Appendix F: Characteristics of Selected Technologies

Characteristics for selected technologies presented here are compiled from company brochures and other publications. Users are advised to use these numbers as guidelines or benchmarks while estimating technology specific numbers for their own countries. This list is partial. Refer to the accompanied CD for a more detailed list of technologies. Also refer to Appendices K and M for data on technologies in India and Japan.

Technology	Parameter	Typical value	Data source	Remarks
Residential sector				
Refrigerator – 141-200 liter capacity (Matsushita)	Electricity use (kWh/year)	390	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	40 to 65		
Refrigerator – 201-250 liter capacity (Toshiba, Hitachi)	Electricity use (kWh/year)	420 to 440	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	60 to 110	ECC (2002)	
Refrigerator – 251-300 liter capacity (Sanyo, National)	Electricity use (kWh/year)	390 to 400	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	64 to 120	ECC (2002)	
Refrigerator – 301-350 liter capacity (Hitachi, Matsushita)	Electricity use (kWh/year)	320 to 370	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	100 to 175	ECC (2002)	
Refrigerator – 351-400 liter capacity (Toshiba, Hitachi)	Electricity use (kWh/year)	300 to 310	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	118 to 220	ECC (2002)	
Refrigerator – 401-450 liter capacity (Toshiba, Matsushita)	Electricity use (kWh/year)	280	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	168 to 275	ECC (2002)	
Refrigerator – 451 and above liter capacity (Toshiba, Matsushita)	Electricity use (kWh/year)	280 to 290	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Fixed cost (1000 JPY*)	188 to 300	ECC (2002)	
Color TV – standard, size: 14 to 20 (Aiwa, Sharp, Funai)	Rating (W)	49.1 to 66.1	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	57 to 82	ECC (2002)	
	Fixed cost (1000 JPY*)	14 to 28	ECC (2002)	
Color TV – standard, size: 21 (Aiwa, Victor)	Rating (W)	72.6 to 76.6	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	82 to 84	ECC (2002)	
	Fixed cost (1000 JPY*)	24 to 26	ECC (2002)	
Color TV – standard, size: 25 to 29 (Hitachi, Mitsubishi)	Rating (W)	110.1 to 12201	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	121 to 132	ECC (2002)	
	Fixed cost (1000 JPY*)	36 to 70	ECC (2002)	
Color TV – wide with built-in BS tuner, size: 28 (Sanyo, Mitsubishi)	Rating (W)	120.1 to 135.4	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	125 to 138	ECC (2002)	
	Fixed cost (1000 JPY*)	50 to 70	ECC (2002)	
Color TV – wide with built-in BS tuner, size: 32 to 36 (Toshiba)	Rating (W)	171.2 to 184.3	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	186 to 201	ECC (2002)	
	Fixed cost (1000 JPY*)	144 to 277	ECC (2002)	
Air conditioner – 2.2 kW capacity (Toshiba, Hitachi, National)	Rating (W)	Cool: 365 to 370; Warm: 530 to 535	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	727 to 760	ECC (2002)	
	Fixed cost (1000 JPY*)	10 to 20	ECC (2002)	

Technology	Parameter	Typical value	Data source	Remarks
Air conditioner – 2.5 to 2.8 kW capacity (Sanyo, Toshiba, Hitachi, National, Sharp)	Rating (W)	Cool: 430 to 470; Warm: 615 to 685	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	827 to 941	ECC (2002)	
	Fixed cost (1000 JPY*)	10 to 25	ECC (2002)	
Air conditioner – 3.2 kW capacity (Mitsubishi)	Rating (W)	Cool: 1040; Warm: 1165	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	1763	ECC (2002)	
