MetaEconomics

Alternative Trajectories for Computer and Television Recycling

Achieving the 80 per cent target by 2021-22

Report to the Department of Sustainability, Environment, Water, Population and Communities

August 2011

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metá - (prefix): *sense of change of position or condition, behind or after, beyond, of a higher order …*

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Contents

Executive summary

Liable parties under the proposed National Television and Computer Product Stewardship Scheme (the scheme) will soon be obliged to become a member of an Approved Arrangement responsible for the collection and recycling of TV and computer waste. The Government will set recycling targets for the scheme, with the aim of increasing the recycling rate to 80 per cent of the estimated waste stream by 2021-22.

There is a multitude of possible trajectories that lead to this target. This study examines the implications of four different trajectories that phase in recycling rates from their current levels to reach 80 per cent over the coming decade.

The four alternative trajectories (or pathways) are:

- Alternative 1 — commence a few points above the business-as-usual (BAU) annual recycling rate, increase to reach 65% of current recycling capacity in Year 2 then increase linearly to 40% target in Year 5, then increase linearly to achieve an annual recycling rate of 80 per cent by 2021-22;
- Alternative 2 — commence with a low starting target, increase the recycling rate slowly in early years, then more rapidly in the latter years of the 10 year pathway to 2021-22;
- Alternative 3 — post a higher initial recycling target, then steady annual increases to achieve the 80 per cent target after 10 years;
- Alternative 4 — post a higher initial target, increase the recycling rate slowly in the early years, then mandate more rapid increases later.

Detail on capacity and trajectories

Information on current (2009-10) recycling levels and processing capacity has been provided previously in the report by Wright & Rawtec (October 2010). This describes Australia's current and future e-waste recycling infrastructure capacity and needs in 2010, including an analysis of the current and potential processing capacity for TV and computer waste. A summary of demand and capacity estimates is reproduced in Table ES.1.

'Current capacity' as depicted in Table ES.1 represents a 'soft' limit. It reflects the current configuration of disassembly operations (eg. number of workbenches and personnel) and a single shift operation. Capacity increases associated with more workbenches, re-deploying personnel and double shifts are indicated by 'Potentially Available Capacity'. This represents a 'hard' limit to capacity beyond which new facilities and processing infrastructure will be required (entailing approval and construction lead times) in order to handle significantly higher levels of recycling demand.

Table ES.1 Estimated e-waste demand and processing capacity, May 2010

Product	Current Demand		Current Capacity		Potentially Available Capacity	
	(Units)	(Tonnes)	(Units)	(Tonnes)	(Units)	(Tonnes)
Televisions	347,000	8,700	1,365,000	34,100	1,635,000	40,900
Computers (assembled)	570,000	10,900	1,084,000	26,500	1,483,000	34,300
All computers and peripherals*	2,892,000	12,500	5,549,000	29,600	7,556,000	38,600
Mobile phones	902,000	180	1,240,250	248	2,029,500	406
Other electrical and electronic	102,000	3,820	138,750	5,252	227,500	9,000
Totals	**4,243,000**	**25,200**	**8,293,000**	**69,200**	**11,448,000**	**88,500**

* includes assembled computers

Source: Wright Corporate Strategy & Rawtec (Oct 2010), A study of Australia's Current and Future E-Waste Recycling Infrastructure Capacity and Needs, p.16-17

For TVs, the hard limit on annual recycling throughput, assuming the situation has not changed much since May 2010, is 40,900 tonnes (or 40.9 kilotonnes (Kt)) per year. For computers and peripheral devices it is 38,600 tonnes (38.6 kilotonnes (Kt)) per year. For the combined recycling stream of both product groups, it is 79.5 Kt per year.

Combining information from the Wright & Rawtec study on demand for recycling in 2009-10 and previous Meta Economics modeling on the estimated waste stream in 2009-10 suggests a BAU recycling rate for available TV and computer waste of about 17 per cent. In the absence of other data, it has been assumed that this rate remains steady over 2010-11 and 2011-12.

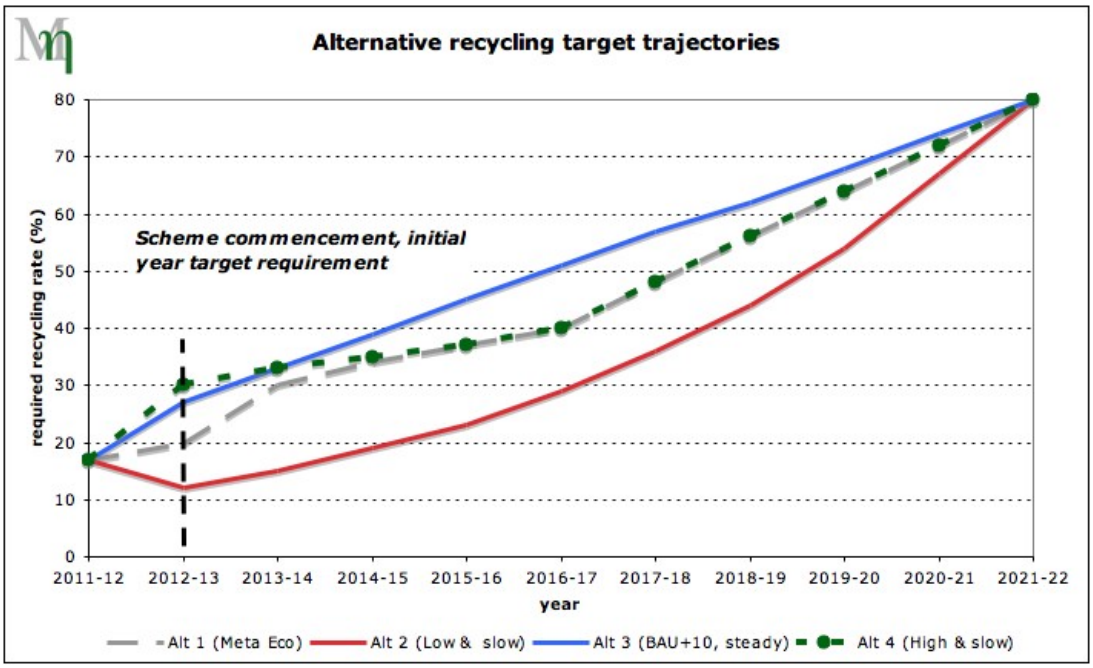
Details of the four alternative trajectories analysed in this study are provided in Table ES.2. They apply to both TV and computer recycling obligations.

Table ES.2 Annual recycling targets under 4 alternative trajectories

Obligation year	Alt 1: Meta Eco (July '11)	Alt 2: low start, slow early growth	Alt 3: BAU+10, steady growth	Alt 4: High start, slow early growth
	Annual target requirement (% of available waste)			
BAU = 2011-12	17	17	17	17
2012-13	20	12	27	30
2013-14	30	15	33	33
2014-15	34	19	39	35
2015-16	37	23	45	37
2016-17	40	29	51	40
2017-18	48	36	57	48
2018-19	56	44	62	56
2019-20	64	54	68	64
2020-21	72	67	74	72
2021-22	80	80	80	80

The 4 trajectory options are also presented graphically in Figure ES.1.

Figure ES.1 Trajectory pathways from 2012-13 to reach 80 per cent recycling rates in 2021-22

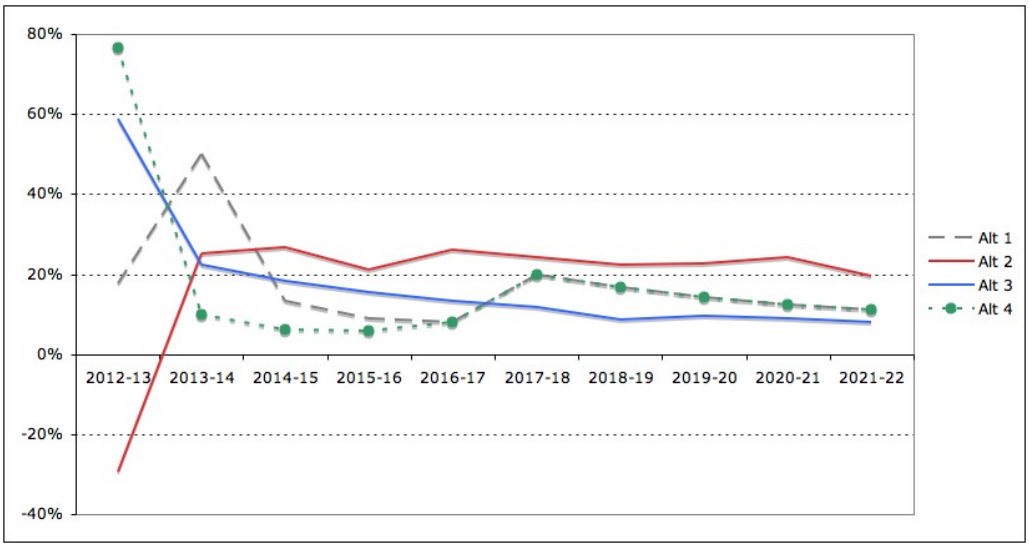


Implications of trajectories

The degree of year-on-year change associated with these trajectories is illustrated in Figure ES.2. This depicts the percentage change in the recycling targets under the different trajectory options, from one year to the next. It shows the degree of growth in recycling effort that each trajectory implies, and particularly highlights the required upscaling of effort from BAU levels.

As demonstrated in Figure ES.2, Alternative 1 requires an increase in recycling rates from BAU of about 18 per cent in year 1, a further increase of about 50 per cent in year 2, and then increases in the range of 9-20 per cent per year. Alternative 2 allows for an initial drop in recycling effort, and then tightens targets by around 20-25 per cent per year. Alternative 3 requires a large increase in recycling rates from BAU levels in year 1, increasing the rate by almost 60 per cent, and then easing the required annual expansion rate over the following years to 2021. Alternative 4 requires an even higher initial increase in recycling rates over BAU — around a 76 per cent increase in Year 1 of the scheme. It remains to be tested with industry, if current collection infrastructure can tolerate an increase to these levels for the commencement of the scheme. However, the Scheme will provide up to 19 months for the achievement of the Year 1 target, by counting towards that target any 'early action' during 2011-12.

Figure ES.2 Year on year changes in target requirements

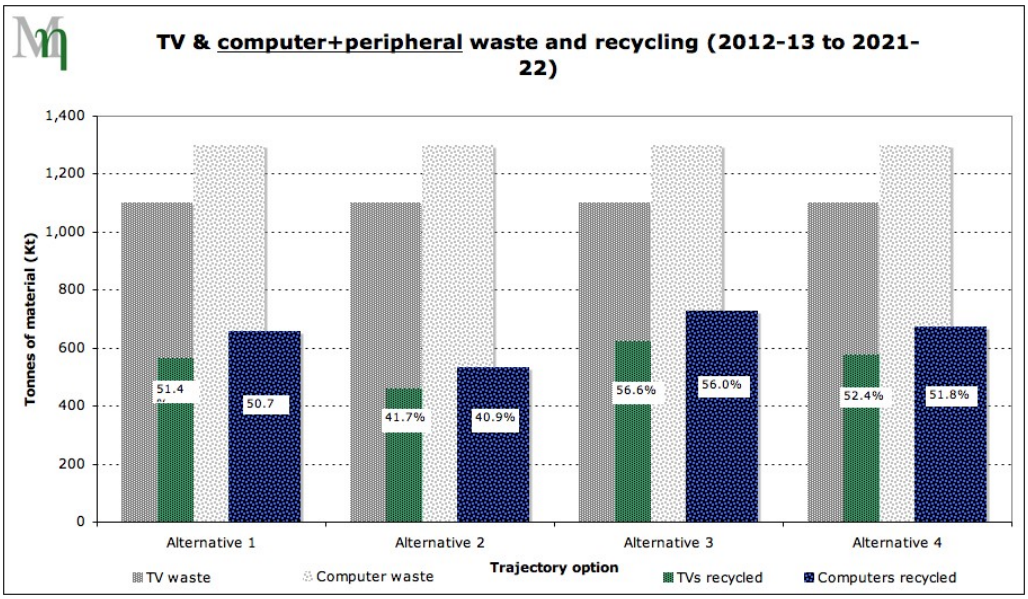


The percentage recycling targets under the different trajectories can be applied to estimates of annual waste generation (based on previous Meta Economics modelling) to generate a profile of annual recycling requirements under the scheme in terms of kilotonnes. The estimate of total waste generated in the period 2012-13 to 2021-22 for each category is:

- Televisions = 1,099.2 kilotonnes (Kt)
- Computers = 1,132.5 kilotonnes (Kt)
- Computers plus peripherals = 1,298.7 kilotonnes (Kt).

