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Implementation road map and conditions for success

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5.1 INTRODUCTION AND READERS' GUIDE

Chapters 2–4 of this Handbook covered the first six steps of the proposed e-waste development cycle. This chapter builds on the previous Chapter 4 that generates various intervention options in the domains of Policy and Legislation (Section 4.2), Business and Finance (Section 4.3), and Technologies and Skills (Section 4.4). So far these options are discussed rather individually. The development objectives and requirements listed in this previous chapter, however, need to be aligned to enhance interrelations, to avoid contradictions and overlaps. Hence, this part 4 of the e-waste development cycle focuses more on the actual decision process itself. It provides mechanisms to place the possible interventions in perspective in order to take the right decisions based on understanding the interrelations between various options. The following steps as described in [Table 5.1](#) are therefore a listing of all intervention options ([Section 5.2](#)), the selection and grouping of options and their feasibility, and the potential roles and responsibilities of stakeholders involved ([Section 5.3](#)). The outcome is a new or revised e-waste development framework that ideally is transformed into a national road map that also provides timing and resources in relation to the decisions taken ([Section 5.4](#)). For the full reader's guide covering the Chapters 2–5, see [Table 2.1](#).

Finally, the new or revised road map needs to be implemented in practice. Here, three additional development areas are regarded as crucial conditions to success and require more continuous attention ([Section 5.5](#)): “Monitoring and Control” is required to monitor performance over time, to intervene in case of noncompliance, and to provide facts and figures for a next development round in [Section 5.6](#). Secondly, “Awareness and Education” in

Table 5.1 Key development questions posed (covering Chapter 5 of this handbook)			
Development areas	Starting countries	Emerging countries	Established countries
<i>Step 7: How to develop a national road map? (Sections 5.2–5.4)</i>			
Implementation Road Map	5.2.1 How to be both ambitious and realistic in the first policy round?	5.2.2 How to plan a review round carefully and well on time?	5.2.3 How to target the more complex challenges in conjunction?
<i>Step 8: How to successfully implement the policy framework/road map? (Sections 5.6–5.8)</i>			
Monitoring and Control	5.6.1 How to develop a basic monitoring framework? How to measure progress? What indicators to use?	5.6.2 How to improve reporting and a more structured monitoring and enforcement framework?	5.6.3 How to track system performance more real time and establish smart enforcement?
Education and Awareness	5.7.1.1 How to inform consumers about the initial collection infrastructure?	5.7.1.2 How to continuously involve all end users as well as local collectors, municipalities, and regional authorities?	
Design feedback	5.8.1 What about prevention measures in the policy framework? 5.8.2 How can green procurement contribute? 5.8.3 What product information do recyclers need?		
<i>(back to step 1: Country status and input to evaluation for the next development cycle)</i>			

particular of consumers is crucial for both collection as well as the long-term societal acceptance of the policy framework (Section 5.7). Finally, providing “Design Feedback” by means of advancing design for recycling (DfR) is an important preventive product policy-related domain that is described separate so far from the waste management policies. In addition, also the role of green public procurement and product design information is discussed in Section 5.8. Similar to the previous chapters, Table 5.1 provides an overview of the key development questions as well as a readers’ guide on where to find the information more directly. For a more complete reader’s guide covering all chapters, see Table 2.1 in Chapter 2.

A general question for all three country types in each development round is:

- Step 7: How to develop a (next) national road map?

The timing of how and when an intervention is translated into a requirement in the form of a tangible target, often depends on other requirements as well as infrastructure, technologies, and skills available. Therefore, planning and alignment of interventions is particularly needed and depends on the

resources available. As an example, Méndez-Fajardo et al. (2017) provides a description of how this process can be organized, applied to the case of the e-waste policy development process in Colombia. In addition to four key questions presented by this source, a fifth one is added here:

- What strategies and actions will be used to achieve the strategic objectives?
- Who will carry out these strategic objectives?
- When should they be carried out and for how long?
- How will the results be measured or confirmed?
- How do the various intervention options relate to each other?

5.2 INTERVENTION OPTIONS

5.2.1 Starting countries

In addition to the above five questions that apply to all countries, for starting countries, specific key questions are:

- How to be both ambitious and realistic with the first policy initiating round?
- What will be the first goals to be achieved in our e-waste situation?
- How to arrange this legally, organizationally, and financially?

Since a fully completed e-waste system development process can easily take more than 20 years, it is important for starting countries to select interventions that are the most relevant for the short term and that are both ambitious and realistic at the same time. As highlighted in Section 2.1.2, the main goals for starting countries are typically “disaster prevention,” achieving “basic toxic control,” and developing initial infrastructure for both collection as well as treatment. From this perspective it is important not to be overly ambitious, too far reaching or too complex at this stage. At the same time, the first draft of the legal basis should not hinder later extension and revision. Hence, the recommendation is to set the first responsibilities and definitions carefully as introduced in Section 2.1.2. Secondly, alignment of the interventions is important—from the first draft of the legal basis, specifying interventions not just individually but also in relation to **what** needs to be arranged and by **whom** is instrumental for planning purposes. Here, the role of the financial

instruments and the organizational measures should address **how** things are executed and **when**. Per definition in complex processes like this, not every step will run according to plan. There should be room for flexibility and timely adaptation, which can be specifically included in the process by using an iterative approach and planning various revision milestones scheduled ahead. It is advised here to set also a specific date for a first full revision of the adapted policy framework. As an example, based on the three development areas described in Sections 4.2–4.4, a listing of possible intervention options in these domains is presented in [Table 5.2](#). This table includes specifically the key areas specified in Chapter 4 but can be dependent on the country specifics and subsequent deviating preferences, including also other intervention options. [Table 5.2](#) provides some examples of who could be involved as well as an aimed timing per planned intervention. Obviously this should be adapted to the country-specific goals as deemed necessary. When available, results from the suggested steps from

Table 5.2 Example listing of intervention options for starting countries

Policy and Legislation (examples from Section 4.2.1)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Entity primarily in charge	Ministry of Environment	After 6 months/until 1st full revision in +5 years
Scope	Ministry of Commerce	+1 year/idem
Involvement of the informal sector	Reuse and repair association	+1 year/idem
Banning polluting practices	Environmental inspectorate	+1.5 years/idem
Improving working conditions	Ministry of Social Affairs	+2 years/idem
Import restrictions	Customs	+1 year/idem
Future extensions	Ministry of Environment	Review study +4 years/1st full revision in +5 years
Business and Finance (examples from Section 4.3.1)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Pilot funding source	NGO or international partner	+1 year
Market input register	Producer responsibility organization	+1.5 years/+2.5 years
Business conditions for dismantlers	Ministry of Commerce	+2 years/+3 years
Financing mechanism and fee levels	Ministry of Commerce	+2 years/+3 years and again at 1st full revision in +5 years
Coordinating entity	Producer responsibility organization	+1.5 years/at 1st full revision in +5 years
Technologies and Skills (examples from Section 4.4.1)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Setting up collection points	Repair association	+2.5 years/at 1st full revision in +5 years
Setting up dismantling activities	Contracted recycling start-ups	+2.5 years/idem
Shipment trials of critical fractions	Ministry of Environment and Customs	+3 years/idem

the stakeholder analysis of Section 2.5 can specifically feed the middle column, and as well, the problem definition results from Section 2.7 can assist in determining the first and last column of [Table 5.2](#).

5.2.2 Emerging countries

For emerging countries, the extension of the legal framework, the coverage that the chosen financing provides, and organizational improvement needs to be aligned based on the lessons from the first implementation round and from a first evaluation and assessment exercise, when available (see Sections 2.5 and 2.7 for stakeholder analysis information and the renewed problem definition). Hence a key question here is:

- How to plan a review round carefully and well on time?