	Fixed cost (1000 JPY*)	10 to 28	ECC (2002)	
Air conditioner – 3.6 4.0 kW capacity (Daikin)	Rating (W)	Cool: 780 to 895; Warm: 890 to 1215	ECC (2002)	These are high efficiency appliances; Valid for Japan
	Electricity use (kWh/year)	1309 to 1525	ECC (2002)	
	Fixed cost (1000 JPY*)	15 to 38	ECC (2002)	
Transport sector				
Gasoline car – curb wt.: 750-990 kg (Suzuki, Toyota, Nissan, Honda)	Fuel consumption at 10/15 mode (km/l)	19.0 to 23.0	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	914 to 1310	JAMA (2001)	
Gasoline car – curb wt.: 1000-1330 kg (Toyota, Honda, Volkswagen)	Fuel consumption at 10/15 mode (km/l)	12.4 to 15.0	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	1499 to 1998	JAMA (2001)	
Gasoline car – curb wt.: 1590-1840 kg (Toyota, Honda)	Fuel consumption at 10/15 mode (km/l)	9.2 to 9.5	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	2275 to 3760	JAMA (2001)	
Hybrid car (gasoline) – curb wt.: 820-1220 kg (Toyota, Honda)	Fuel consumption at 10/15 mode (km/l)	29.5 to 35.0	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	2090 to 2180	JAMA (2001)	
Hybrid car (gasoline) – curb wt.: 1670-1840 kg (Toyota)	Fuel consumption at 10/15 mode (km/l)	13.0 to 18.0	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	3630 to 4420	JAMA (2001)	
Electric car – curb wt.: 1270 kg (Suzuki)	Fuel consumption at 10/15 mode (km/l)	7.0	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	3000	JAMA (2001)	
CNG car – curb wt.: 770-810 kg (Daihatsu)	Fuel consumption at 10/15 mode (km/l)	18.8 to 22.6	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	1549 to 1550	JAMA (2001)	
CNG car – curb wt.: 1170-1190 kg (Honda, Nissan)	Fuel consumption at 10/15 mode (km/l)	17.2 to 18.8	JAMA (2001)	These are high efficiency vehicles; Valid for Japan
	Fixed cost (1000 JPY*)	2050 to 2660	JAMA (2001)	
Existing passenger cars	Average energy intensity (MJ/km-person)	1.73	IPCC (2001)	Europe, 1993
		2.59	IPCC (2001)	USA, 1994; High due to low passenger occupancy
		2.46	IPCC (2001)	Japan, 1994; High due to low passenger occupancy
Existing buses	Average energy intensity (MJ/km-person)	0.71	IPCC (2001)	Europe, 1993
		1.03	IPCC (2001)	USA, 1994; High due to low passenger occupancy
		0.73	IPCC (2001)	Japan, 1994

Technology	Parameter	Typical value	Data source	Remarks
Existing rail passenger locomotives	Average energy intensity (MJ/km-person)	0.48	IPCC (2001)	Europe, 1993
		2.15	IPCC (2001)	USA, 1994; High due to low passenger occupancy
		0.19	IPCC (2001)	Japan, 1994; Low due to high passenger occupancy and high efficiency
Existing passenger aircrafts	Average energy intensity (MJ/km-person)	2.78	IPCC (2001)	Europe, 1993
		2.46	IPCC (2001)	USA, 1994
		2.13	IPCC (2001)	Japan, 1994
Average existing passenger cars with gasoline internal combustion engine	Average fuel consumption rate (l/100 km)	8.6	IPCC (2001)	This is average figure for passenger cars existing in advanced markets in 1997
Most efficient models of existing passenger cars with gasoline internal combustion engine	Average fuel consumption rate (l/100 km)	7.0 to 7.5	Estimated based on IPCC (2001)	This is average figure for passenger cars introduced in Europe in the 1990s; It has remained essentially constant over past 10-15 years; EU has targeted to reduce average fuel consumption of new cars to 5.8 l/100 km by 2010
New car with aluminum-intensive material	Average fuel consumption rate (l/100 km)	3.0	IPCC (2001)	Few of such cars have been introduced in luxury-car segment in advanced countries