A comparison of the four trajectories, in terms of waste available over the phase-in period and the total amount that is required to be recycled under each trajectory, is provided in Figure ES.3.

Figure ES.3 Comparison of recycling outcomes under trajectory alternatives 1-4



Source: Meta Economics TVComp model (26 August 2011)

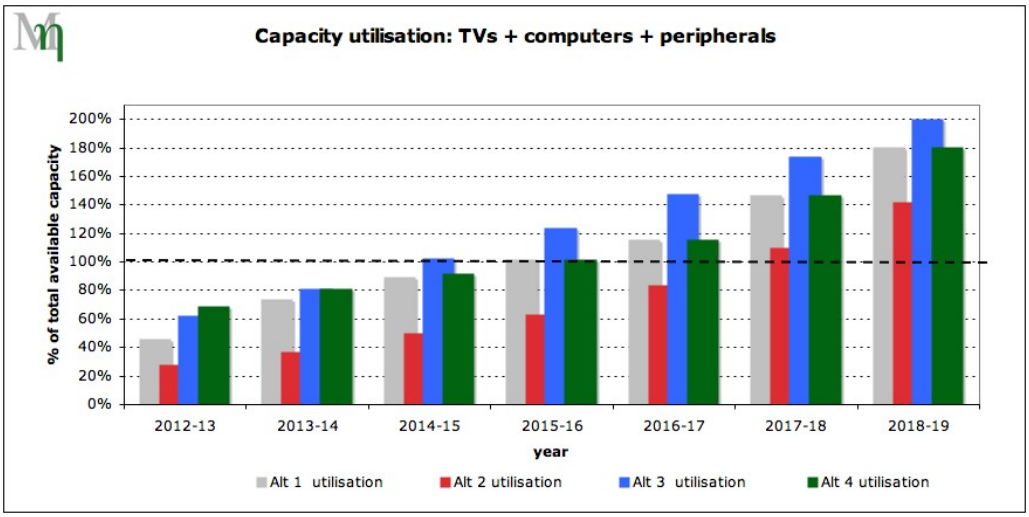
This suggests that of the options examined, Alternative 3 is likely to deliver the highest recycling rate over the 10 year period — given assumptions about future growth in the level of available waste for TVs, computers and peripheral devices. Alternative 3 achieves a recycling rate of 56.6 per cent for TVs over the 10 years to 2021-22, and 56.0 per cent for computers and peripherals.

Alternative 4 achieves the next highest recycling rate over the target phasing period, averaging 52.4 per cent for TVs and 51.8 per cent for computer waste. Alternative 1 achieves rates about 1 percentage point below that, while Alternative 2, the soft start option, achieves overall recycling rates about 10 percentage points lower.

Comparison of total potential recycling infrastructure capacity utilisation (for both TVs and computers) implied by the 4 trajectories is depicted in Figure ES.4. This suggests that the limits of current potential recycling capacity are unlikely to be tested by any of the proposed trajectories until late in 2014-15, assuming no other use of this capacity by other parties (such as local and state governments). Alternatives 1 and 4 do not push the limits of combined TV and computer recycling capacity until late in 2015-16, and Alternative 2 does not do this until well into 2017-18.

Importantly, these broad results are not substantially altered by scenario testing, including consideration of the digital televisions switchover, which has the effect of increasing available waste levels by around 3.58 million TVs between now and midway through 2014 (assuming a disposal lag of up to 6 months after the finalisation of the switchover in December 2013).

Figure ES.4 Comparison of overall capacity utilisation



Conclusions

Broad conclusions of the study are:

- all of the alternative trajectories are likely to be robust in the face of factors than can increase available waste levels and place additional demands on recycling infrastructure;
- Alternative 3 is the best performing option in terms of the total amount of recycling, delivering around 1,348.5 Kt of materials recycling over the 10-year period;
- Alternative 2 results in substantially less recycling over the period, but the gap between other contenders is more modest with Alternative 1 delivering close to the same overall level of recycling as Alternative 4 (1,222.8 Kt versus 1,249.0 Kt)
- uncertainty over future levels of waste generation implies that care must be taken to ensure that initial target requirements are within the capacity of Approved Arrangements, and processors gear their planning for additional capacity to the future demand created by the scheme. New capacity is likely to be required within 3 to 4 years of scheme commencement under trajectories consistent with Alternatives 1,3 and 4;
- there is insufficient information to form a robust view of the capacity of Approved Arrangements to establish and expand their operations to meet the demands of ambitious target trajectories — this remains a key issue and represents a potential caveat to Alternative 3's strong performance. However, a plan for 'credit for early action' under the scheme can alleviate the pressures associated with high initial targets; and
- the adjustment burden represented by the annual target in any particular year can also be alleviated under an approach that allows the transfer of obligations and over-achievement between years along the compliance pathway.

Chapter 1

Study objectives

In June 2011 Parliament passed the *Product Stewardship Act 2011*, a key element of the National Waste Policy. The Act is framework legislation, allowing for different products to be covered over time as the need may arise. The first scheme to be covered by the Act is a co-regulatory national television and computer recycling scheme. Under this scheme, importers and manufacturers of televisions, computers and peripherals will be obliged to become a member of an Approved Arrangement responsible for the collection and recycling of TV and computer waste. The Government will set recycling targets for the scheme, with the aim of increasing the recycling rate to 80 per cent of the estimated annual waste stream by 2021-22. The first target will apply to the 2012-13 financial year, although recycling undertaken following (planned) commencement of the Regulations in late 2011 will be allowed to count towards the 2012-13 target.

1.1 Evaluating trajectories

There is a multitude of possible trajectories that lead to the target of 80 per cent by 2021-22.

The purpose of this study is to examine the implications of alternative 'characteristic' trajectories. That is, broad approaches that can be prescribed for mandating annual recycling requirements that lift recycling rates from their current levels to 80 per cent. Two broad parameters distinguish the shape of trajectories. These are the:

2. initial recycling target; and
3. rate at which the recycling target increases.

In this study, four alternative trajectories (or pathways) are examined:

- Alternative 1 — commence a few points above the business-as-usual annual recycling rate, increase to reach 65% of current recycling capacity in Year 2 then increase linearly to 40% target in Year 5, then increase linearly to achieve an annual recycling rate of 80 per cent by 2021-22;
- Alternative 2 — commence with a low starting target, increase the recycling rate slowly in early years, then more rapidly in the latter years of the 10 year pathway to 2021-22;
- Alternative 3 — post a higher initial recycling target, then steady annual increases to achieve the 80 per cent target after 10 years;

- Alternative 4 — post a higher initial target, increase the recycling rate slowly in the early years, then mandate more rapid increases later.

Evaluation criteria

Even though each of these trajectories achieves the same target level of recycling in 2021-22, they are likely to achieve different levels of total recycling over the next decade, and place different levels of burden on Approved Arrangements and recycling infrastructure. In comparing and contrasting the performance of these alternatives, this report applies the following evaluation criteria:

1. total amount of TV and computer waste recycled over the period
    - more recycling is preferable to less, other things being equal
2. rate at which annual recycling requirement increases
    - large increases can outrun the ability of liable parties and Approved Arrangements to develop and expand the collection infrastructure necessary to achieve targets
3. timeframe in which the recycling requirement exceeds current available recycling capacity within Australia
    - the trajectories should allow sufficient time for additional infrastructure to come on line, thereby avoiding bottlenecks and associated problems with cost and quality.

1.2 Applying trajectories to the waste stream

The evaluation of trajectories for policy purposes is inexorably linked to the number of TVs, computers and peripheral devices that are estimated to arise in the waste stream each year. For example, does a 30 per cent recycling target in a particular year imply a requirement to recycle 5,000 tonnes or 50,000 tonnes of discarded equipment? The difference between those numbers can have a significant impact on the workload carried by Approved Arrangements, and the amount of material that finds its way to recycling facilities.

In evaluating the practical implications of alternative trajectories, it is useful to consider them in the context of the amount of available waste that is likely to be generated over the next decade. Information on current levels of TV and computer recycling, and the current level of processing capacity embodied in Australia's electronic waste recyclers is also important.

Past analysis by Meta Economics (July 2011), commissioned by the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) provides information on projected TV and computer waste levels. This applies data on equipment import levels and survey estimates of average life, growth and penetration in the Australian user population to forecast current and future levels of TV and computer waste. This provides an operational framework in which to examine the throughput implications of

different annual waste recycling requirements. For 2009-10, Meta Economics estimated the level of available TV waste nationally at 2.06 million units, and the level of computer waste (that is, assembled computers being retired and discarded) at 2.57 million units.

Information on current (2009-10) recycling levels and processing capacity is provided in the report by Wright & Rawtec (October 2010). This describes the state of the e-waste recycling market in Australia in 2010, including an analysis of the current and potential processing capacity for TV and computer waste. A summary of demand and capacity is reproduced in Table 1.1.

Wright & Rawtec (Oct 2010) indicate that, as at May 2010, about 347,000 TVs per year were being recycled, equivalent to 8,700 tonnes of material against a current throughput capacity of about 34,100 tonnes per year. For computers and peripherals, around 2,892,000 units were being processed (equivalent to 12,500 tonnes – although around 25 per cent of these were earmarked for re-use and refurbishment rather than disassembly and recycling per se) while current capacity stood at about 29,600 tonnes.

For both lines, similar disassembly processes are used and excess capacity from one process can be switched to support additional recycling demand for the other.

Table 1.1 Estimated e-waste demand and processing capacity, May 2010

Product	Current Demand		Current Capacity		Potentially Available Capacity	
	(Units)	(Tonnes)	(Units)	(Tonnes)	(Units)	(Tonnes)
Televisions	347,000	8,700	1,365,000	34,100	1,635,000	40,900
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Other electrical and electronic	102,000	3,820	138,750	5,252	227,500	9,000
Totals	**4,243,000**	**25,200**	**8,293,000**	**69,200**	**11,448,000**	**88,500**

* includes assembled computers

Source: Wright Corporate Strategy & Rawtec (Oct 2010), A study of Australia's Current and Future E-Waste Recycling Infrastructure Capacity and Needs, p.16-17

For both TV and computer recycling capacity, 'soft' and 'hard' capacity constraints apply. 'Current capacity' as depicted in Table 1.1 represents a 'soft' limit. It reflects the current configuration of disassembly operations (eg. number of workbenches and personnel) and a single shift operation. Capacity increases achievable through more workbenches, re-deploying personnel and double shifts are indicated by 'Potentially Available Capacity'. This represents a 'hard' limit to capacity, beyond which new facilities and processing

infrastructure will be required (with associated approval and construction lead times) in order to handle significantly higher levels of recycling demand.

For TVs, the hard limit on annual recycling throughput, assuming the situation has not changed much since May 2010, is 40,900 tonnes (or 40.9 kilotonnes (Kt)) per year. For computers and peripheral devices it is 38,600 tonnes (38.6 kilotonnes (Kt)) per year. For the combined recycling stream of both product groups, it is 79.5 Kt per year.

These numbers are important inputs to the quantitative analysis of TV and computer waste recycling target trajectories that follows.

Analysis of throughput tonnages implied by these four trajectories is undertaken in Chapter 2. A further review of these trajectories against the backdrop of available infrastructure and developments that might result in additional demands on Approved Arrangements and available infrastructure is provided in Chapter 3. Conclusions are presented in Chapter 4.

Chapter 2

Trajectory options, and quantity requirements

Target trajectories increase the annual requirement on Approved Arrangements to source and recycle TV and computer waste. The rate at which this requirement grows, and the quantity of material that is implied by the annual target will affect the rate at which the collection and processing infrastructure must expand in order to support the objectives of the scheme.

2.1 Alternative target trajectories in detail

Details of the four alternative trajectories developed for analysis in this study are provided in Table 2.1. They apply to the obligations placed on liable parties for the recycling of waste TVs and to parties with obligations to recycle waste computers and peripheral equipment.

The detailed annual targets correspond to the characterisations provide in Chapter 1. Alternative 1 mirrors the broad approach proposed by Meta Economics in its July 2011 report to SEWPAC.

Based on the Wright & Rawtec analysis, business as usual (BAU) recycling levels in 2009-10 are 347,000 TV units and 570,000 for assembled computers (note approximately 25 per cent of computer recycling is refurbishment and reuse). Applying this to the July 2011 Meta Economics modelling of the estimated amount of waste TVs and computers generated in 2009-10 translates into BAU processing rates of:

- 347,000 / 2,062,000 = 16.8 per cent for TVs; and
- (570,000 x 0.75) / 2,573,000 = 16.6 per cent for computer units (reflecting the net-out of refurbished units, as noted above).

Combining information from the Wright & Rawtec (Oct 2010) study and the Meta Economics (July 2011) modeling suggests a BAU recycling rate for available TV and computer waste of about 17 per cent.[1] We assume that this 2009-10 background rate of recycling also applies to 2010-11 and subsequent years.