As discussed in Section 2.1.2, the goal for emerging countries is to have a successful implementation of the first legal framework and realization of the collection and recycling targets set. This is needed in order to mature, professionalize, and expand the existing system. In order to propose more ambitious requirement and targets compared to the original basic ones from the first legal framework, some follow-up question are put on the table:

- How would a second road map for the next 5 years look like?
- What are the strengths and weakness of the current implementation (which can be based on the assessment as highlighted in Section 2.5 when available)?
- To what extent is a more thorough revision of the legal framework necessary?
- What is the willingness of other stakeholders to cooperate and to implement further interventions?
- Which stakeholders are convinced that a second revision is needed and how to convince the remaining ones?

Again as an illustration, example intervention options from Chapter 4 are provided here for emerging countries in [Table 5.3](#):

Table 5.3 Example listing of intervention options for emerging countries

Policy and Legislation (examples from Section 4.2.2)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Review responsibilities	Ministry of Environment	+6 months/at 2nd revision +5 years
Scope extension/update	Ministry of Commerce	+1 year/idem
(review of) Collection target	Ministry of Environment	+1 year/idem
Recycling and reuse targets	Ministry of Environment	+1.5 years/idem
Implementation rules collection	Producer Responsibility Organization	+1.5 years/idem
Implementation rules treatment	Producer Responsibility Organization	+2 years/idem
Rules for shipments of critical fractions	Customs	+1.5 years/idem
Future revision	Ministry of Environment	2nd revision + 5 years
Business and Finance (examples from Section 4.3.2)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Review of financing mechanism and levels	Ministry of Commerce	+1 year/idem
Consumer education, R&D funds	Producer Responsibility organization	+1.5 years/idem
Business conditions for pre-processors	Ministry of Commerce, Recyclers Association	+2 years/idem
Allocation of costs	Producer Responsibility organization	+1.5 years/idem
Technologies and Skills (examples from Section 4.4.2)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Accessibility collection points	Producer Responsibility organization	+2.5 years/idem
Certification of facilities	Independent 3rd party	+3 years/idem
Optimizing preprocessing	Recyclers Association	+3 years/idem

5.2.3 Established countries

As discussed in Section 2.1.2, commonly the goal for established countries is to improve efficiency of collection and treatment on one hand, as well as to target the more complex challenges. In almost all cases the collection volumes can be maximized and quality and control over treatment improved. The latter particularly applies to recover more materials beyond those with positive economic values, including harmful substances and critical raw materials. Finally, how to realize actual incentives to improve product design feedback remains a relevant item. Therefore a key question here is:

- How to target the more complex challenges in relation to each other?

By definition, policy and implementation cannot keep pace with new product types and technologies, rapidly changing product, component, and reuse values. This is subsequently posing different recycling challenges compared to the past. The same counts for market dynamics in collection and trade and technology options in treatment like changes in sorting, separation, and end-processing technologies. This is posing new challenges and opportunities compared to existing treatment requirements and standards. Hence, it makes sense to streamline and update existing implementation rules on a more continuous basis as well as leaving more and more of such implementation responsibility to nongovernment stakeholders. This potentially allows making revision rounds much faster and better informed compared to current revisions in order to remain updated according to technical and scientific progress. In this light, the discussion on **who** is responsible for **what** and **when** differs significantly compared to the previous development rounds. As an example, here Table 5.4 provides an overview of some of the possible interventions and changes to the e-waste system, where many stakeholders are more empowered to execute their respective responsibilities. In the longer term, when monitoring systems become more mature, reliable, and transparent, transfer of responsibilities can take place leading to less government involvement, particularly in more operational tasks.

Table 5.4 Example listing of intervention options for established countries

Policy and Legislation (examples from Section 4.2.3)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Proportionality of the scope	Ministry of Environment	+1 year/at 3rd revision +5 years
Administrative burden	Ministry of Commerce	+1 year/idem
Implementation rules update	Independent 3rd party	+1.5 years/idem
System efficiency	Independent 3rd party	+2 years/idem
Design feedback loop	Ministry of Commerce	+2 years/idem
Business and Finance (examples from Section 4.3.3)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Economic level playing field	Recyclers Association and Producer Responsibility Organization	+1 year/at 3rd revision +5 years
Consumer education, R&D funds	Producer Responsibility Organization	+1.5 year/idem
Reward quality of treatment	Producer Responsibility Organization	+2 years/idem
Finance collection in starting countries	Producer Responsibility Organization and NGOs	+1.5 year/idem
Technologies and Skills (examples from Section 4.4.3)	Who is involved? (examples)	When to be implemented/when to be reviewed? (examples)
Collection by all actors	Producer Responsibility Organization	+2.5 years/at 3rd revision +5 years
Innovation, enhanced critical raw materials recovery and toxics control	Producer Responsibility Organization and research institutes	+3 years/idem

5.3 SELECTION OF OPTIONS

For all three country types, the listing from the previous [Section 5.1](#) is one element needed for the decision process. Due to the intervention options being closely related to each other, the options in the nonexhaustive lists of [Tables 5.2–5.4](#) need to be seen in relation to each other. To illustrate the complexity of setting a requirement and how potentially overlapping with other elements the detailing of an intervention option can be, the example of specifying “a collection target” as presented in Chapter 11 of [Huisman et al. \(2008\)](#). This example illustrates that in case of using a collection target, proper legal definitions, a well-defined scope, a functioning registration system, specific financial agreements, as well as a monitoring framework for the collected volumes are all needed **in conjunction** in order to implement the intervention in practice.

From the listing of all interrelations between the interventions options, ideally a complete set of potential options is derived and the selection process starts. This is the most central and decisive step within the development process and includes selection, evaluation of the options, and conversion into legal text and accompanying policy documents:

1. The first step is the selection of the intervention options under Policy and Legislation and, explicitly, description of the relation to the development areas Business and Finance as well as Technology and Skills. An example of this exercise for starting countries for describing the relations of an intervention related to the “product scope” is presented in [Table 5.5](#).

Table 5.5 Grouping of intervention options, example for starting countries for one policy intervention

Policy and legislation intervention	Affects other interventions:	How to align:
Product scope	Pilot funding source	Ideally the funding and the pilot project(s) covers the same selected products, or representative target products in scope.
	Market register	Idem, the product scope should also be described in practical terms with a simple FAQ and examples of products being inside/outside the scope.
	Setting up collection points	The collection points, the first dismantling activities, and the trials with removing and shipping critical fractions should be organized in order to specifically target the collection of the selected products.
	Setting up dismantling activities	
	Shipment trials of critical fractions	For the scope specified, the pilot study and initial collection and recycling trials should also give first reference values for the fee levels under the chosen financing mechanism.
Fee levels		

More elaborate lists of options are also provided in Chapter 9 of [Huisman et al. \(2008\)](#) for multiple possibilities proposed for the revision of the European Union (EU) Waste Electrical and Electronic Equipment (WEEE) Directive regarding adapting the product scope, its definitions, and alternatives; revising collection targets; setting recycling and recovery targets; and enhancing reuse as developing more effective treatment requirements and standards.

2. The second step is the evaluation of options: The anticipated improvement potential of the various options is evaluated, ranked, and prioritized based in relation to environmental, economic, technical, and social impacts. The central questions to answer are: How much improvement is expected in these individual areas? And: How feasible is using the option in practice? Matrices providing a summary overview of the ranking and feasibility of this part are displayed in Chapter 10 of [Huisman et al. \(2008\)](#) for the selected improvement areas.

A simplified example of this part of the selection exercise is presented in [Table 5.6](#), adapted from [Huisman et al. \(2008\)](#) for presenting the impacts of adapting an existing product scope.

3. The third step is the actual translation of selected options into legal text and corresponding nonlegal requirements: Here proposals for actual translation of the most promising options are formulated. For example, in Section 10.6 of [Huisman et al. \(2008\)](#), specific conclusions and alignment of options is provided, forming the basis for the actual political decision process in the years following the EU WEEE Directive study. Here, as an example of the interconnectedness, one of the core recommendations was to reform the product scope, originally structured along individual electronics subsectors and branch organizations reflecting more the market inputs, into a waste stream oriented scope, structured along the most common grouping of waste streams like Large Household Appliances, Cooling and Freezing, etc. This change simultaneously will facilitate the alignment of treatment requirements and standards as well as the reporting requirements according to the collection categories used in practice. Additionally, in the writing process of the legal text, having independent research and technical support in the background can avoid overlaps and contradictions, which improves the clarity and quality of the legal framework. The same counts for thinking over possible rebound effects, which are to be considered as well.

