smelting furnaces.

- Furnaces for R&D and for trials.

Note 1 of the Japan Energy Act defines the temperatures in Table 1 as the average outer wall surface temperature excluding specific parts (we assume these are the heat bridges) during normal, steady operation at an outside temperature of 20°C.

Air ratio for burners – Upper limits for gas: air ratio are specified. Higher proportions of burner air reduce energy efficiency. In the table below, for example, 1.20 is equivalent to 3.5% excess oxygen which is fairly common as good practice in the EU; 1.0 – 1.5% is generally regarded as optimum, although care is needed to avoid carbon monoxide impurities. Limits apply only to specified processes, which are mostly high temperature processes, but which include the "burner portion" of drying furnaces. The "Burner portion" may imply indirect-fired drying, where the gas/ air ratio would influence energy consumption.

Table 2. Burner air ratios (λ values) by fuel and furnace type (Japanese Energy Act)

Item		Gas fuel		Liquid fuel		
		Continuous type	Intermittent type	Continuous type	Intermittent type	
Standard	Melting furnace for metal forging	1.25	1.35	1.3	1.4	
	Continuous reheating furnace (billet, bloom, slab)	1.20	-	1.25	-	
	Metal heating furnace other the above	1.25	1.35	1.25	1.35	
	Metal heat treatment furnace	1.20	1.25	1.25	1.3	
	Oil heating furnace	1.20	-	1.25	-	
	Thermal decomposition furnace and reforming furnace	1.20	-	1.25	-	
	Cement kiln	1.30	-	1.3	-	*1
	Coal kiln	1.30	1.35	1.3	1.35	*1
	Drying furnace	1.25	1.45	1.3	1.5	*2
Target	Melting furnace for metal forging	1.05-1.20	1.05-1.25	1.05-1.25	1.05-1.30	
	Continuous reheating furnace (billet, bloom, slab)	1.05-1.15	-	1.05-1.20	-	
	Metal heating furnace other than the above	1.05-1.20	1.05-1.30	1.05-1.20	1.05-1.30	
	Metal heat treatment furnace	1.05-1.15	1.05-1.25	1.05-1.20	1.05-1.30	
	Oil heating furnace	1.05-1.20	-	1.05-1.25	-	
	Thermal decomposition furnace and reforming furnace	1.05-1.20	-	1.05-1.25	-	
	Cement kiln	1.05-1.25	-	1.05-1.25	-	*1
	Coal kiln	1.05-1.25	1.05-1.35	1.05-1.25	1.05-1.35	*1
	Drying furnace	1.05-1.25	1.05-1.45	1.05-1.30	1.05-1.50	*2

*1 = Value of liquid fuel in case of pulverised coal firing
*2 = Burner portion only

There is no equivalent gas: air ratio standard or legislation in EU for industrial furnaces.

It is important to note that Japan is an island and is able to minimise changes in the Wobbe Index of its piped natural gas unlike within the EU, where a variety of gas sources are used, so that the Wobbe Index can fluctuate without warning. Japanese users are able to use lower λ values than EU users, because in the EU there is a risk of toxic CO formation if the gas composition were to change, such that more oxygen might be needed for complete combustion.

Note that there is no Japanese requirement for ceramics processes. The legislation does not explain this omission but, according to Cerame-Unie, this is because it is not technically possible to impose a gas/ air ratio limit for ceramics furnaces, as combustion gas volume is an important characteristic and often requires additional air to achieve this.

Waste heat recovery is regulated by requiring that specific proportions of waste heat are recovered and by imposing minimum heat recovery values for industrial furnaces that depend on capacity and process temperature. Indicative waste gas temperatures are provided.

Table 3. Waste heat recovery requirements (Japanese Energy Act)

Exhaust gas temperature(℃)	Capacity category	Standard waste heat recovery rate %	Target waste heat recovery rate (%)	Reference	
				Waste gas temperature (℃)	Preheated air (℃)
Less than 500	A ・B	25	35	275	190
500 - 600	A ・B	25	35	335	230
600 - 700	A	35	40	365	305
	B	30	35	400	270
	C	25	30	435	230
700 - 800	A	35	40	420	350
	B	30	35	460	310
	C	25	30	505	265
800 - 900	A	40	45	435	440
	B	30	40	480	395
	C	25	35	525	345
900-1,000	A	45	55	385	595
	B	35	45	485	490
	C	30	40	535	440
1,000 or more	A	45	55	-	-
	B	35	45	-	-
	C	30	40	-	-

Capacity categories

A = furnaces with rated capacity ≥84,000 MJ/hour

B = furnaces with rated capacity of 21,000 – 84,000 MJ/hour

C = Furnaces with rated capacity of 840 – 21,000 MJ/hour.

This type of waste heat requirement would be very effective in the EU, as many new furnaces have no or very little heat recovery. The Japanese requirements are the standard waste heat recovery rates in this table. For example, a furnace operating at over 1000°C rated for >84,000 MJ/hour must recover at least 45% of the heat in the flue gases and aim to recover at least 55% of the heat. As a guide, Table 3 indicates reference temperatures of flue gases after heat recovery, although upper flue gas temperature limits (for specific excess oxygen to the gas burner) could be used as an alternative eco-design requirement. The reference temperatures in Table 3 are all 535°C or less, which is consistent with combustion gas exit temperatures after heat recovery with a recuperator. The heat recovery ratio is calculated in Japan using the following[2] equations and relationships:

Heat recovery ratio percent = (Qa/Qg) x 100%; where

$Q_g = V_g \times \rho \times C_p \times T$

Qg is the heat content of combustion gas before heat recovery under normal load conditions

Vg is the flow rate of the combustion gas before heat recovery

ρ is the density of the combustion gas before heat recovery

Cp is the specific heat of the combustion gas

T is the temperature at the exit of the furnace chamber before heat recovery

$Qa = Va \times \rho \times Cp \times \Delta T$

Qa is the recovered heat

Va is the flow rate of the combustion gas after heat recovery

ρ is the density of the combustion gas after heat recovery

Cp is the specific heat of the combustion gas

ΔT is the difference in temperature before heat recovery and after heat recovery (at constant $\%O_2$)

[2] Formula and compliance details provided by Japan Industrial Furnace Manufacturers Association (JIFMA)