[1] The Meta Economics study did not model peripheral devices specifically. In this analysis, we assume the recycling rates estimated for computers also apply to peripherals and parts.

Table 2.1 Annual recycling targets under 4 alternative trajectories

Obligation year	Alt 1: Meta Eco (July '11)	Alt 2: low start, slow early growth	Alt 3: BAU+10, steady growth	Alt 4: High start, slow early growth
	Annual target requirement (% of available waste)			
BAU = 2011-12	17	17	17	17
2012-13	20	12	27	30
2013-14	30	15	33	33
2014-15	34	19	39	35
2015-16	37	23	45	37
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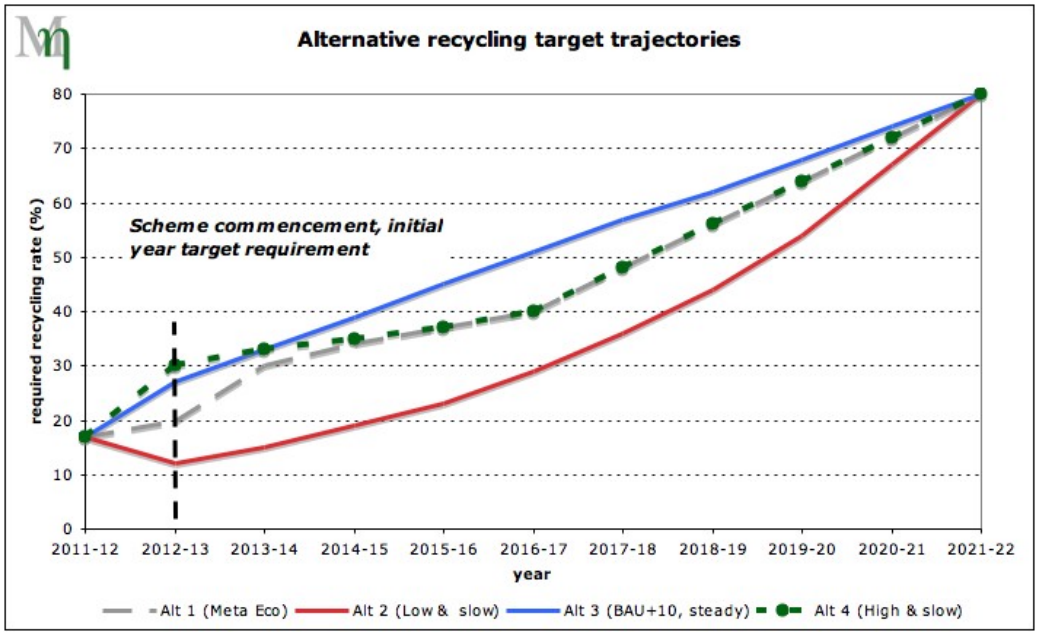
2018-19	56	44	62	56
2019-20	64	54	68	64
2020-21	72	67	74	72
2021-22	80	80	80	80

The 4 trajectory options are presented graphically in Figure 2.1. The lower level of obligations under Alternative 2 over the decade is obvious from the chart.

Figure 2.1 Trajectory pathways from 2012-13 to reach 80 per cent recycling rates in 2021-22



Similarly, it can be seen that Alternative 4 imposes a higher recycling obligation in the early years of the scheme (to 2016-17) than Alternative 1, after which annual recycling requirements under these trajectories converge.

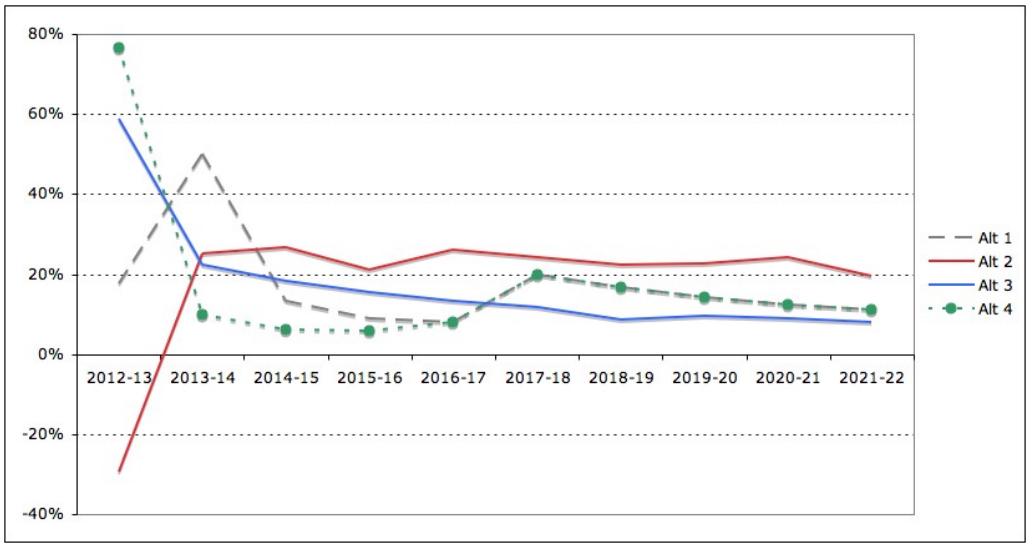
Alternative 3 sets a slightly lower initial target than Alternative 4, but moves more rapidly toward 80 per cent recycling than any of the other trajectories.

The degree of year-on-year change associated with these trajectories is illustrated in Figure 2.2. This depicts the incremental change in the recycling targets from one year to the next under the different recycling target trajectories, expressed as a percentage. It shows the degree of growth in recycling effort that each trajectory implies, and particularly highlights the required upscaling of effort from business as usual (BAU) levels.

As demonstrated in Figure 2.2, Alternative 1 requires an initial increase in recycling rates from BAU of about 18 per cent in year 1, a further increase of about 50 per cent in year 2 and then increases in the range of 9-20 per cent per year. Alternative 2, allows for an initial drop in recycling effort, and then tightens targets by around 20-25 per cent per year. Alternative 3 requires a large increase in recycling rates from BAU levels in year 2, increasing the rate by almost 60 per cent, and then eases the required annual expansion rate over the remaining years to 2021. Alternative 4 requires an even higher initial increase in recycling rates over BAU levels — around a 76 per cent increase in Year 1 of the scheme.

It remains to be tested with industry, if current collection infrastructure can tolerate an increase to these levels for the commencement of the scheme. However, it must be noted that the Scheme will provide up to 19 months for the achievement of the Year 1 target, by counting towards that target any 'early action' during 2011-12.

Figure 2.2 Year on year changes in target requirements

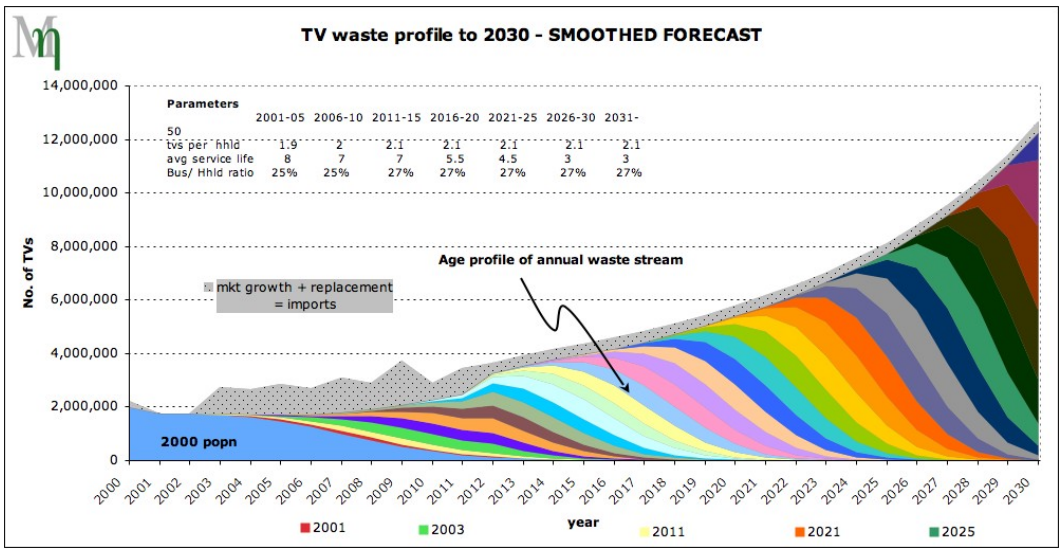


2.2 Estimates of annual waste generation

The performance of these competing trajectories can also be understood in terms of the amount of actual recycling that they imply. To achieve this, we need to link these annual requirements to an estimate of the amount of available waste generated in the applicable year.

The Meta Economics TVComp vintage model developed for SEWPAC in July 2011 generated a stylised forecast of the TV and computer waste stream to 2030 as illustrated in Figures 2.3 and 2.4. These depict current and predicted lifespans for TVs and computers, as used in the November 2009 Decision Regulatory Impact Statement on televisions and computers. They also reflect actual import data from 2001-02 to 2009-10, and ABS and other survey advice on household and business user populations and usage levels (eg. TVs and computers per household). For TVs, Figure 2.3 depicts a smooth transition from an average lifespan of about 7 years (currently) to around 3 years by 2028-29.

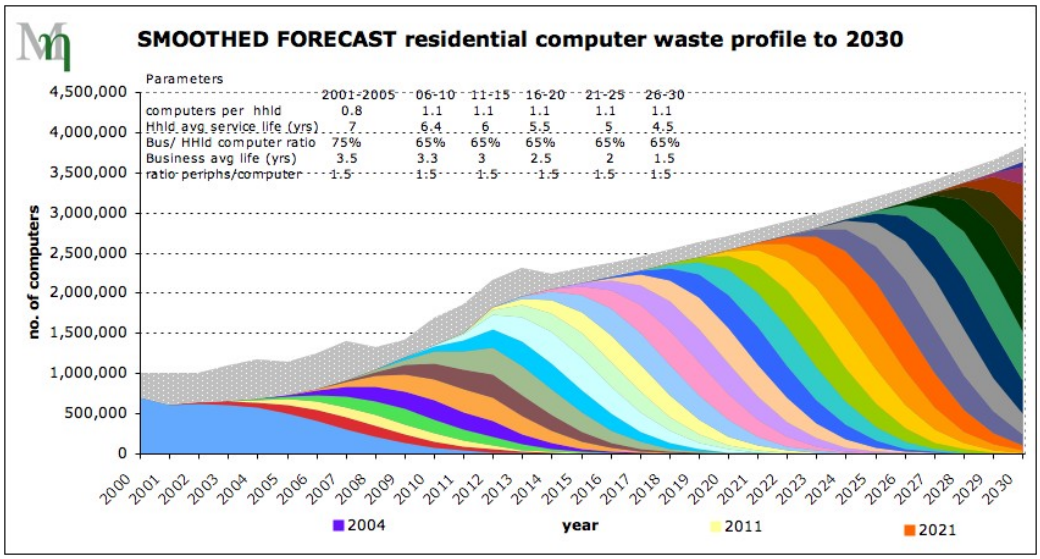
Figure 2.3 Smoothed TV waste projection to 2030

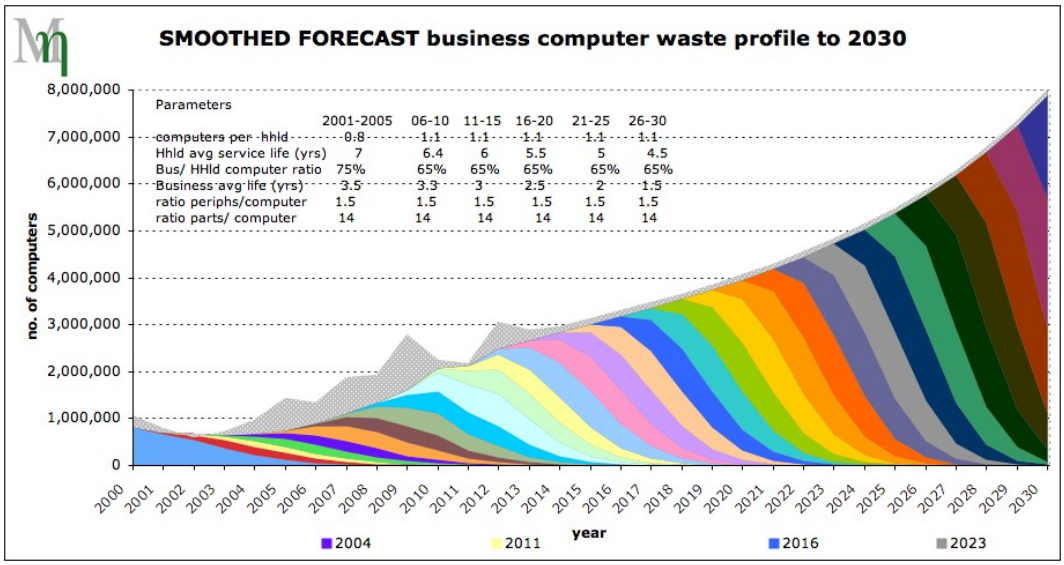


Source: Meta Economics TVComp model FORECAST (26 August 2011)

For computers Figure 2.4 depicts a smooth transition from an average life for household computers of 6.4 years currently to 4.5 years by 2027-28, and a transition for computers used in business and professional applications from 3.2 years currently to 1.5 years by 2028-29.