Table 5.6 Evaluation of the impacts of individual intervention options

Description of the intervention options	Environmental impacts	Economic impacts	Social impacts + administrative burden
Add new types of equipment (including parts)	Low. Current scope already covers the most relevant products.	Varies per categories	Negative. Different provisions for parts built in or purchased for service.
Exhaustive list of equipment types	Very low. Only a small number of products are affected.	Neutral	Low: lists needs to be kept updated constantly.
Differentiate B2B/B2C per (sub)category	Neutral	Positive	Positive: Ensures level playing field.
Exclude “real” professional B2B equipment	Neutral, most professional products are already undergoing specific collection, refurbishing, and treatment due to high values.	Positive	Positive
Define a waste stream oriented scope	Positive. Allows more specific environmental target setting also in line with treatment standards to be developed where really needed.	Positive. Less administrative burden.	Very Positive
Define scope by means of criteria list	Neutral	Positive	Positive
Define scope by means of reference to other nomenclatures, int. trade statistics	Neutral	Neutral	Can streamline company reporting in the long term. Can only function when key products are also well represented in trade codes

Adapted from Huisman, J., Magalini, F., Kuehr, R., Maurer, C., Ogilvie, S., Poll, J., Delgado, C., Artim, E., Szlezak, J., Stevels, A., 2008. Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE). United Nations University, Bonn, Germany.

As a reference tool, illustrated in Fig. 5.1 with the example of the EU, StEP (2018) provides a geographical StEP World map covering e-waste data for all individual countries. The source can be used to directly see which countries and regions have legal instruments in place. With one click to the specific documents, a complete repository of legal texts is available as a reference, including also the history of the legal documents and key country parameters (Fig. 5.1).



European Union

Overview of e-waste related information

Subject	Unit	Year	Amount	Source
Population	(total inhabitants in million)	2012		515 IMF WEO
Purchasing Power*	(USD per Inhabitant)	2012		-- IMF WEO
EEE Put on Market*	(kg per inhabitant)	2012		19.4 UNU-IAS SCYCLE (2015)*
	(total in metric kilotonnes)	2012		9.8 UNU-IAS SCYCLE (2015)*
E-waste Generated*	(kg per inhabitant)	2014		18.7 UNU-IAS SCYCLE (2015)*
	(total in metric kilotonnes)	2014		9.5 UNU-IAS SCYCLE (2015)*

E-waste Rules, Regulations, Policies and Guidance

Number of E-waste Regulatory Instruments	5 Regulatory Instruments <small>click here to view</small>	compliance & risks
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Legend

- ✔ In force
- ⓘ Approved
- ⊖ Proposed

E-waste Rules, Regulations, Policies and Guidance

- EU: Methodology for the Calculation of the Weight of EEE placed on the Market and of Quantity WEEE, Regulation (EU) 2017/699 ✔
- EU: Collection, Logistics & Treatment Requirements for End-of-Life Household Appliances Containing Volatile Fluorocarbons or Volatile Hydrocarbons, Standard EN 50574-2, 2014 ✔
- EU: Equivalent Conditions for the Treatment of WEEE outside the European Union, Draft Regulation, October 2014 ⊖
- EU: Collection, Logistics & Treatment Requirements for End-of-Life Household Appliances Containing Volatile Fluorocarbons or Volatile Hydrocarbons, Standard EN 50574-1, 2012 ✔

■ FIGURE 5.1 Screenshot of the STEP e-waste world map information for the EU. From *StEP Initiative*, 2019: <http://www.step-info.org/overview-eu.html>.

5.4 IMPLEMENTATION ROAD MAP

For all three country types, the previous Sections 5.2 and 5.3 provide an overview of what needs to be tackled, the options to intervene, their interrelations, as well as the subsequent impacts. The output of this is ideally

updated and consistent legal texts and corresponding policy documents. However, the practical implementation benefits substantially when having a structured plan on top of this. **Practical implementation calls for a structured and explicitly communicated plan: A clear road map where all issues to be addressed are covered as unambiguously as possible.** In this road map each issues can be tagged with a time schedule for realization and an “owner,” being a person primarily in charge for the realization. The plan ideally includes a time path and wider conditions to derive to a successful national e-waste development. The main reason behind this advice is that often the perception exists that having a well-designed legal framework suffices and will automatically generate the intended results if everyone follows the rules. Unfortunately, experience shows that **the chief bottlenecks are commonly in the implementation phase.** Hence, the entire outcomes of [Sections 5.2 and 5.3](#) need to be converted into a national development road map or action plan. The plan can provide for the practical organization of stakeholder consultations, provide appropriate timing of the chosen interventions, as well as allow to measure progress against the targets, indicators, and milestones set.

Planning interventions

The Sustainable Recycling Industries (SRI) project ([Méndez-Fajardo et al., 2017](#)) makes a useful distinction between an action plan on one hand and a monitoring plan on the other hand. In this document, the latter is discussed in [Section 5.6.2](#), including the topic of indicators to measure progress. It, however, does make sense to develop both plans at the same time to align the timing and execute them individually later where it requires different roles and responsibilities. The difference between this chapter and the SRI approach is that here a more iterative development is suggested instead of one single round, with goals that can be too far reaching for starting and emerging countries in particular. Specifically for the scheduling of milestones, Chapter 8 of [Méndez-Fajardo et al. \(2017\)](#) provides useful examples of original versus revised timelines applied in the example of Colombia. It is, however, suggested here to leave out too far-fetched development elements in the case of starting and emerging countries and instead schedule a revision round in advance.

Stakeholder consultations

At certain points in the policy development process, the need for extended stakeholder consultations is high. Depending on the decision culture in

the country, it is advised to plan several milestones allowing interaction and discussion about various proposals. This can provide valuable information regarding the feasibility, the magnitude of the desired improvement potential, as well as insights into potential rebounds or undesired administrative burden. It is recommended to instruct stakeholders to provide actual evidence and facts that either confirm or reject the effects of the intended interventions. This is done because experience shows that stakeholders tend to communicate positions rather than enhancing the documents. The same counts for proposing alternatives that are possibly more effective. These need to be substantiated. Based on the provided fact basis and analysis of the various feedback, the evaluation of options could be adapted if necessary and the steps described in [Sections 5.2 and 5.3](#) can be updated where necessary.

Again, depending on whether there is a first, second, or later policy cycle, these steps can be performed in high or low detail. It is recommended to incorporate an evaluation to provide room to remove previous requirements that have become outdated or do not function sufficiently, for instance, due to technical or scientific progress. In later stages, to receive acceptance for the revised framework when available in the form of draft legal texts, it is recommended to request feedback on the draft legal texts and simultaneously to involve stakeholders to determine a feasible timing needed for implementation as well as a description of the resources needed from an organizational and financial point of view. The stakeholder feedback forms an important forward-looking input to the next proposed step: the (co-)organization of a national implementation plan.