Fuel cell passenger cars using hydrogen	Average fuel consumption rate (gasoline equivalent l/100 km)	About 2.5	IPCC (2001)	Likely to be introduced internationally by 2005; Possible barriers include lack of hydrogen supply infrastructure and on-board storage for hydrogen fuel cells, and on-board reforming for methanol and gasoline
Fuel cell passenger cars using methanol	Average fuel consumption rate (gasoline equivalent l/100 km)	About 3.2	IPCC (2001)	
Fuel cell passenger cars using gasoline	Average fuel consumption rate (l/100 km)	About 4.0	IPCC (2001)	
Best models of existing light trucks	Average fuel consumption (l/100 km)	11.5	IPCC (2001)	Valid for advanced country markets in 1997
Best models of existing passenger aircrafts	Average fuel consumption (seat-l/100 km)	4.5	IPCC (2001)	Valid for 1997
Industry / Manufacturing sector				
Iron & steel industry				
	Average specific carbon emission (kg-C/GJ)	23.6	IPCC (2001)	Applicable for OECD countries
	Best specific carbon emission (kg-C/GJ)	19.8	IPCC (2001)	Applicable for OECD countries
Existing process of making pig iron from iron ore, coke, etc. (BOF route)	Average energy intensity (MJ/kg of iron)	20 to 25	Smil (1999),	
	Pelletized ore intensity (kg/kg of iron)	1.6	Smil (1999)	
	Coke intensity (kg/kg of iron)	0.4	Smil (1999)	
	Injected coal intensity (kg/kg of iron)	0.1	Smil (1999)	Alternatively, 0.06 kg of fuel oil is used
	Limestone intensity (kg/kg of iron)	0.2	Smil (1999)	
Existing process of steel-making from iron (BOF route)	Energy intensity (MJ/kg of steel)	20 to 50	Smil (1999)	
Best performing BOF process (from iron ore to rolled steel)	Energy intensity (MJ/kg of steel)	15 to 20	Phylipsen et al. (1998)	Based on a comparison of steel making for various countries in 1988
Best performing EAF process	Energy intensity (MJ/kg of steel)	4 to 9	Phylipsen et al. (1998)	Based on a comparison of steel making for various countries in 1988

Technology	Parameter	Typical value	Data source	Remarks
Aluminium industry				
Existing (Hall-Heroult) process for production of aluminum from bauxite	Energy intensity (MJ/kg of aluminum)	200 to 342	Smil (1999)	
	Dry bauxite intensity (kg/kg of aluminum)	4.47	Smil (1999)	
	Sodium hydroxide intensity (kg/kg of aluminum)	0.23	Smil (1999)	
	Steam intensity (kg/kg of aluminum)	6.60	Smil (1999)	
	Cryolite intensity (kg/kg of aluminum)	0.04	Smil (1999)	
	Carbon anode intensity (kg/kg of aluminum)	1.00	Smil (1999)	
	Alumina intensity (kg/kg of aluminum)	1.90	Smil (1999)	
Best performing aluminium production process in Germany	Fuel intensity of alumina production (MJ/kg Al)	5.6	Phylipsen et al. (1998)	Valid for Germany in 1989
	Electricity intensity of alumina (MJ/kg Al)	2.2	Phylipsen et al. (1998)	Valid for Germany in 1989
	Fuel intensity of anode production (MJ/kg Al)	3.7	Phylipsen et al. (1998)	Valid for Germany in 1989
	Fuel intensity of primary aluminium production (MJ/kg Al)	3.0	Phylipsen et al. (1998)	Valid for Germany in 1989
	Electricity intensity of primary aluminium production (MJ/kg Al)	55.1	Phylipsen et al. (1998)	Valid for Germany in 1989
Copper industry				
Existing process of copper production from sulfide ore	Energy intensity (MJ/kg of copper)	60 to 125	Smil (1999)	
Titanium industry				
Existing process of producing titanium from ore concentrate	Energy intensity (MJ/kg of titanium)	900 to 940	Smil (1999)	
Cement industry				
Existing cement production using limestone and clay as raw material	Energy intensity (MJ/kg of cement)	5 to 9	Smil (1999)	