Figure 2.4 Smoothed computer waste projection to 2030





Source: Meta Economics TVComp model (26 August 2011)

These profiles yield the estimates of available waste levels for TVs and computers provided below in Table 2.2. Table 2.2 also converts the 'units' measure to kilotonnes of material based on the unit/mass ratio reported by Wright/ Rawtec (reproduced in this report in Table 1.1).[2]

Table 2.2 TVComp estimates of available waste to 2023

Year	TV waste (units)	TV waste (tonnes)	Computer waste (units)	Computer waste (tonnes)
2009-10	2,062,810	51,718.9	2,572,731	57,198.8
2010-11	2,260,123	56,665.9	3,143,435	69,887.0
2011-12	2,457,751	61,620.9	3,336,356	74,176.2
2012-13	3,242,266	81,290.3	3,974,428	88,362.3
2013-14	3,517,502	88,191.0	4,246,395	94,408.8
2014-15	3,739,393	93,754.2	4,497,531	99,992.3
2015-16	3,939,476	98,770.7	4,731,931	105,203.6
2016-17	4,153,314	104,132.1	4,954,472	110,151.3
2017-18	4,405,091	110,444.6	5,182,792	115,227.5
2018-19	4,698,552	117,802.3	5,427,944	120,677.8
2019-20	5,023,886	125,959.1	5,690,022	126,504.5
2020-21	5,373,435	134,723.0	5,968,104	132,687.1
2021-22	5,750,495	144,176.7	6,265,111	139,290.3
2022-23	6,165,618	154,584.7	6,585,388	146,410.9
2023-24	6,628,703	166,195.1	6,932,777	154,134.3

Source: Meta Economics TVComp model (26 August 2011)

[2] The conversion rates used (based on averaged Wright & Rawtec demand and capacity values) are: 100,000 TV units = 2.507 kilotonnes of material, 100,000 computer units = 2.223 kilotonnes of material and 100,000 peripheral units = 0.069 kilotonnes of material.

Further, using the recycling rate and weight ratio of peripherals to computers reported in Table 1.1, it is possible to extrapolate the TVComp estimates for computer waste to derive an estimate for computer waste plus peripherals (these products will form a single compliance category under the proposed scheme). Wright & Rawtec found that in the year to May 2010, 1,600 tonnes of peripherals were recycled along with 10,900 tonnes of waste computers. This suggests a ratio of **0.1468** tonnes of peripheral waste for each tonne of computer waste generated.

Using that ratio estimate, Table 2.3 shows estimates for total computer waste (incorporating computers and peripheral devices) generated to 2023, plus the total of TV and computer waste (including peripherals).

Table 2.3 Total TV and computer waste, 2011 to 2023 — including peripherals (kilotonnes)

Year	TV waste Kt	Computer + peripheral waste Kt	TV+ computer + peripheral waste Kt
2011-12	61.6	85.1	146.7
2012-13	81.3	101.3	182.6
2013-14	88.2	108.3	196.5
2014-15	93.8	114.7	208.4
2015-16	98.8	120.6	219.4
2016-17	104.1	126.3	230.5
2017-18	110.4	132.1	242.6
2018-19	117.8	138.4	256.2
2019-20	126.0	145.1	271.0
2020-21	134.7	152.2	286.9
2021-22	144.2	159.7	303.9
2022-23	154.6	167.9	322.5
2023-24	166.2	176.8	343.0

Source: Meta Economics TVComp model (26 August 2011)

These are the numbers used to test the quantitative annual recycling requirements implied by the alternative trajectories under review.

The recycling requirement in a particular year will be:

$$R_N = TR_N \times AW_N$$

Where R_N is the amount required for recycling in year N

TR_N is the recycling target in year N required by the trajectory; and

AW_N is the estimated amount of waste generated in year N.

This approach can be used to test the degree to which targets test the limits of recycling capacity in a particular year.

2.3 Trajectory implications for recycling

The recycling implications of the four alternative trajectories are reported below. For each, the estimate of total waste generated in the period 2012-13 to 2021-22 for each category is:

- Televisions = 1099.2 Kt
- Computers = 1132.5 Kt
- Computers plus peripherals = 1298.7 Kt.

These totals are not influenced by the target trajectories chosen.

Trajectory alternative 1

The quantitative implications of Alternative 1 are reported in Table 2.4. It shows the annual recycling requirement (in kilotonnes) under this trajectory for TVs and computer waste (including peripheral devices). It also shows the amount of TVs and computer materials that fall outside the recycling obligation each year. That is, the total waste estimate for the category minus the required recycling component.

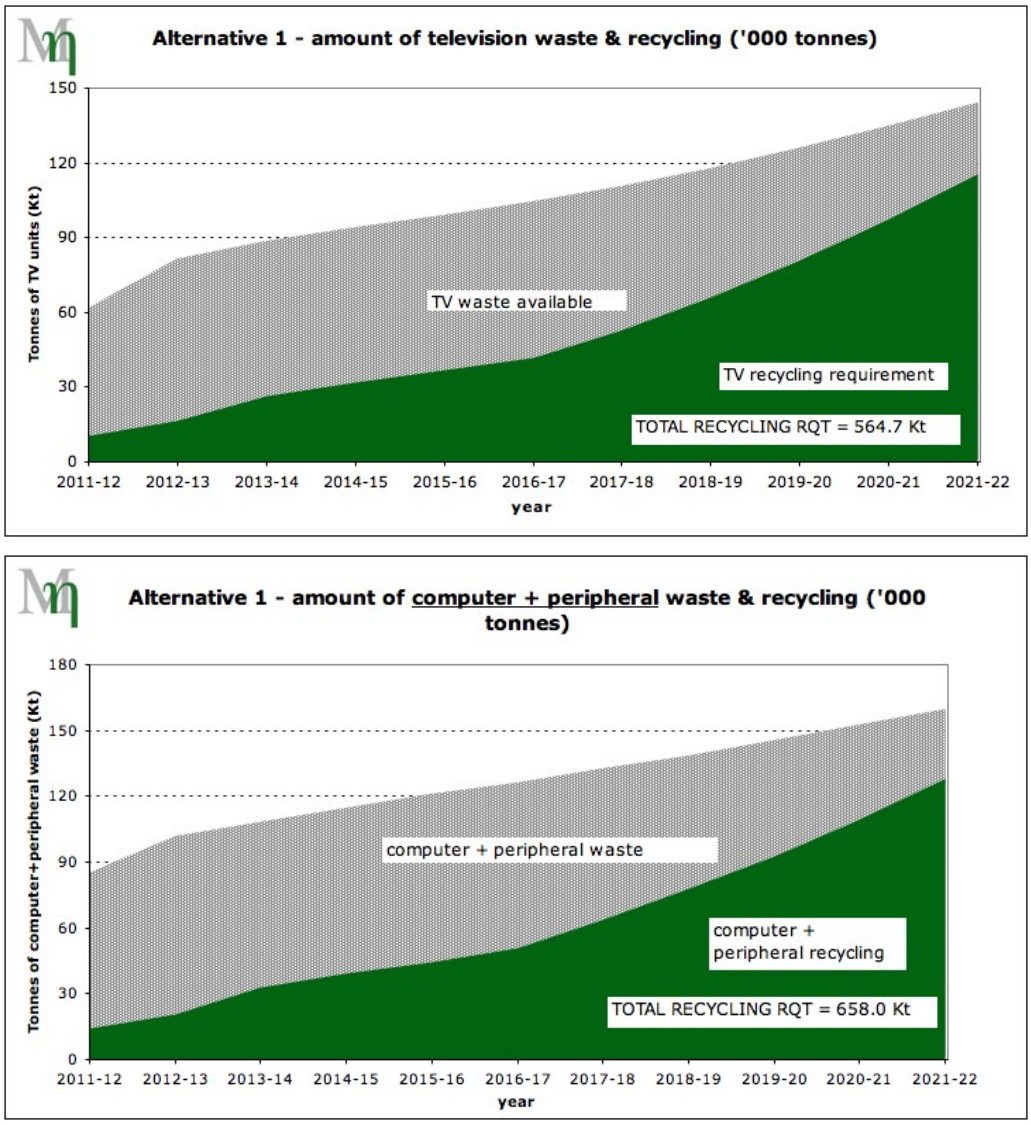
Table 2.4 Recycled waste tonnages under Alternative 1

Year	Television waste Kt		Computer + peripheral waste Kt	
	Recycling rqt	Remainder	Recycling rqt	Remainder
2011-12*	10.5	51.1	14.5	70.6
2012-13	16.3	65.0	20.3	81.1
2013-14	26.5	61.7	32.5	75.8
2014-15	31.9	61.9	39.0	75.7
2015-16	36.5	62.2	44.6	76.0
2016-17	41.7	62.5	50.5	75.8
2017-18	53.0	57.4	63.4	68.7
2018-19	66.0	51.8	77.5	60.9
2019-20	80.6	45.3	92.8	52.2
2020-21	97.0	37.7	109.6	42.6
2021-22	115.3	28.8	127.8	31.9
2022-23	123.7	30.9	134.3	33.6
2023-24	133.0	33.2	141.4	35.4

* BAU year, prior to scheme commencement

A graphical representation of these recycling amounts is provided in Figure 2.5. A trajectory requirement in line with Alterative 1 leads to recycling of an estimated 567.4 Kt of television waste and around 658.0 Kt of computer waste from the time scheme recycling targets commence in 2012-13 to the end of 2021-22, when the 80 per cent target is in place.

Figure 2.5 Recycling levels under Alternative 1



Source: Meta Economics TVComp model (26 August 2011)

Trajectory alternative 2

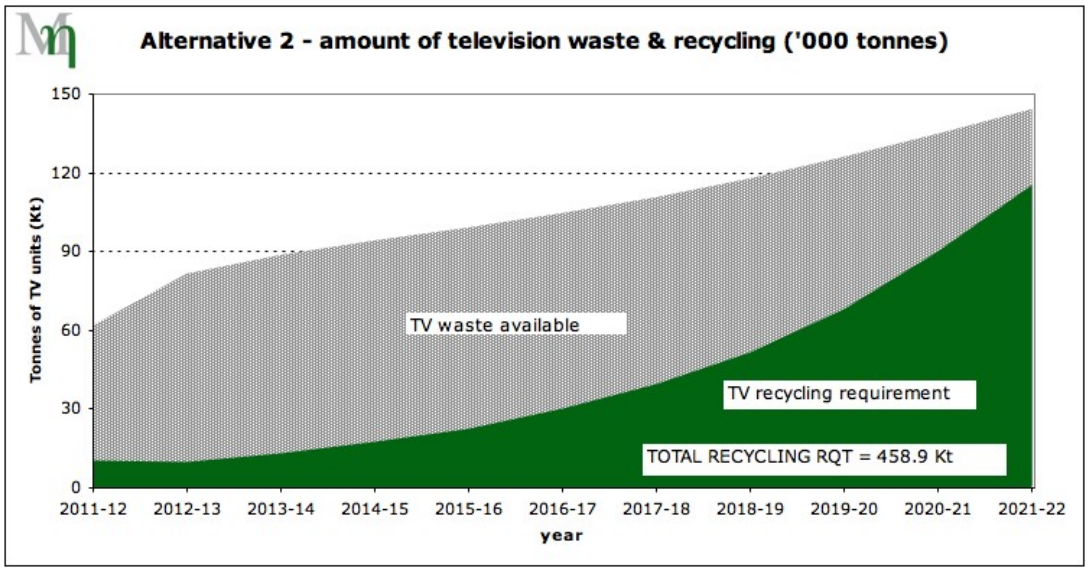
The quantitative implications of Alternative 2 are reported in Table 2.5 and Figure 2.6. The same methodology as used to report on Alternative 1 applies. Trajectory alternative 2 results in total TV recycling over the period 2012-13 to 2021-22 of 458.9 Kt, and computer/peripheral recycling of 531.1 Kt.