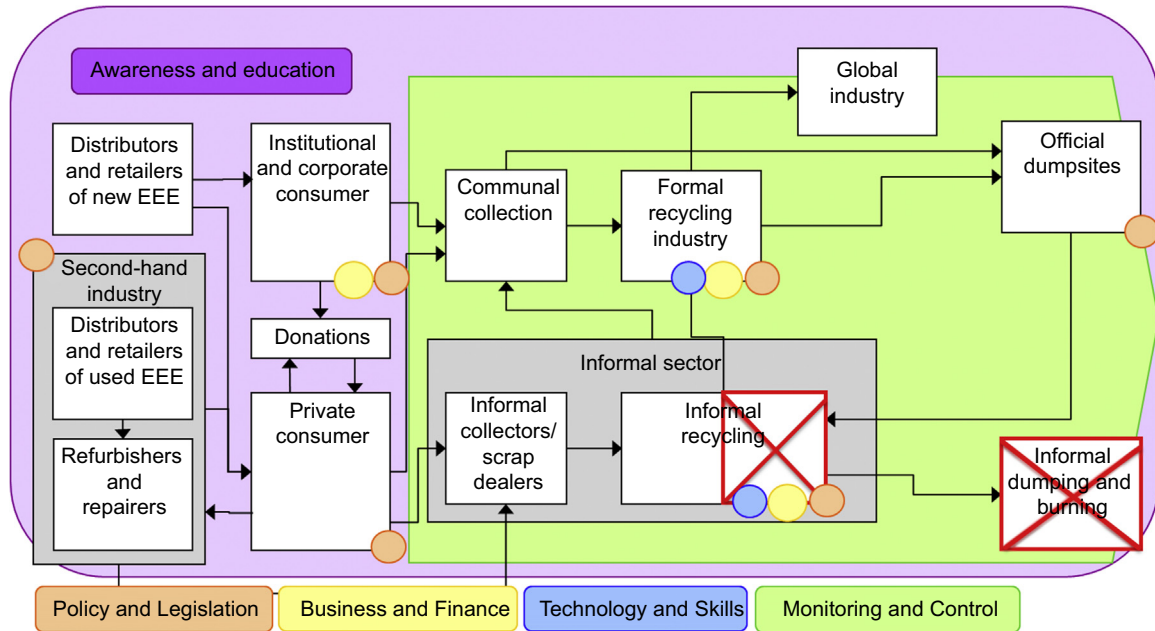
A national implementation road map

The rationale behind a national implementation plan is to ultimately achieve active stakeholder commitment to execute and implement the policy framework and concurrently steer progress in the other development areas at specific stages in the collection and recycling chain. The advantage of clearly formulating such a national road map is that all key information, the allocation of roles and responsibilities, as well as timing and resources, are **converging into one reference document**. This can be made available for both the actors involved and to the general public, making the decision and implementation process more visibly accessible. However, compared to the number of e-waste publications and country assessments, so far there have not been that many road maps published via the coordinating stakeholders themselves. The most relevant examples

are found in [Wath et al. \(2010\)](#), [Schluep et al. \(2012\)](#), [Schluep, 2014](#), and [Méndez-Fajardo et al. \(2017\)](#).

Depending on the specific country needs and the information that is available or not from previous implementation rounds, the following components can be included in the road map document. The following list also contains examples and references, which can be used as a reference:

- A list of key issues and objectives, when available from the problem definition discussed in Section 2.7. Other examples and visualization are, for instance, available in Chapter 8 of [Méndez-Fajardo et al. \(2017\)](#).
- A list of the specific requirements in the three domains of Policy and Legislation, Business and Finance, and Technologies and Skills, as highlighted as examples in [Tables 5.2–5.4](#), including the main targets, the timing for achieving them, and the main responsible actors.
- A listing of existing and related policies, cross-referenced in relation to the new or updated requirements. Here, the analysis results from Section 2.6 can be displayed, for instance, in a simple table format. Other examples are published for Switzerland, Sweden, Norway, and Denmark in [Ylä-Mella and Román \(2018\)](#), for India in [Wath et al. \(2010\)](#), and for several countries in comparison in [Li et al. \(2015\)](#).
- A frequently updated and online FAQ document can be provided for recurring key questions from both implementing actors, producers, as well as consumers and other business end users. An elaborate example is available in [European Commission \(2014\)](#). This also supports the communication of responsibilities in practical terms than more difficult-to-comprehend legal texts.
- A list of key responsibilities per stakeholder. Here, results can be taken from the stakeholder analysis in Section 2.5 or by elaborating on Table 4.2 from Section 4.2.1 ([McCann and Wittman, 2015](#)), additionally from the Annex K in [Schluep et al. \(2012\)](#), and the elaborate example of Colombia in [Méndez-Fajardo et al. \(2017\)](#).
- A list of working groups supporting the implementation can be instrumental. Dependent on the national situation, describing the relevant technical, communication, legal and finance groups, as well as the coordinating entity or monitoring bodies can be provided in the form of a diagram or list. This can explicitly show the desired information flows and controlling responsibilities. Informative examples are available in the Figs. 4 and 5 from [Wath et al. \(2010\)](#) for India, Chapter 8 of [Méndez-Fajardo et al. \(2017\)](#) for Colombia, and Fig. 22.8 of [Zeng and Li. \(2018\)](#) in this handbook.



■ **FIGURE 5.2** Example of visualizing the intended interventions in the end-of-life chain. Schluep, M., Muller, E., Ott, D., Rochat, D., 2012, *E-Waste Assessment Methodology, Training and Reference Manual*. EMPA, Switzerland, October, 2012.

- A mass flow diagram with the main quantities when available. Here, useful examples are provided in Section 3.2, as well as in Yoshida (2018) and Zeng and Li (2018) in this handbook.
- Closely related, and possibly visualized in the same system diagram, the location of the main interventions in the end-of-life chain. A good example summarizing proposed actions at specific points in the value chain by affected stakeholders in one diagram is derived from the EMPA e-Waste Assessment Methodology in Schluep et al. (2012), which is also applied in a “Case study E-waste management” for the GIZ (global chemicals waste platform in 2014, Schluep, 2014). Fig. 5.2 is a further iteration of Fig. 2.4 in Section 2.7.3 and provides a clear visualization of the points in the end-of-life chain where the interventions are supposed to make an impact.

On top of the proposed national road map, key conditions for successful implementation are discussed in the next sections.

5.5 CONDITIONS FOR SUCCESS

Obviously, the development road map from the previous section needs to be converted into actions in practice. For starting, emerging, and established countries, a general key question is:

- Step 8: How to successfully implement the national e-waste development road map?

Here it has been chosen to deviate from previous sources like (Schluep et al., 2012), which includes Monitoring and Control plus Awareness and Education respectively as fourth and fifth development areas. In this chapter these two areas are positioned more as a continuously ongoing step in the implementation phase. The main reason is they are important conditions to success as well as of a different nature compared to the other development areas mentioned in Sections 4.2–4.4. They require continuous attention and are more indirectly empowering of the stakeholders involved. These conditions for success, including the additionally suggested prevention area of “Design Feedback,” **cannot be managed “top-down.”** This part of the implementation relies more on the willingness and continuous improvement from those involved in a more “bottom-up learning by doing” manner.

To support this, it is proposed that the national e-waste road map is also extended with the following items, which will be elaborated upon in the next sections:

- A monitoring road map, including responsibilities, resources, and timing. For more information, see Monitoring and Control [Section 5.6](#) as well as the example of Chapter 6 in [Méndez-Fajardo et al. \(2017\)](#). Another example of a road map for emerging countries is available in the conclusions of the Countering WEEE Illegal Trade (CWIT) report as recommendations for law enforcement entities in [Huisman et al. \(2015\)](#); see also [Section 5.6.2](#) and [Fig. 5.3](#).
- A list of training needs and allocation of resources for end user communications. See also [Section 5.7](#) for more information.
- A continuous discussion can be planned on how to arrange for more Design Feedback. This additional area has a “special prevention

character” and is recommended to go beyond setting basic product requirements in product policies. Therefore, Design for Recycling possibilities (Section 5.8.1), an information feedback loop to recyclers (Section 5.8.2), as well as the potential role of Green Public Procurement (Section 5.8.3) are discussed as a third area of development in Section 5.8.