Best performing cement production	Fuel intensity of process with very high clinker:cement ratio (MJ/kg of cement)	2.5 to 3.5	Phylipsen et al. (1998)	Based on a comparison of cement making in various countries in 1988/89
	Fuel intensity of process with very low clinker:cement ratio (MJ/kg of cement)	0.8 to 1.5	Phylipsen et al. (1998)	Based on a comparison of cement making in various countries in 1988/89
Existing cement production using limestone and clay as raw material, and coal as fuel	Average carbon emission intensity (t-C/ton cement)	0.34	Watson et al (1996)	This is average for existing process; 60% of this is from energy used in production, and 40% as process gas
Brick industry				
Existing brink-making from clay	Energy intensity (MJ/kg of brick)	2 to 5	Smil (1999)	
Glass industry				
Existing glass-making from sand, etc.	Energy intensity (MJ/kg of glass)	18 to 35	Smil (1999)	

Technology	Parameter	Typical value	Data source	Remarks
Limestone industry				
Existing process of limestone extraction from sedimentary rock	Energy intensity (MJ/kg of limestone)	0.07 to 0.10	Smil (1999)	
Sulfuric acid industry				
Existing process of producing sulfuric acid from sulfur	Energy intensity (MJ/kg of sulfuric acid)	2 to 3	Smil (1999)	
Ammonia industry				
Existing ammonia production process	Energy intensity (GJ/ton)	33.0 to 46.0	IPCC (2001)	Applicable for OECD countries
		39.5	IPCC (2001)	Applicable for South Asia
		44.0	IPCC (2001)	Applicable for Indonesia
Nitrogenous fertilizer industry				
Existing process of urea making (including ammonia making)	Energy intensity (MJ/kg of nitrogen)	70 to 110	Smil (1999)	Nitrogen comprises about 47% of urea
Pulp & paper industry				
Existing process of paper-making from standing timbre	Energy intensity (MJ/kg of paper)	25 to 50	Smil (1999)	
Best performing pulp and paper industry	Primary energy intensity (MJ/kg of paper)	12 to 20	Phylipsen et al. (1998)	Based on a comparison of pulp and paper making in various countries in 1988
Petroleum refining sector				
Best performing oil refining	Energy intensity for gasoline (MJ/kg of gas)	3.8	Phylipsen et al. (1998)	Based on a comparison of oil refining in various countries in 1988
	Energy intensity for kerosene (MJ/kg of gas)	1.6	Phylipsen et al. (1998)	Based on a comparison of oil refining in various countries in 1988
	Energy intensity for gasoil including naphtha (MJ/kg of gas)	3.2	Phylipsen et al. (1998)	Based on a comparison of oil refining in various countries in 1988
	Energy intensity for fuel oil (MJ/kg of gas)	1.8	Phylipsen et al. (1998)	Based on a comparison of oil refining in various countries in 1988
	Energy intensity for other petroleum products (MJ/kg of gas)	1.8	Phylipsen et al. (1998)	Based on a comparison of oil refining in various countries in 1988
Electricity generation sector				
Existing typical pulverized coal fired power plant	Efficiency (J/J)	0.30	IPCC (2001)	Existing worldwide average
	Fixed cost ($/kW)	1300	IPCC (2001)	This is typical cost of modern plant with SO2 and NO_x controls; Can be 50% higher depending on location; Less efficient designs with fewer pollution controls are cheaper
Best existing pulverized coal fired power plant (with new materials allowing higher temperatures and pressures)	Efficiency (J/J)	0.45	IPCC (2001)	Efficiency of up to 0.55 is possible by 2020
	Fixed cost ($/kW)	1740	IPCC (2001)	