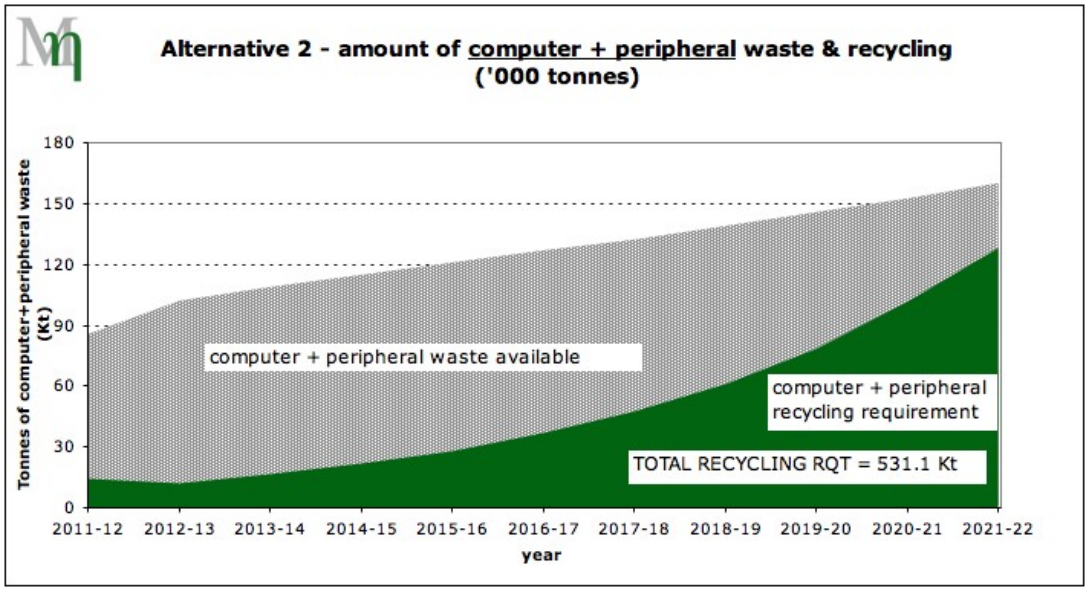
Table 2.5 Recycled waste tonnages under Alternative 2

Year	Television waste Kt		Computer + peripheral waste Kt	
	Recycling rqt	Remainder	Recycling rqt	Remainder
2011-12*	10.5	51.1	14.5	70.6
2012-13	9.8	71.5	12.2	89.2
2013-14	13.2	75.0	16.2	92.0
2014-15	17.8	75.9	21.8	92.9
2015-16	22.7	76.1	27.7	92.9
2016-17	30.2	73.9	36.6	89.7
2017-18	39.8	70.7	47.6	84.6
2018-19	51.8	66.0	60.9	77.5
2019-20	68.0	57.9	78.3	66.7
2020-21	90.3	44.5	101.9	50.2
2021-22	115.3	28.8	127.8	31.9
2022-23	123.7	30.9	134.3	33.6
2023-24	133.0	33.2	141.4	35.4

* BAU year, prior to scheme commencement

Figure 2.6 Recycling levels under Alternative 2





Source: Meta Economics TVComp model (26 August 2011)

Trajectory alternative 3

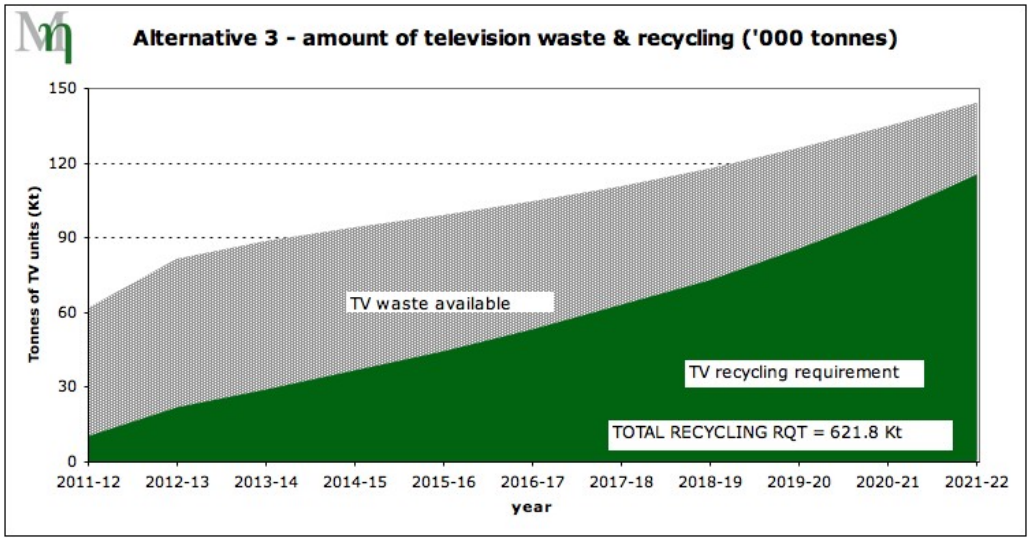
Recycling achievements under Alternative 3 are reported in Table 2.6 and Figure 2.7. Trajectory alternative 3 results in total TV recycling over the period 2012-13 to 2021-22 of 621.8 Kt, and computer/peripheral recycling of 726.7 Kt.

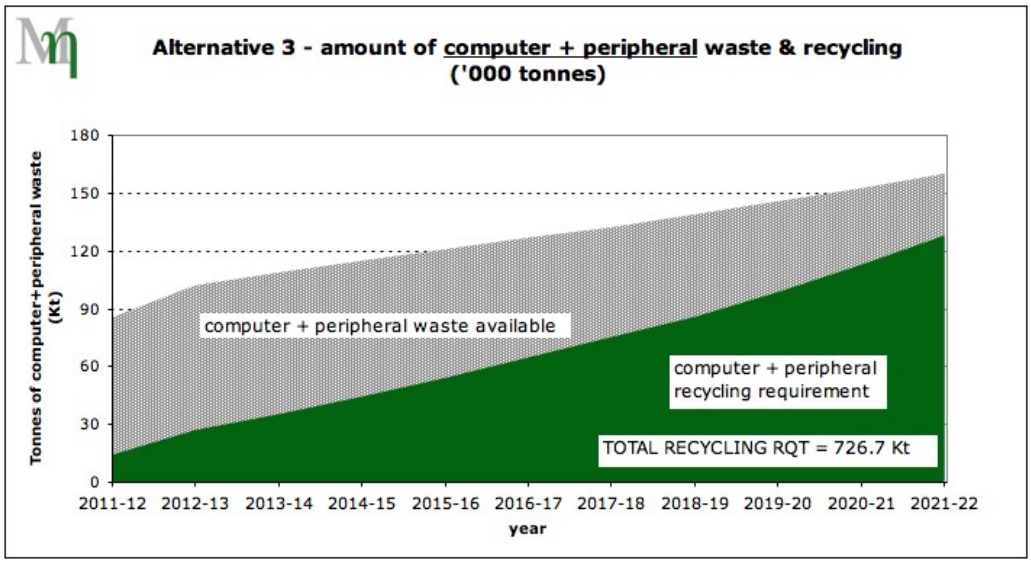
Table 2.6 Recycled waste tonnages under Alternative 3

Year	Television waste Kt		Computer + peripheral waste Kt	
	Recycling rqt	Remainder	Recycling rqt	Remainder
2011-12*	10.5	51.1	14.5	70.6
2012-13	21.9	59.3	27.4	74.0
2013-14	29.1	59.1	35.7	72.5
2014-15	36.6	57.2	44.7	69.9
2015-16	44.4	54.3	54.3	66.4
2016-17	53.1	51.0	64.4	61.9
2017-18	63.0	47.5	75.3	56.8
2018-19	73.0	44.8	85.8	52.6
2019-20	85.7	40.3	98.7	46.4
2020-21	99.7	35.0	112.6	39.6
2021-22	115.3	28.8	127.8	31.9
2022-23	123.7	30.9	134.3	33.6
2023-24	133.0	33.2	141.4	35.4

* BAU year, prior to scheme commencement

Figure 2.7 Recycling levels under Alternative 3





Source: Meta Economics TVComp model (26 August 2011)

Trajectory alternative 4

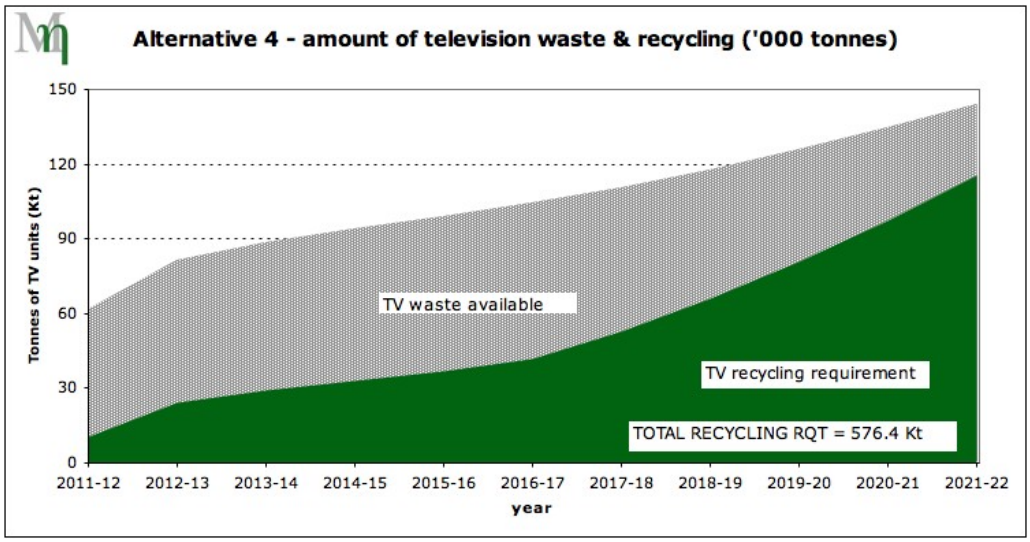
Finally, estimates of recycling throughput associated with target requirements under Alternative 4 are reported in Table 2.7 and Figure 2.8. Trajectory alternative 4 results in total TV recycling over the period 2012-13 to 2021-22 equivalent to 576.4 Kt, and computer/peripheral recycling of 672.6 Kt.

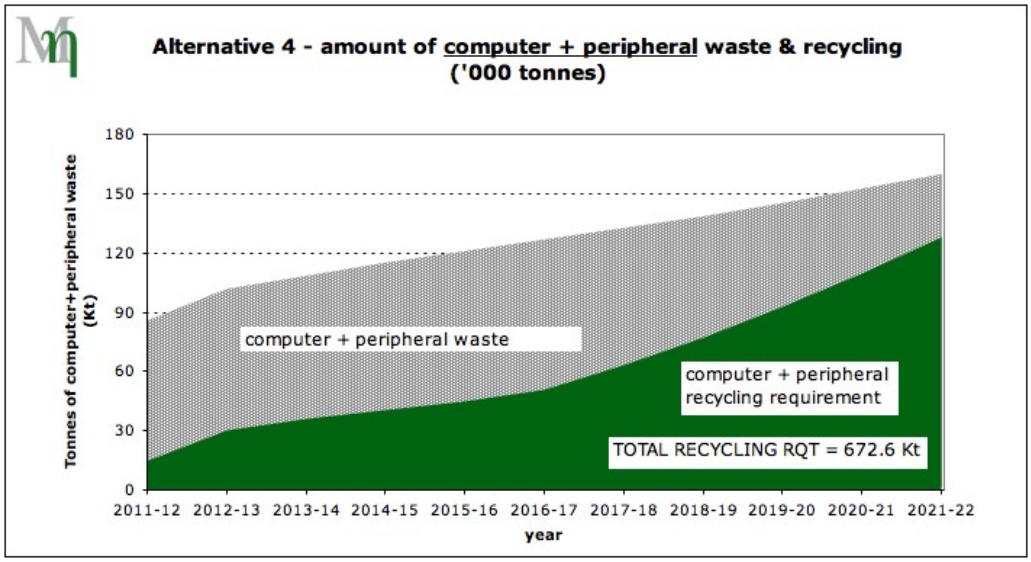
Table 2.7 Recycled waste tonnages under Alternative 4

Year	Television waste Kt		Computer + peripheral waste Kt	
	Recycling rqt	Remainder	Recycling rqt	Remainder
2011-12*	10.5	51.1	14.5	70.6
2012-13	24.4	56.9	30.4	70.9
2013-14	29.1	59.1	35.7	72.5
2014-15	32.8	60.9	40.1	74.5
2015-16	36.5	62.2	44.6	76.0
2016-17	41.7	62.5	50.5	75.8
2017-18	53.0	57.4	63.4	68.7
2018-19	66.0	51.8	77.5	60.9
2019-20	80.6	45.3	92.8	52.2
2020-21	97.0	37.7	109.6	42.6
2021-22	115.3	28.8	127.8	31.9
2022-23	123.7	30.9	134.3	33.6
2023-24	133.0	33.2	141.4	35.4