5.6 MONITORING AND CONTROL

The purposes of developing monitoring and control mechanisms are multiple:

- Adequate and complete reporting of market inputs, both via sales of new equipment as well as via second-hand imports, requires attention to avoid “free riders” as much as possible. Requirements can include the registration of producers and amounts placed on the respective market; financial obligations, including, for instance, auditing and some bookkeeping requirements, dependent on the chosen financing mechanism. Noncompliance here can potentially undermine an economically level playing field for producers when not reporting.
- Reporting on performances provides both knowledge and transparency needed to monitor progress of the implementation on a national scale and to report against the targets set in Section 5.3. This is ideally reflected in the road map and its milestones from Section 5.4.
- To control and enforce in case of noncompliance or undesired practices in collection and treatment. Data on quantities and fractions from treatment are important for analysis required by enforcement agencies. They serve as a basis for investigation and detection of noncompliance, enforcement action, prosecution, and ultimately penalizing and sentencing of the most severe cases of environmental, economic, and social damages to society (Huisman et al., 2015). Here, any existing standards for logistics, pre- and end-processing developed as introduced in Section 2.2.2 should be accompanied by monitoring of the results from collection and treatment according to these standards. Here, the economic consequences can be significant as well. See Section 3.5.3 for information on the economic order of magnitude (in euros per ton) of “competition distortion” in these cases as well as the recent information with compliance costs information from (Magalini and Huisman, 2018).
- It forms the basis for a mid- to long-term next evaluation round and country assessment as presented in Section 4.2 and any renewed impact assessment as discussed in Section 4.3.

Obviously this step in the development cycle is to be tuned closely to the other information intensive assessment steps in the development cycle. The same counts for collection and treatment. Control is recommended for instance via benchmarking and field checks on whether collected amounts are handed over to recyclers, treatment standards and reporting over recycling performance, and enforcement and appropriate penalties on illegal waste shipments are relevant (Schluep et al., 2012). When present, Monitoring and Control is also applicable to technical standards and auditing procedures for recycling processes.

Typical examples of lack of enforcement can be found in Section 11.5 of the UNU WEEE Review study (Huisman et al., 2008) regarding collection amounts specifically in Huisman (2010), regarding transboundary shipments to other countries are described in Huisman et al. (2015). Regarding involvement and enabling of competent law enforcement bodies, this is specifically described in Section 5.7.2. Obviously, due to differences in the development status of the country and the general availability of information, the Monitoring and Control actions are different for starting, emerging, and established countries.

5.6.1 Starting countries

For starting countries, often there is not much complete information and commonly reporting standards are not yet implemented. Hence some of the key questions are:

- How to make first “terms of reference” to measure progress? What indicators will be used?
- How to develop basic monitoring capacities?
- What basic information do enforcement agencies need in the mid-term?
- What will be a good time table for evaluation moments?
- Who can deliver information and who can evaluate?

Prepare for future auditing

There are various reporting standards available in the literature, as well as from various countries and compliance schemes. Typically, auditing of performance cannot take place yet in the case of starting countries, since there is little information or time series of key information available. Therefore in drafting the initial reporting templates, it is recommended to limit the

reporting formats to cover the basic information as well as to be able to expand in coming years in such a way that more detailed auditing procedures can be realized covering more information. It is recommended to use harmonized formats where possible that allow comparing market input, collection, and treatment information along the same categories with other countries as well as in relation to classifications already in use internationally (Baldé et al., 2015). Using disconnected and self-invented codifications can hamper traceability and comparison of information in the end. In addition, the specific Deliverable 6.1 of the CWIT project (Huisman et al., 2015) provides an overview of codes already in use in the international and EU domain. It also contains specific recommendations regarding the distinction between waste and second-hand products, possible definitions, compatibility tables, and collaboration possibilities between stakeholders using the reporting formats in practice.

Developing institutional capacity

A key decision in the early stages is to decide and assign who will be in charge of the monitoring of the system at large and how the information flows will be handled. It is advised to establish a first monitoring body with a specific mandate from the national government entity in charge. In addition, a limited number of representatives from the producer and recycler associations as well as a neutral technical expert can be included. In the early stages, the role of the monitoring body or technical working group can be kept rather simple to aim specifically at the gathering of basic information and providing key monitoring information. In later stages, also specifying research assignments and involving of more national experts from universities or research institutes may be applicable. Here it is important to trigger research capacity and knowledge provision for the longer term, which will be discussed next in [Section 5.7.1](#). Interested researchers can also be closely involved from the beginning in the suggested pilot projects, in particular by allowing access to the first monitoring results. It also obviously makes sense that these experts are also involved in the early country status assessment steps in order to be able to analyze in conjunction the qualitative information, the stakeholder assessment (see [Section 4.2](#)), and the more quantitative performance from the monitoring in the coming years.

Data for enforcement, learning by doing

It is important to distinguish three types of information relevant for (future) enforcement action. Firstly, data is needed regarding market inputs both for sales and second-hand imports. Here, in the beginning stages

monitoring, depending on the chosen product scope, can be limited to checking the initial declaration of equipment placed on the market, the units and average weights declared, and enforcing that there no obvious free riders absent in the registrations. Secondly, the collectors and recyclers receiving quantities from the commencing system can be visited and requested to provide simple mass balances and evidence of proper depollution as well as simple checks on the processing configurations. Thirdly, specifically for countries with significant imports of second-hand equipment, in cooperation with the port authorities or customs, inspections can take place at ports and roads crossing the national borders. Here, the experiences in the Nigerian “Person-in-the-Port” project (Odeyingbo et al., 2017) gives many practical clues on how import processes look like, how to set up analysis protocols to measure the import volumes and their qualities, and how to control and enforce better in the future. For these three enforcement areas it is recommended at this stage in time to focus more on the information gathering processes themselves and the identification of key areas of noncompliance. This should support and indicate to the sector it is becoming supervised via visible presences and inspections. When applied in a proactive dialogue format, the sector can be suggested to professionalize by itself over time, rather than restricting the sector by maximizing penalties early on.

Information needs for policy decisions and the next development cycle

Reliable reporting is indispensable for “managing” the system after the rules have been set. Continuous attention to the system through reporting is needed to keep it going well and to identify issues that have to be addressed in the next stage of the e-waste cycle. Here, the monitoring information is essential for the preparation for a first evaluation stage (see Sections 2.7, 3.2, and 3.3) and ultimately a second development cycle. Instead of providing answers, in this step it is relevant to identify clearly what Monitoring and Control information would be needed to answer key follow-up questions such as: How can achievements be quantified in relation to the set targets and objectives? Where is noncompliance economically rewarding and low inspection risk making regular enforcement needed? What are the economic or other drivers behind this? How to collect signals from the sector itself? In addition, the Monitoring and Control information is specifically of relevance for conducting a more structured country assessment and mass flow analysis later on as presented in Section 3.4.3.

5.6.2 Emerging countries

Whereas for starting countries the focus in this step is to develop a basic reporting system, for emerging countries with more information and reporting standards, formats, and exchanges generally established, the focus here should be more on the analysis of the information that is regularly not exploited to the extent possible. Especially the actual enforcement chain is a common weak point due to lack of resources, experiences, and communication channels. Therefore, a key question for emerging countries is:

- How to improve reporting and a more structured monitoring and enforcement framework?

Effective auditing

A structured evaluation framework capable of tracking market inputs and outputs, the performance of collection, and quality of treatment is instrumental for steering the efficiency of the e-waste system. In this regard, as a subsequent step in addition to establishing reporting, the active auditing and interpretation of results allows to intervene where quantities are missing and performance is not in line with the financing provided.

Especially for Europe, the WEEE Forum and its members have constructed reporting templates of market inputs and collection information, as well as realized the exchange of information in the so-called WEEE Forum key figures tool, and provided benchmarking information via a web-based application, which is informative for monitoring purposes and benchmarking between different countries (WEEE Forum, 2010–2017). Similarly, the WEEE Forum and its members have established a monitoring tool for the reporting of treatment performance and downstream operations (WEEE Forum, 2018), which is also aligned with the technical treatment requirement of the WEEE LABEX/CENELEC mentioned in Section 4.2.2.2. Here, the advantages in the long term are better depollution results, increased traceability, and transparency and harmonization of requirements for operators. For more information, see Chapter 6 of this handbook (Herreras and Leroy, 2018).

National WEEE monitoring

As shown in Section 3.5.3, in many cases, selling products for reuse or fractions for treatment acquired through informal collection are neither reported in official statistics nor traced. Furthermore, not all European

countries place an obligation on preprocessors to report and record the amounts and destinations of all types of input and output fractions. Obviously, informal collection activities do not appear in official statistics. Accurate mass balance calculations, based on reliable quantitative data, are crucial to determine progress toward achieving WEEE collection targets or the amounts of e-waste that end up outside the official WEEE chain. See the Deliverable 6.4 of the CWIT project ([Huisman et al., 2015](#)) for more details and proposed actions.