Best existing CCGT (combined cycle gas turbine) power plant	Efficiency (J/J)	0.60	IPCC (2001)	Efficiency has been improving at 0.01 per year in the past decade; Efficiency of up to 0.70 is possible in next 10-20 years
	Fixed cost ($/kW)	450 to 500	IPCC (2001)	This includes cost of selective catalytic reduction for NO_x, dry cooling, and switchyard; Cost can be higher in some regions if new gas supply infrastructure is required
New IGCC (Integrated Gasification Combined Cycle) power plant (using gasification of coal or biomass or other fuel, and then running a CCGT)	Efficiency (J/J)	0.51	IPCC (2001)	Efficiency of up to 0.60 is possible by 2020
	Fixed cost ($/kW)	About 2000	IPCC (2001)	Fixed cost is expected to decline to 1100 by 2030

Technology	Parameter	Typical value	Data source	Remarks
CHP (Combined Heat and Power) plants (using any fuel)	Total efficiency including both heat and electricity utilization (J/J)	0.90	IPCC (2001)	This high efficiency is possible only if there are sufficiently high heating/cooling load densities available; Various factors including regulation can facilitate or hinder viability of CHPs
Phosphoric acid fuel cells (PAFCs), using natural gas to produce hydrogen as part of integrated system	Efficiency (J/J)	0.36 to 0.38	IPCC (2001)	This is efficiency from natural gas to electricity conversion; Efficiency of 0.50 is possible by 2010; Existing efficiency of 0.80 in cogeneration, expected to rise to 0.90 by 2010
	Fixed cost ($/kW)	1500	IPCC (2001)	This is for integrated system including fuel processor based on natural gas; Fixed cost may to decline to 750 by 2010
Molten carbonate fuel cells (MCFCs), using carbonaceous fuels (e.g. coal, natural gas) and internal reforming to produce hydrogen as part of integral system, and using steam turbine in a bottoming cycle	Efficiency (J/J)	0.65	IPCC (2001)	Not yet introduced commercially due to technical problems like electrode corrosion, sintering of structural fuel cell material, and sensitivity to fuel impurities
Solid oxide fuel cells (SOFCs), with internal reforming (possible due to high temperature) to produce hydrogen, and using by-product heat in a bottoming cycle	Efficiency (J/J)	About 0.65	Estimated based on IPCC (2001)	Not yet introduced commercially due to technical problems related to materials and development of structures
	Fixed cost ($/kW)	1620	IPCC (2001)	Fixed cost expected to decline to 700 in next 2 to3 decades
Hybrid SOFC/CCGT systems, using natural gas to produce hydrogen for fuel cell, coupled with CCGT	Efficiency (J/J)	0.72 to 0.74	IPCC (2001)	Not yet introduced
Existing nuclear power plant	Fixed cost ($/kW)	1700 to 3100	IPCC (2001)	
Pebble bed modular reactor (PBMR -advanced nuclear power plant)	Fixed cost ($/kW)	2090	IPCC (2001)	Still in R&D stage; Uncertainty about cost estimate due to reactor safety and waste disposal
Existing wind power plant	Fixed cost ($/kW)	1000	IPCC (2001)	Fixed cost expected to decline to 635 in next 10-20 years
Solar PV power plant	Fixed cost ($/kW)	4000 to 5000	IPCC (2001)	Fixed cost expected to decline as installed capacity increases
Solar thermal (flat plate solar collectors) power plant	Fixed cost ($/kW)	4000	IPCC (2001)	Fixed cost expected to decline to 2500 by 2030

Note: Also refer to following publications for additional information on efficiencies and costs of new technologies – Blok et al (1995), Brown et al (1998); IEA (1999); IPCC (1996a); Ishitani and Johansson (1996), Penner et al (1999); Perkins (1998); WEC (1995).
* JPY = Japanese Yen in 2002 price (1US$ = 118.05 JPY).