* BAU year, prior to scheme commencement

Figure 2.8 Recycling levels under Alternative 4



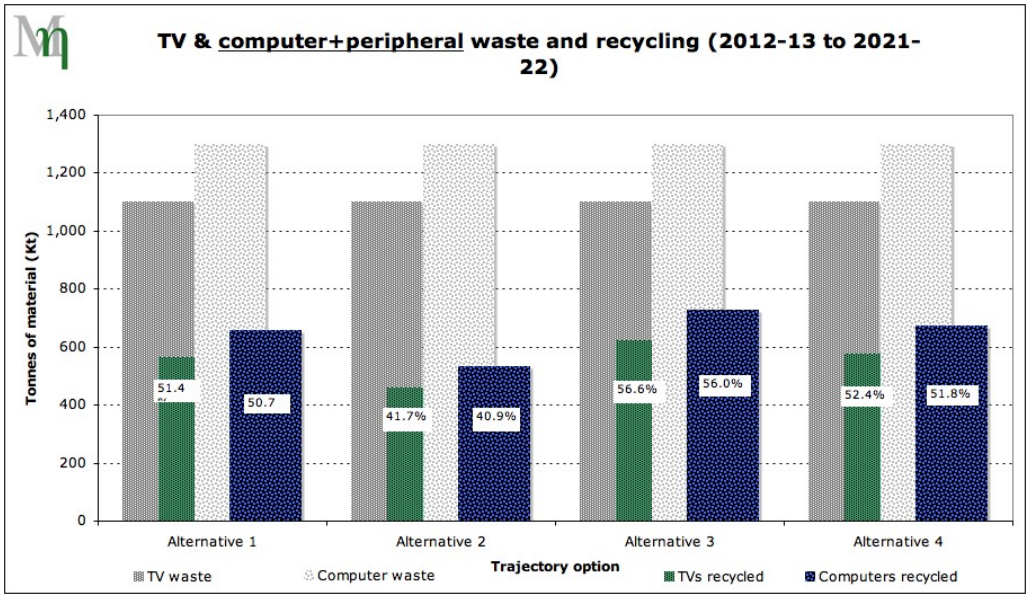


Source: Meta Economics TVComp model (26 August 2011)

2.4 Overall comparison of throughput

A comparison of the four trajectories, in terms of waste available over the 10-year period and the total amount that is required to be recycled under each trajectory, is provided in Figure 2.9.

Figure 2.9 Comparison of recycling outcomes under trajectory alternatives 1-4



Source: Meta Economics TVComp model (26 August 2011)

This suggests that of the options examined, Alternative 3 is likely to deliver the highest recycling rate — given assumptions about future growth in the level of available waste for TVs, computers and peripheral devices. Alternative 3 achieves a recycling rate of 56.6 per cent for TVs over the 10 years to 2021-22, and 56.0 per cent for computers and related waste.

Alternative 4 achieves the next highest recycling rate over the target phasing period, averaging 52.4 per cent for TVs and 51.8 per cent for computer waste. Alternative 1 achieves rates about 1 percentage point below that, while Alternative 2, the soft start option, achieves overall recycling rates about 10 percentage points lower.

On the criterion of raw amount of recycling achieved over the implementation period of the proposed scheme, Alternative 3 comes out on top. The following chapter tests this performance further, against the backdrop of capacity constraints and potential fluctuations in the amount of waste that could be available for recycling in a particular year.

Chapter 3

Capacity constraints and waste variability

Increasing recycling targets against a growing population of TV and computer waste will see the amount of material collected for recycling increase. At some point, the quantity of computers and TVs presented for recycling will exceed the current level of recycling infrastructure capacity. While more capacity can be brought on line, the lead times associated with building new infrastructure need to be considered in determining recycling targets, and their interaction with likely and potential available waste levels.

3.1 Waste recycling capacity

Wright & Rawtec (2010) was used as the principal source of information on available TV and computer recycling capacity in Australia, and the requirements for new capacity (as presented in Table 1.1). In their report, they warn that …

'… The biggest governance risk will be to ensure that the progressive development of e-waste recovery and recycling capacity keeps pace with progressive increase in e-waste recycling demand.'

Wright & Rawtec (2010), p. ES.7

Although they are not specific about the lead time involved in building new facilities, they do indicate that current processing capacity can easily be extended through increasing shifts and bench space for disassembly in existing facilities, and *'… increase capacity by a further factor of two … [in] … 6 to12 months based on the likely time to recruit additional technicians'* (Wright & Rawtec 2010, p.18).

This provides a processing buffer in the event that high and unanticipated levels of TV and computer waste are presented for recycling under the scheme. Of course, in designing the scheme and targets, policy makers have a high degree of control over the quantity targets that they set for liable parties and approved arrangements.

When do trajectories meet capacity constraints?

Wright & Rawtec (2010) report the following levels of potentially available capacity across Australian recyclers (this draws on information reproduced in Table 1.1):

- potentially available capacity TV recycling — 40.9 Kt per year
- potentially available capacity computers and peripherals — 38.6 Kt per year
- combined potentially available capacity — 79.5 Kt per year.

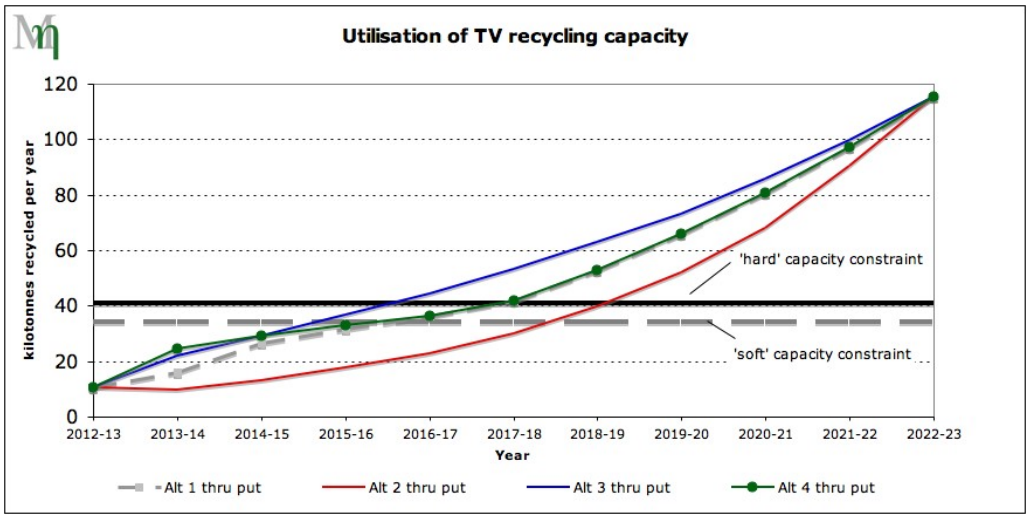
These are the throughput volumes that can be accommodated through reconfiguring existing work arrangements and floor space. As noted, a further doubling is reportedly possible within 6 to 12 months. Beyond this, it is commonly observed that new light industrial facilities can take in the order of 2-3 years to move from the planning and approval to commissioning stage.

How do the alternative trajectories perform against these capacity constraints? The recycling requirements of the various trajectories, relative to the 'soft' and 'hard' constraints of current capacity and available capacity, are shown in Figures 3.1 and 3.2. Each figure depicts a full range and sub-range view of the trajectory alternatives, and the timeframe over which they exceed the 'hard' barrier of available processing capacity. They assume, annual recycling outcomes are approached via smooth incremental contributions throughout the reference year.

Figure 3.1 provides this information for TV recycling, and uses the TVComp waste stream estimates of Chapter 2. The detailed view shows that Alternative 3, the most rapidly increasing trajectory, can be expected to exceed available processing capacity midway through 2015-16, about 3½ years after commencement of the product stewardship scheme. Alternative trajectories 1 and 4 are estimated to exceed available TV recycling capacity late in 2016-17. Alternative 2 does not exceed current levels of recycling capacity until early in 2018-19.

Figure 3.2 shows the rate at which static capacity constraints for computer waste recycling are approached and exceeded under the 4 alternative trajectories. This exhibits a pattern of escalation toward capacity that is similar to that observed for TVs, though greater annual waste tonnages bring forward the date that available capacity is reached. Alternative 3 puts pressure on currently configured capacity (the 'soft' capacity constraint) about 12 months after scheme commencement, and exceeds potentially available capacity (the 'hard' constraint) early in 2014-15, the third year of the scheme. Alternative 4 reaches the 'hard' constraint by the middle of 2014-15, and Alternative 1 reaches it just a few months later. Alternative 2 does not push the limits of available capacity until early in 2017-18.

Figure 3.1 Trajectories and capacity constraints — TV waste



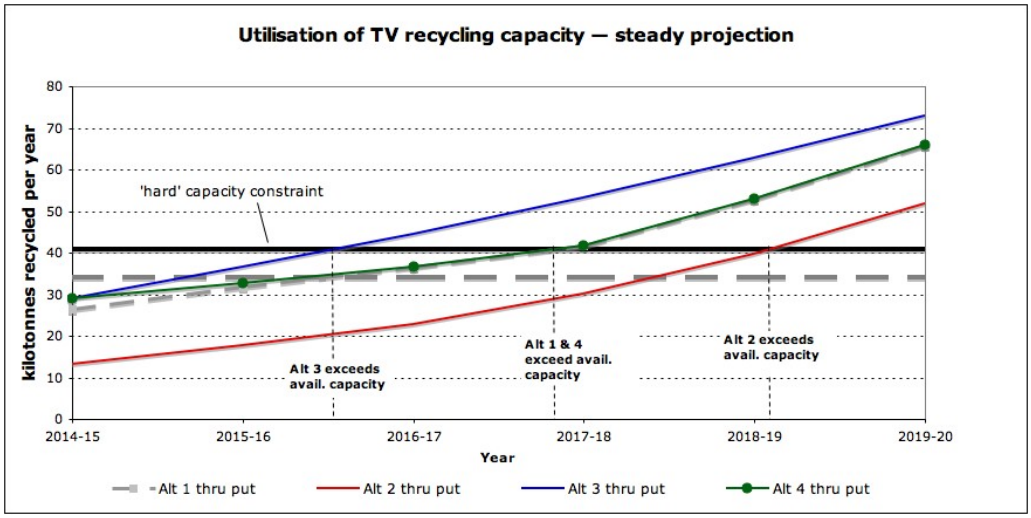
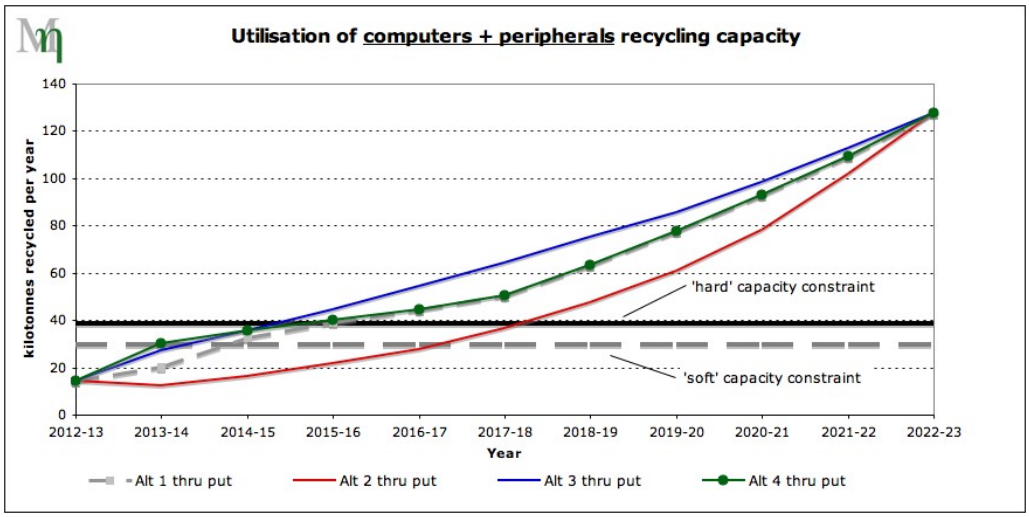
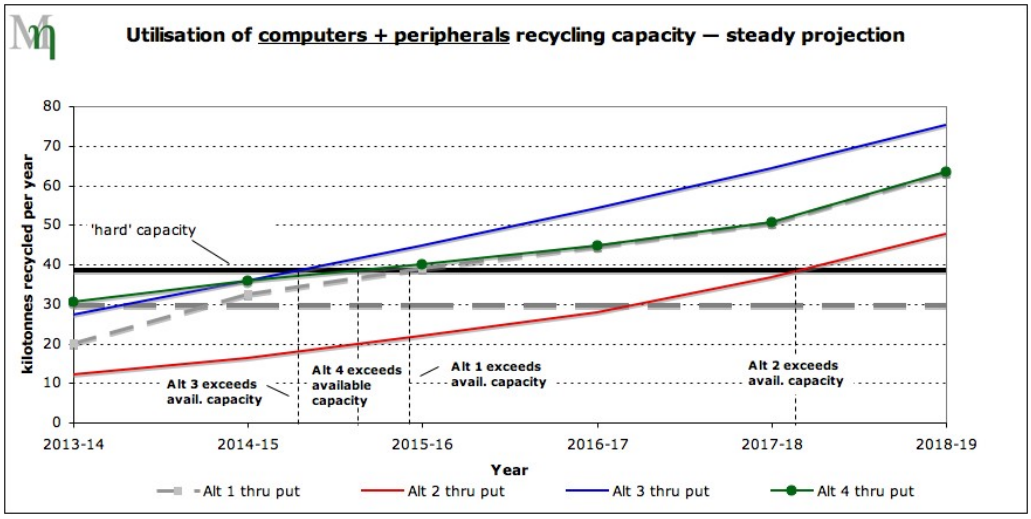