International monitoring of export of critical fractions

In case materials are transferred interregionally and become less traceable, a common international platform for assessing the treatment quality and mass balance could help to monitor the treatment and improve the mutual trust. For e-waste standards such international exchange does exist; for trade of complex materials this is not the case. A new idea and recommendation is to seek possibilities to arrange this in similar ways as the certification and due diligence programs that are emerging for primary minerals. Having such a framework or international market information exchange would also allow for producer organizations to seek to reach compliance goals that are more country independent, similar to the international fate of their products. For more information on the benefits of this, see also [Wang \(2014\)](#) and the Best-of-2-Worlds project results ([Wang et al., 2012](#)).

Information management for enforcement, penalties and rewards

In the law enforcement field, commonly a lack of information exchange and a lack of statistics about illegal WEEE activities is observed ([Huisman et al., 2015](#)). By definition, statistics on illegal activities related to WEEE are not reported in a structured manner. This CWIT project report provides several actions for improvement that can be taken up in the further development of the e-waste system for emerging countries (and likely many established systems as well), that is, to put in place formal agreements for the exchange of information between law enforcement, judicial authorities, and the WEEE industry. Secondly, it is recommended to consolidate and implement an operational intelligence management system that handles management and use of waste information at enforcement agencies and use intelligence to prioritize and direct resources toward the operations and policies that will be most effective. More details can be found in Deliverable 6.2 (use restricted to law enforcement agencies) of the CWIT project ([Huisman et al., 2015](#)). For information on the use of penalties, see Section 4.3.2.2.

Information needs for policy decisions, the next development cycle

For emerging countries, the questions are the same compared to those posed in [Section 5.6.1](#). These questions can be the input for second evaluation and third development cycle of the e-waste system. Here, the Monitoring and Control information is also specifically of relevance for conducting a more structured country assessment and mass flow analysis later on as presented in [Section 3.2.4](#). Finally, also comparison and benchmarking is possible based on quite a number of studies presented there. Finally, for an example of a Monitoring and Control plan, see also the SRI report ([Méndez-Fajardo et al., 2017](#)) and [Fig. 5.3](#) next in [Section 5.6.3](#).

5.6.3 Established countries

For established countries with more mature Monitoring and Control frameworks, some specific key challenges commonly remain. In practically all cases, still not all market flows and treatment fractions are being controlled that take place outside the designated reporting systems.

- How to involve all flows and streamline enforcement?
- How to track system performance more in real time?
- How to establish smart enforcement?

Real-time auditing

Some countries have included the “all actors” model as mentioned in [Section 4.2.3.3](#), which enables also more direct and real-time monitoring of ideally all collection and treatment volumes in the country. In addition, where CENELEC (EU) or other treatment standards are available, making these mandatory at the same for these “all actors report” quantities allows more direct benchmarking in the long run and thus intervention possible when the treatment quantities are also understood better. In addition, see the scavenging assessment of [Section 3.5.3](#) based on [Magalini and Huisman \(2018\)](#). In this respect there are many best practices available in countries like Ireland, the Netherlands, France, and Belgium, where the compliance schemes and authorities are closely cooperating in improving the monitoring of the system and taking actions like addressing directly actors in the trading chain when they are structurally remaining noncompliant. This also applies to the collection channels. In the Netherlands for instance, information normalized in kilograms per inhabitant for each municipality is available,

allowing to address specific collection points that for some reason are clearly underperforming (Huisman et al., 2012). Finally, also understanding the material composition from e-waste collection and treatment is relevant for understanding future compositions and the content of valuable, hazardous and critical raw materials (CRMs). Here, the ProSUM project also provides specific protocols to measure CRMs in waste flows in its Deliverable 4.4 (Rotter et al., 2017; Huisman et al., 2017). Further additional practical suggestions to improve the inclusion of all quantities in the Monitoring and Control framework can be found in the Deliverables 6.1 and 6.4 of the CWIT project (Huisman et al., 2015).

Review existing data collection processes and modernise targets

Data gaps in national and international reporting severely affects the meaningfulness of the monitoring of various policy instruments, as well as in the monitoring and comparing of progress made over time. It is important to understand and tackle these data gaps in order to better substantiate targets for collection and treatment and ultimately for circular economy monitoring. Here, a recent publication from the ORAMA project (Huisman et al., 2018), provides a comprehensive assessment of these data gaps, obstacles in the data collection process and an inventory of recommendations that is converted in all sorts of possible actions and case studies to improve data availability and quality. This also relates to quickly changing perspectives on the relevance of raw materials in established countries. Over time, the views on the original perspectives of e-waste legislation is changing from more waste management and control over potentially harmful substances, towards more circularity and higher material efficiency. In the long term this means that originally simple weight based indicators should be replaced by more meaningful and targeted environmental, social and economic ones like sketched in Sections 3.4–3.6. It is recommended for established countries to conduct research on this subject as a basis for modernising previously defined targets. Here, (Huisman et al., 2018) provides a list of priority actions to improve the required data collection processes as well as harmonisation needs and classifications to achieve this in the long term.

A national monitoring and control road map

For established countries, after a successful third evaluation, possibly even a fourth development cycle could be considered. This fourth round is not included in these chapters, since there is basically no experience available. It is likely that the main needs to improve even further lie in a more

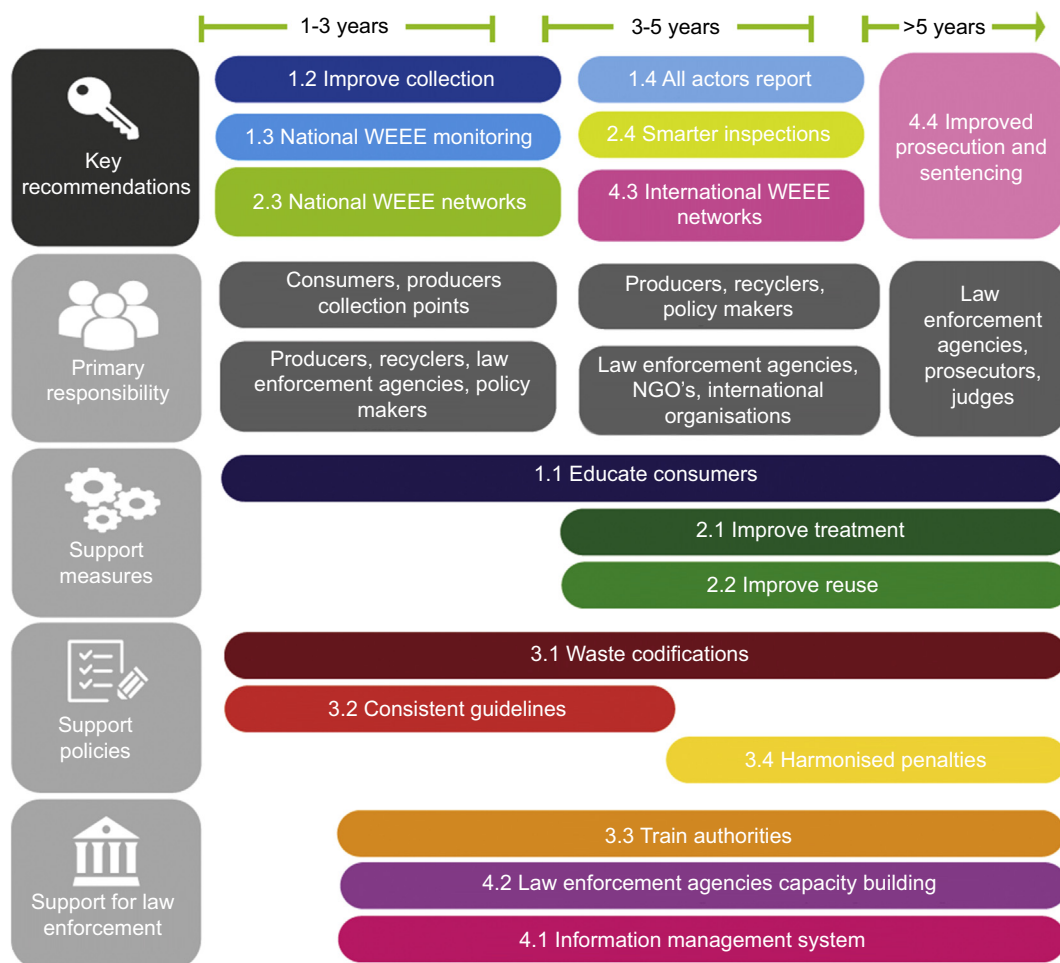
continuous and effective monitoring and enforcement of what has been developed rather than additional new rules and regulations. Therefore, the approach of the sketched third development round is expected to be adequate when followed in the suggested “à la carte” manner. As an example of a more comprehensive Monitoring and Control road map, combining primarily short-, medium-, and long-term recommendations for emerging and established countries, is presented in Fig. 5.3 derived from Huisman et al. (2015). It illustrates the possible timing and responsibilities of various actions that can be taken. More detailed information for each element in Fig. 5.3 is available in the CWIT report and the specific recommendation reports created by the project.