Figure 3.2 Trajectories and capacity constraints — computer & peripherals waste

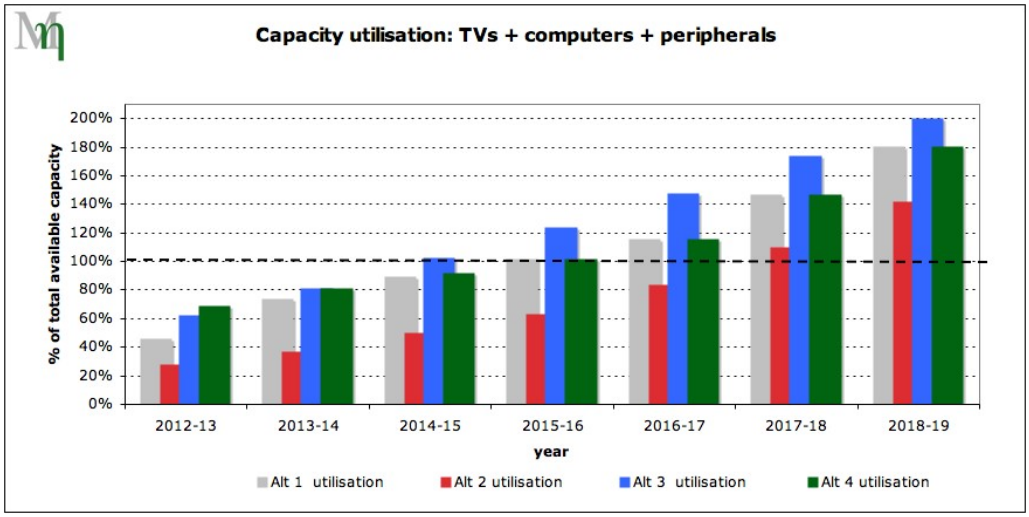




An overall comparison of capacity utilisation implied by the 4 trajectories, which pools the recycling requirements and available capacities for TVs, computers and peripherals, is given in Figure 3.3. This shows that Alternative 3, which displays the highest ramp up rate, is likely to exceed total potentially

available capacity — as it currently exists — at around the end of the third year of the scheme. The end of year over-run is in the order of 2 per cent of currently available capacity.

Figure 3.3 Comparison of overall capacity utilisation



This would suggest a reasonable lead time is available for new capacity to be brought on-line in response to the growing demands of the scheme.

However, the steady state assumptions make for a smooth increase in the estimated level of waste generation. The impact of introducing variability into the levels of waste generation is examined in the following section.

3.2 Sensitivity analysis: varying waste and tastes

Experience suggests that in a real world setting the rate at which electronic devices are bought and replaced can be volatile. New technologies can quickly make older ones obsolete, and changes in tastes can result in rapid changes in purchase and usage levels. These developments, in conjunction with delays in expanding the infrastructure necessary to support higher volumes of recycling, can add to the costs of increasing recycling targets.

The following analysis examines the implications of developments that could impact on the availability and collection of waste over the early years of the television and computer product stewardship scheme.

Higher TV disposal associated with the switch to digital

Between 2010 and 2013, analog free-to-air television services are being replaced with digital only broadcasts. The Australian Government has announced a region-by-region timetable for switchover from analog to digital television. The roll out began in Mildura/Sunraysia on 30 June 2010, then regional South Australia on 15 December 2010, regional Victoria on 5 May, 2011 and will be completed in all areas of Australia by 31 December 2013.

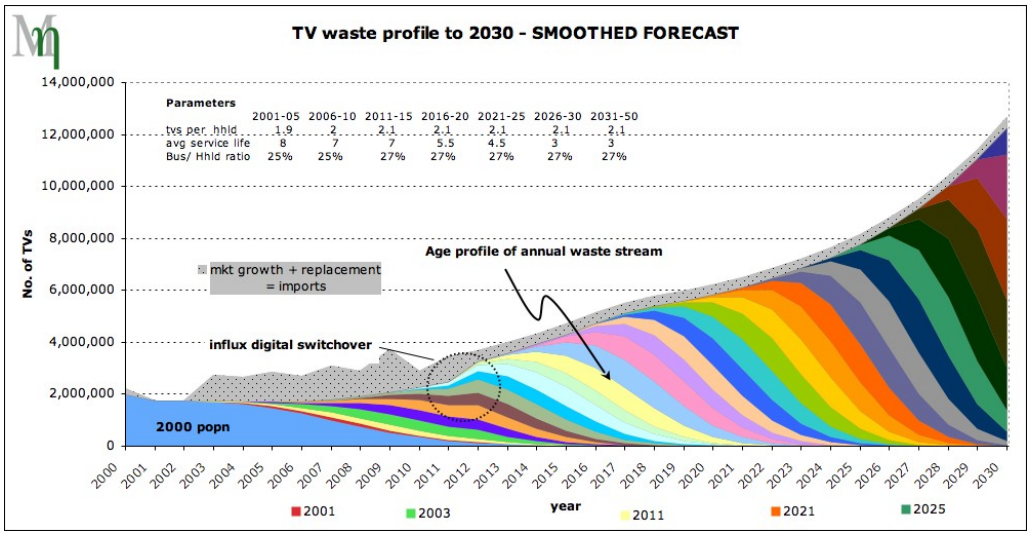
According to the most recent survey report from the Digital Switchover Taskforce, (Digital Tracker, report for 1 Jan-Mar 2011, p.24), about 77 per cent of household conversions from analog to digital occurs through the purchase of

a digital TV, rather than through adding a set top box or digital TV recorder to an existing analog TV set. The same survey found that 79 per cent of Australian households had converted at least their main television to digital.

Based on these raw numbers, and disregarding the probably lower incidence of digital ready second (and third) TVs in Australian homes, at a conservative estimate about 77 per cent of Australia's remaining 21 per cent of (analog) televisions are likely to be replaced with digital sets over the next 2 to 3 years. That is, about 16 per cent (or 3.58 million units) of the current Australian stock of televisions is likely to be discarded (and replaced) between now and the middle of 2014.

This development can be simulated in the TVComp model as an influx of replacement TVs over the period. It alters the 'equilibrium' waste profile as indicated in Figure 3.4.

Figure 3.4 Estimated enhancement of waste profile resulting from digital TV switch over



Source: Meta Economics TVComp model — SENSITIVITY (26 August 2011)

The corresponding impact on annual TV waste output is provided in Table 3.1. In comparison with Table 2.1, these waste estimates reflect the replacement of an additional 3.58 million televisions between 2011 and 2014, and a subsequent readjustment of expected obsolescence and drop out rates over the years that follow as these new machines age and leave the population.

The forced obsolescence of analog TVs increases the level of TV waste for the period to 2021-22 to 1,208 Kt, and boosts the amount of TVs required to be collected and recycled under all trajectories, particularly those trajectories with higher initial rates.

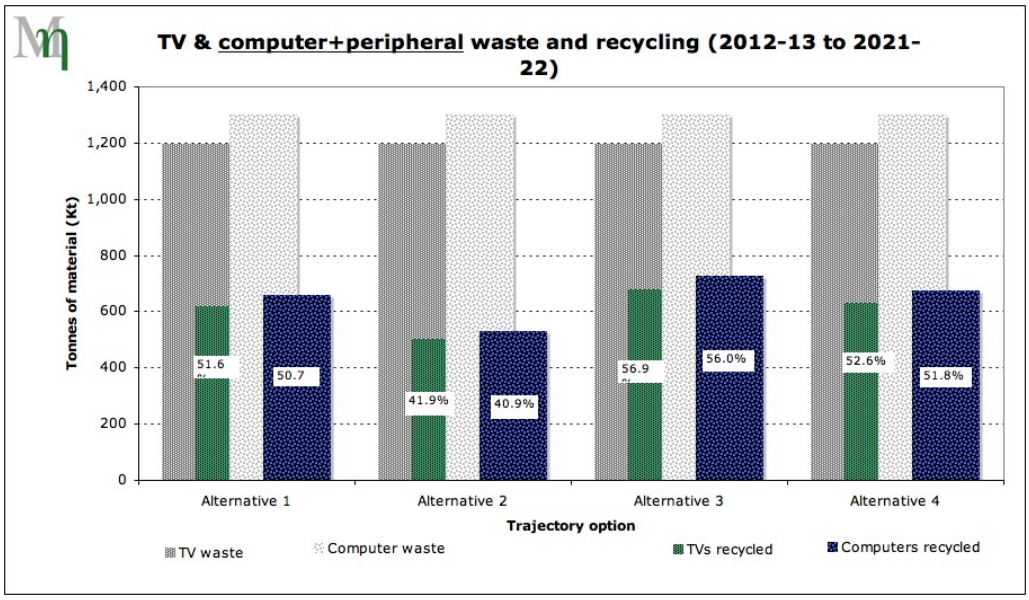
A comparison of recycling rates across the trajectory alternatives for the period 2012-13 to 2021-22 is shown in Figure 3.5.

Table 3.1 TVComp estimates of available TV waste to 2023, reflecting indicative estimates for the digital switchover

Year	TV waste (units)	TV waste (tonnes)
2011-12	2,458,664	61,643.7
2012-13	3,252,155	81,538.2
2013-14	3,567,860	89,453.5
2014-15	3,898,550	97,744.6
2015-16	4,287,930	107,507.2
2016-17	4,713,794	118,184.5
2017-18	5,094,088	127,719.2
2018-19	5,371,143	134,665.5
2019-20	5,576,790	139,821.5
2020-21	5,796,450	145,328.9
2021-22	6,085,096	152,565.8
2022-23	6,437,711	161,406.6
2023-24	6,827,406	171,177.0

Source: Meta Economics TVComp model — SENSITIVITY (26 August 2011)

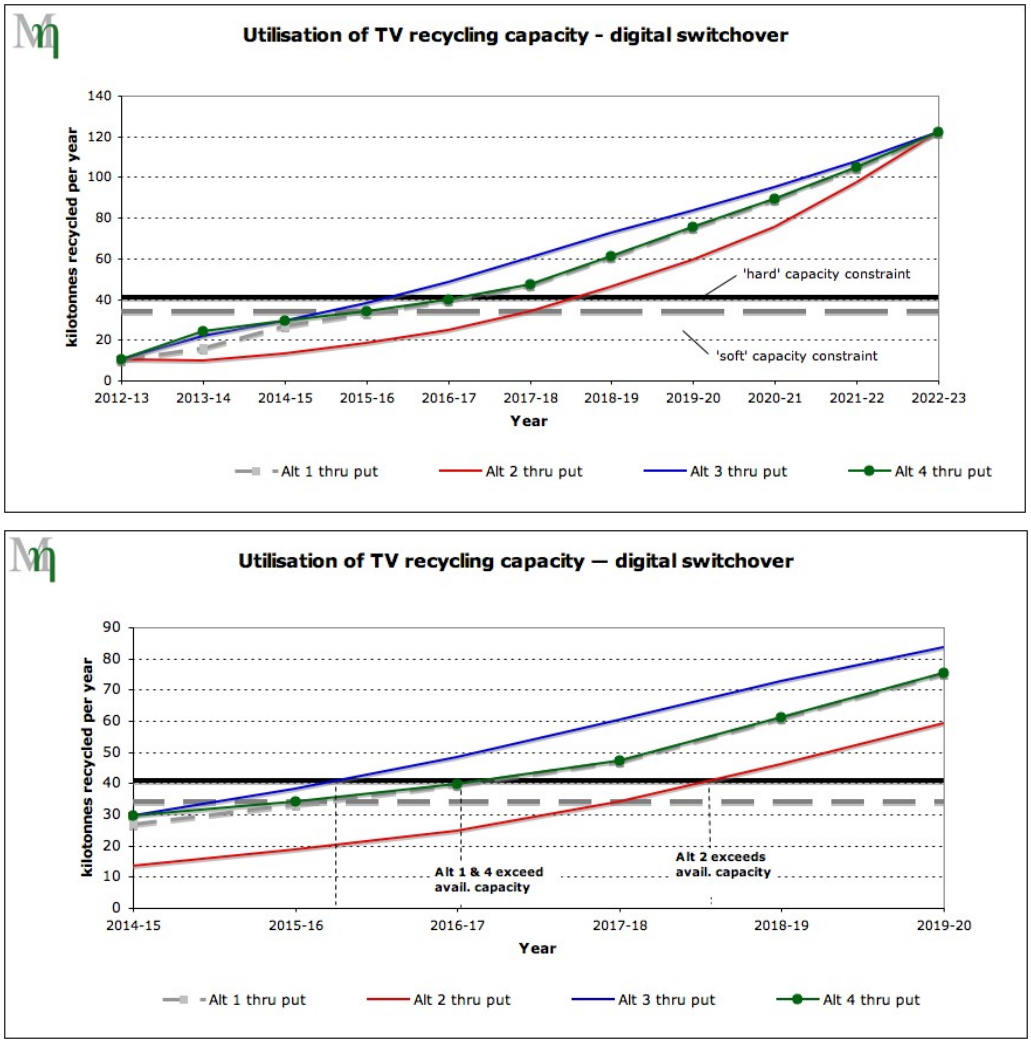
Figure 3.5 Estimated recycling outcomes for alternative trajectories following the digital TV switchover



Importantly, the greater availability of waste in the period following the commencement of recycling requirements boosts the amount of waste required to be recycled under the scheme. This in turn causes capacity constraints to be reached sooner than in the previous scenario. The relationship between recycling throughput due to the trajectories and available processing capacity is shown in full scale and detailed view in Figure 3.6.

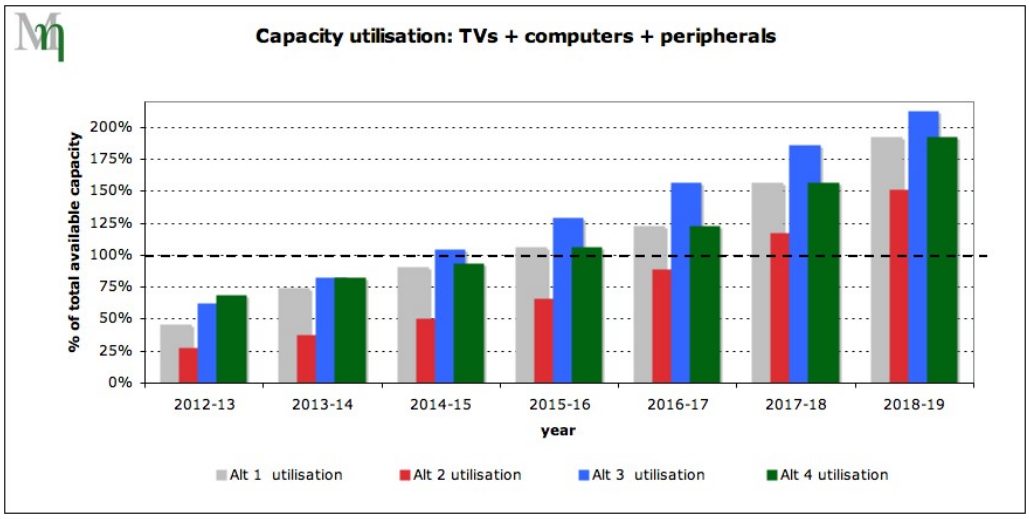
The enhanced waste stream adds to the throughput under the trajectory alternatives, and brings forward pressure on available capacity by a few months. This sees Alternative 3 exceed available recycling capacity early in 2015-16, a little over 3 years after target obligations commence. Based on Wright & Rawtec's assessment of the industry, this would be unlikely to seriously compromise scope for new processing capacity to be developed in anticipation of future scheme needs.

Figure 3.6 Capacity utilisation of alternative trajectories following the digital TV switchover



The combined capacity and recycling outlook for the 4 alternative trajectories — inclusive of the waste increase associated with the digital TV switchover — is presented in Figure 3.7. Importantly, only Alternative 3 of the proposed target trajectories exceeds available capacity in the first 3 years of the scheme and, based on waste estimates, this is by a margin of only 4 per cent by the end of 2014-15. Taking 2-3 years as a conservative estimate of the lead time for major capacity increases, and recalling scope to switch disassembly capacity between TV and computer waste, this suggests that the most ambitious trajectories under review would be unlikely to exceed processor capabilities, providing they were keyed into out-year program requirements.

Figure 3.7 Total capacity utilisation — including estimated impacts of the digital TV switchover



A storage overhang of TV and computer waste

Storage is another development with potentially significant implications for targets and recycling efforts. Though difficult to reliably estimate, there is evidence to suggest that a supplementary supply of discarded computers (and some old TVs) is being held in storage awaiting recycling.

In the ACT, where users are required to pay to dispose of computers, monitors and TVs at resource management centres, this stockpile could be substantial. Applicable fees include:

- Flat panel TVs — $15
- Medium sized cathode ray tube (CRT) TVs — $25
- Large CRT TVs 54 to 69 cm — $40
- Very large CRT TVs (over 69 cm) — $60
- Computer terminal — $15
- Computer monitor or laptop — $22.50

(Source: ACT Government, Computer and Television Recycling Fact Sheet, Version 2 07/07/2011)

Moreover, anecdotal evidence suggests a range of local councils and waste disposal centres may be storing e-waste rather than sending these items to landfill. Under these circumstances, there may be a large supply overhang and the level of 'available waste' that will be provided to operators of Approved Arrangements under the scheme may be substantially above previous estimates.

There is little evidence on which to form a reliable view of the level of stored TV and computer waste that might come forward under the proposed scheme. However, it is possible to test the levels of waste that, in combination with the alternative target trajectories, might over-reach processing capacity within Australia.

The waste figures used in the previous section to estimate the impact of the digital TV switchover provide a starting point. These can be coupled with projections of computer waste to 2021-22, and estimates of combined recycling capacity within Australia.

But what levels of increase in the waste stream, and therefore the recycling requirement implied by each of the target trajectories, would be required to exceed total available processing capacity? The answer is provided in Table 3.2, which illustrates how much additional waste, beyond what has been projected under the Meta Economics TVComp vintage model, would be necessary to exceed capacity under each of the alternative trajectories in the first 2 to 3 years.

In general, quite large increases in available waste are required to drive collection and recycling tonnages under the scheme above capacity levels. However this margin of safety diminishes over time. By the end of Year 3, Alternative 3 is already expected to be exceeding current available capacity by about a 4 per cent margin, but a 22 per cent surge in waste would be required to reach this limit in Year 2. For Alternative 1, a 34 per cent increase in waste levels would be required to do this in Year 2, and a 10 per cent increase would be required in Year 3. If Alternative 4 were adopted, a 22 per cent waste surge would see the current 'hard' capacity limit exceeded, and available waste would only need to be about 7 per cent above the current forecast level for this to occur in 2014-15.

Table 3.2 Waste increases necessary to drive annual recycling requirements above available capacity

Trajectory option	Year 1 (2012-13)	Year 2 (2013-14)	Year 3 (2014-15)
	% increase in waste necessary to exceed available recycling capacity (= 79.5 Kt pa)		
Alternative 1	117	34	10
Alternative 2	262	168	97
Alternative 3	61	22	– 4
Alternative 4	45	22	7

This analysis suggests that the modeled trajectories are unlikely to exceed waste recycling capacity limits in the early years of the scheme (assuming no other use of this capacity by other parties), and according to Wright & Rawtec processors can increase capacity substantially in the space of 12 months or so. Although policymakers have considerable scope to set actual annual target levels in line with processing capacity, the analysis highlights the need to carefully balance target tonnages with capacity levels and reasonable estimates of waste arising within the economy. Processors will also need to be actively planning for the increasing demands of the scheme on their facilities.

Delays and bottlenecks in waste collection

Capacity constraints can also apply in the collection process, and in the ability of Approved Arrangements to extend their reach and infrastructure to cope with increasingly demanding targets. The same principles apply here as discussed in

the context of recycling capacity utilisation. Rapid expansion of collection and recycling requirements can place significant pressures on Approved Arrangements. Unfortunately, there is little information in the public domain on the level of excess collection capacity, or timeframes required to double or treble throughput.

Business as usual collection and recycling levels provide a guide to current capacity, and caution would argue in favour of modest initial increases above these levels. However, the proposed product stewardship scheme for TV and computer waste has been under serious discussion for many months now, and this would suggest a high state of readiness on the part of liable parties. In the absence of information on collection costs and logistics it is impossible to shed much light on how alternative target trajectories might align with the capacity of Approved Arrangements to meet them.

Chapter 4

Conclusions

The foregoing analysis suggests that all of the alternative trajectories are likely to be robust in the face of factors than can increase available waste levels and place additional demands on recycling infrastructure. Although some trajectories drive a higher rate of recycling than others, overall the difference in the amount of recycling from the most to least demanding trajectory is of the order of 36 per cent, or 358 kilotonnes of material. These estimates are net of the digital television switchover, which, on a rough estimate, is likely to drive accelerated obsolescence and replacement for around 16 per cent of the current TV stock, and boost TV waste levels by about 3.58 million units between now and 2014-15.

As Table 4.1 illustrates, the gap between other contenders is more modest, with Alternative 1 delivering close to the same overall level of recycling as Alternative 4 (1,222.8 Kt versus 1,249.0 Kt). Nevertheless, the performance of Alternative 3 in delivering around 1,348.5 Kt of recycling over the period is a highlight.

Table 4.1 Comparative summary of key trajectory characteristics

Trajectory characteristics	Alt 1	Alt 2	Alt 3	Alt 4
Total recycling 2012-13 to 2021-22 — TV waste (Kt)	564.7	458.9	621.8	576.4
Recycle amt relative to Alt 1 — TV waste (%)	100.0%	81.3%	110.1%	102.1%
Total recycling 2012-13 to 2021-22 — Computer + peripheral waste (Kt)	573.8	531.1	726.7	672.6
Recycle amt relative to Alt 1 — computer + peripheral waste (%)	100.0%	80.7%	110.4%	102.1%
Year 1 increase from BAU (%)	17.6%	– 29.4%	58.8%	76.5%
Average annual increase from Year 2 to 10 (%)	17.2%	23.5%	12.9%	11.6%
Average capacity utilisation 2012-13 to 2021-22 (%)	153.8%	124.5%	169.6%	157.1%
Year in which trajectory recycling requirement exceeds available capacity (projection)	2015-16	2017-18	2014-15	2015-16
Year in which trajectory recycling requirement exceeds available capacity (shock scenario)	2015-16	2017-18	2014-15	2015-16
Waste increase necessary to drive recycling rqt above capacity in Year 2 * (%)	34%	168%	22%	22%

* sensitivity test baseline is inclusive of estimated waste increase from digital TV switchover.

Notably Alternative 3 achieves this through a high initial target — almost 59 per cent above the business as usual level assumed for the year before — and steady growth over the remainder of the period. The high level of recycling sustained under Alternative 3 also results in this trajectory option reaching the limits of currently available processing capacity early in the third year of the scheme (assuming no other use of this capacity by other parties, such as local or state governments) — a few months ahead of Alternative 4, 6-9 months ahead of Alternative 1, and nearly 3 years ahead of trajectory Alternative 2. However, previous analysis (Wright & Rawtec 2010) indicates that there should be ample time for processors to expand recycling capacity in this context. It will be very important to ensure that their forward investment planning takes the increased processing demand stimulated by the roll-out of the scheme into account.

Care should also be taken to ensure that initial target levels are within the capacity of Approved Arrangements, taking into account the risk that actual waste levels might exceed the estimates in this document. There is insufficient information to form a robust view of the capacity of Approved Arrangements to establish their operations and expand to meet the demands of ambitious target trajectories. This remains a key question and represents a potential caveat to Alternative 3's otherwise strong performance.

However, it should be noted that the scheme will provide up to 19 months for the achievement of the Year 1 target, by counting towards that target any 'early action' during 2011-12.

It is also worth noting that the adjustment burden represented by the annual target in any particular year could be alleviated under an approach that allowed for the transfer of obligations and over-achievement between years along the compliance pathway.