5.7 AWARENESS AND EDUCATION

Interestingly, Fig. 5.3 indicates another interesting finding from the CWIT project. The highest ranked recommendation from surveying both the electronics industry and recycling community as well as representatives from the law enforcement chain is to increase the consumer awareness and specifically to continue to provide information on how and where consumers can hand in discarded products. The main rationale provided (Huisman et al., 2015) is that education is the most basic action that is driving long-term change. Consumers are always the starting point for collection, thus the quickest win is when consumers increasingly bring old WEEE products to the appropriate collection points increasing collection and decreasing leakages like small appliances ending in the general waste bin. In addition to this, providing information on the system performance is regarded as an important ingredient for the long-term acceptance of the costs of the e-waste system. This also aligns with the rationale behind releasing the national implementation road map to the public. In this section, besides improving awareness of consumers, also further education by means of capacity building and training of all stakeholders involved is discussed. This includes the target audiences of researchers, producers, government entities, recyclers, and law enforcement agencies.

5.7.1 End user education

The term “end user education” is used here, since consumers are not the only source of e-waste. Specifically for emerging and established countries, B2B users, industry and the public sector are contributing a significant portion of the total discarded volumes.



■ **FIGURE 5.3** Monitoring and control recommendation road map. *Huisman, J., Botezatu, I., Herreras, L., Liddane, M., Hintsu, J., Luda di Cortemiglia, V., Leroy, P., Vermeersch, E., Mohanty, S., van den Brink, S., Ghenciu, B., Dimitrova, D., Nash, E., Shryane, T., Wieting, M., Kehoe, J., Baldé, C.P., Magalini, F., Zanasi, A., Ruini, F., Bonzio, A., 2015. Countering WEEE Illegal Trade (CWIT) Summary Report, Market Assessment, Legal Analysis, Crime Analysis and Recommendations Roadmap, August 30, 2015, Lyon, Francebib_Huisman_et_al_2015.*

For starting countries, key questions related to end user education and training and capacity building are:

- How to inform consumers about the initiation of collection infrastructure?
- How to enable quick learning for the informal sector?

5.7.1.1 Starting countries

Consumer involvement is a key ingredient to obtain collection volumes. In newly evolving e-waste systems, informing consumers is an important element to be developed. In the long term, knowledge and awareness support the development of the social norm and motivation of consumers to contribute and accept the policy development as well as the visible or invisible costs. Noticeable here is that the collection is usually organized completely different in starting countries and often at rather high levels but not being directed to formal channels. See also Section 3.2.1. This also affects how awareness actions should be organized, since it does not make sense to improve consumer awareness when official collection infrastructure is omitted. Therefore, a first possibility in case pilot projects are conducted and initial legislation is enacted is to actively communicate these development steps in the country to various media, newswires, and other formats in an engaging style. Secondly, depending on the funds initially made available, specific communication campaigns can be rolled out to increase awareness of informal collectors steering their collection volumes and the hazardous content of products to the right channels. Here, another recent SRI project provides more insights on the current practices and more sustainable alternatives in [Karcher et al. \(2018\)](#).

Various examples are available in the Deliverable 6.4 from the CWIT project ([Huisman et al., 2015](#)). It is recommended to grow these campaigns over time starting with very basic information in the starting periods, for instance, on the environmental and economic reasons to collect and recycle e-waste and in particular in where collection points are made available. It is also recommended that in case consumer survey information is available, see Section 3.6.3 and Annex C of [Schluep et al. \(2012\)](#) to adapt the approach to the main information and awareness gaps identified.

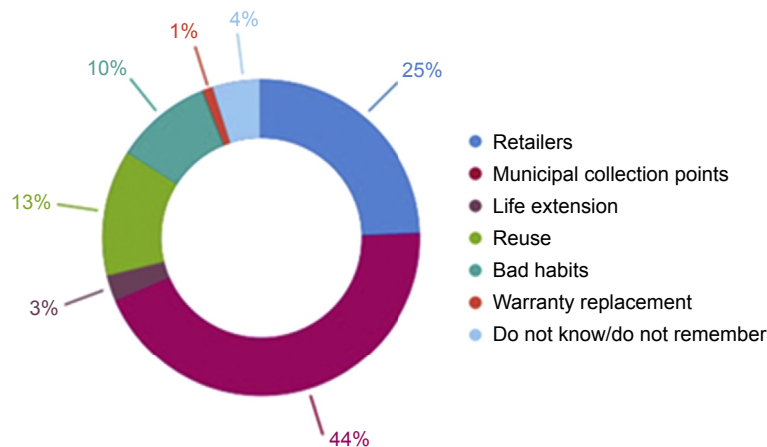
5.7.1.2 Emerging and established countries

For emerging as well as established countries, key questions are:

- How to extend end-user education and continuously involve all end users?
- How to involve local collectors, municipalities, and regional authorities?

For emerging countries, the initial programs for education of end-users can be continued, extended, and intensified to more media channels and formats. Here many examples exist, in particular in Europe of smart TV commercials, projects involving children at school to collect, and other best practices. One of the most inspiring projects is the Dutch Wecycle school project (Wecycle, 2018), teaching and involving children from primary schools into collection campaigns and providing a range of teaching materials. Similarly, many of the WEEE Forum members have their own national campaigns and examples accessible via their respective websites. In many cases, also various collection projects are organized regarding general municipal solid waste by individual municipalities and regions. As an example, the project states that for Sweden the cooperation between municipalities and producers as well as recycling centers, combined with a high level of awareness, has led to substantial increases in the volume collected per inhabitant. A concern, however, is the efficiency of rather scattered approaches (COLLECTORS project, 2018). In many cases substantial costs are spent on relatively low quantities collected, and a wide variety of practices are reinvented repeatedly. It is therefore recommended to evaluate existing approaches and best practices that are working in other countries.

An example of analysis specifically on behavior of consumers is presented in Fig. 5.4, derived from the Italian country study conducted in 2011 (Magalini et al., 2012). It shows to which collection channels consumers (think they) have discarded old appliances. The information including the



■ FIGURE 5.4 WEEE disposal method by waste stream in Italy, 2011, in weight%. Magalini, F., Huisman, J., Wang, F., Mosconi, R., Gobbi, A., Manzoni, M., Pagnoncelli, N., Scarcella, G., Alemanno, A., Monti, I., 2012. Household WEEE Generated in Italy, Analysis on Volumes and Consumer Disposal Behavior for Waste Electric and Electronic Equipment. United Nations University, Bonn, Germany.

details per collection category provides some important findings. This allows intervening in some of these channels when the equipment does not land in the designated reported channels, in particular when the actual volumes from adjacent market assessment show indeed discrepancies to the desired channels consumers have indicated. See also the EU study on the common methodology for measuring the collection rates of the WEEE Directive in [Magalini et al. \(2016\)](#) for more information regarding the collection practices and volumes in the EU member states.

Additionally, a relatively new project is taking inventory of, amongst other waste streams, best WEEE collection practices in Europe. The [COLLECTORS project \(2018\)](#) is designed to provide more structured information in the coming years. Another important aspect is the security of collection points. There are many cases known of robbing, stealing, and scavenging of e-waste from collection points. Here various actions and investing in security measures are possible; see also [Huisman et al. \(2015\)](#).

Communication to business owners is often underdeveloped. This is especially a concern when the (revised) product scope (see Sections 4.2.2.1 and 4.2.3.1) includes B2B appliances. The volumes of both small WEEE, in particular office equipment, in enterprises as well as more professional equipment can be a considerable part of the total ([Huisman et al., 2012](#)). Without proper collection information, substantial amounts of e-waste end up in the unsorted general waste stream as well as in complementary trade outside the designated channels. This leads to lack of control over quality of treatment and these amounts potentially are a source for (illegal) exports. Therefore, it makes sense to dedicate resources to communication of the actual legislation being applicable to business end users as well. Using supporting guidance documents and frequently asked questions, accompanying standards and agreements, as well as making the presence and functioning of national registers explicit via their respective branche organisations, should inform this sector regarding its responsibilities. These documents should explain what the criteria are for professional equipment to be regarded within scope of the policy framework or not.

A final consideration regarding consumer awareness is the use of a visible recycling fee or even deposit. The basic fact that consumers are paying the external costs of collection and recycling has a high awareness factor in itself. There are potential financial drawbacks since there is a risk to accumulate too much funds, as well as the risk of creating monopolies of associations in charge of them. However, when implemented in a cost-efficient and transparent manner, including the possibility for other actors to have a vote in the spending of these funds in a smart manner,

then a visible fee or deposit system for selected appliances can form an accelerating component of the system. This is due to the presence of both the financial funds and the awareness component as crucial long-term development incentives.

5.7.2 Training needs

For all three country types, there are (evolving) training needs for various stakeholders. Key questions are:

- How to involve the key stakeholders and enable quick learning for the informal sector?
- What are the key training needs for the various actors?
- How to improve stakeholder collaboration and research?

Knowledge institutes and universities

For starting countries, generally speaking, universities and (independent) knowledge institutes can greatly assist in supporting the system as discussed in many of the assessment and monitoring sections and obviously in the technical experience related to standards and requirements. Here, various training tools exist that avoid starting from zero, like the EMPA E-waste assessment manual (Schluep et al., 2012), many green and white papers from the StEP community (Gregory et al., 2009; StEP Initiative, 2009; StEP Initiative, 2010; Deubzer, 2012; StEP Initiative, 2014; StEP Initiative, 2016; McCann and Wittman, 2015; StEP Worldmap, 2019), and as a dedicated international training course the E-waste Academy for Scientists (UNU, 2018). A Massive Open Online Course is also available to those having a fresh interest in the e-waste challenge from the EU-funded climate Knowledge Innovation Center (Climate KIC, 2017), which can be used privately as well as part of a university course.

For established countries, it is recommended in addition that government entities and producer associations jointly develop a research agenda and provide key funding as well to investigate the effectiveness and efficiency of the system. In this regard, many practically formulated e-waste assessment studies have proven to provide valuable information as well as to improve the communication and understanding between the key actors steering the next development stages to new levels. See also Section 3.2.4.

Policy makers and recycling start-ups

For policy makers and recyclers starting their business, a dedicated version of the E-waste Academy for these two groups exists called E-waste Academy for Managers (UNU, 2018). Viable business development and mutual understanding between policy makers and managers of recycling facilities is an important element to realize the necessary infrastructure for recycling. Recently, a specific Business Boot Camp addition to the E-waste Academies series is planned for small entrepreneurs (UNU, 2018). Various tools for the informal sector to professionalize from basic processing techniques to more advanced and economically more efficient ones are available in these sources; see also SRI project (2018) for useful treatment guidelines. Additionally, a business plan calculation tool is available via the StEP website enabling basic economic calculations for developing business plans (Spitzbart et al., 2016; StEP Initiative, 2019).

Law enforcement

For starting countries, the focus is commonly on enforcement on waste imports, less on collection and treatment as these are still evolving. Specifically for law enforcement agencies, which includes inspectorates, customs, port and border authorities, and judges and prosecutors, the DOTCOM-waste project provides specific training materials and recommendations. These (restricted) materials are specifically made available for enforcement agencies via the website of DOTCOM Waste project (2017).

For emerging and established countries, in addition to the DOTCOM.waste training materials, also several organizational measures can strengthen the capacities of law enforcement agencies. Generally, there is a lack of knowledge, since the law enforcement agencies are trained to handle many illegal activities of which illegal e-waste trade and environmental crime is only a tiny sector compared to more dangerous threats related to trade in drugs, narcotics, weapons, etc. This constitutes a fundamental challenge for law enforcement agencies and commonly prioritizes environmental crimes in particular lower on the agenda due to other more pressing items. Without adequate skills and knowledge and allocated resources, it is challenging to detect, investigate, and prosecute illegal e-waste activities (Huisman et al., 2015). The CWIT project contains detailed suggestions and actions that improve the communication, training needs, practical guidelines, and public-private partnership ideas that may be relevant for emerging countries. Additionally, technical equipment and means are needed to test and store seized shipments as well as human resources. Here it is recommended to include in the e-waste development road maps and in the monitoring plan a dedicated inspection paragraph that plans for the resources needed.

Since e-waste trade is by definition not confined to national borders, a final element of improvement is to facilitate international cooperation and the exchange of information between sending and receiving countries in particular. See the Deliverable 6.2 of the CWIT project (Huisman et al., 2015) for more information.

5.8 DESIGN FEEDBACK

Electronic products are changing rapidly in their size, composition, and connections between materials and components. The following trends are observed, all affecting the composition and presence of materials in electronics, as well as the recycling potential (Huisman et al., 2017). Products are becoming:

- **Smarter:** products are increasingly fitted with sensors and other technologies like in wearables, IoT appliances. Also smart TVs, LED lamps, scales, smoke detectors, thermostats, dispensers, watches, phones and even tennis rackets and sport shoes are examples of products rapidly changing in this respect.
- **Smaller:** Miniaturization of hardware with more functionality performed by smaller and smaller devices. Examples include planar transformers with less energy consumption per function, fewer circuit board materials in basically all smaller and medium-sized appliances. The result is usually lower value per kilogram of product and higher dispersion rates of minor elements.
- **Multifunctional:** Increasingly there is more convergence of multiple products from different categories becoming more integrated and combined. Examples are voice-activated speakers, smart refrigerators, and home diagnostics.
- **More cross-over products.** These are products that were initially expensive in the business domain but rapidly become cheaply available in the consumer domain. Examples are 3D printers, drones, medical devices, VR, robotics, etc.

Due to these trends, prevention via improved Design for Recycling obviously remains an important strategy. So far, no product-related requirements are mentioned in relation to their inclusion in the Policy and Legislation part of the e-waste development cycle here. The reason is on one hand that product end-of-life requirements need to be embedded in other eco-design strategies and policies. On the other hand, individual and, in particular, smaller countries will not have sufficient leverage to influence products produced for the global market. Here, country by country varying design requirements can cause significant fragmentation. Nevertheless, the following legitimate key question remains for the following sections.

5.8.1 Design for recycling

Irrespective of the country development status, a key question often asked, regards prevention:

- Should prevention via design requirements to improve recycling not be included in the policy framework?

The following quote from [Huisman \(2013\)](#) is still regarded relevant: *“There simply is no financial mechanism that pays back upfront redesign investments in reduced end-of-life costs that are incurred roughly 10 years later. Products do not come back individually to the original producer, but in various mixed collection streams, and sorting back into brands is expensive. Moreover, the value of e-waste is well known by local traders and collection points. Transferring ownership to producer responsibility organizations (PROs) and arranging for logistics and quality treatment generally costs more than the intrinsic material value. Processing facilities vary greatly in sophistication and material prices are very dynamic and unpredictable. Thus, requiring all this to be addressed upfront in product design, many years before the actual disposal of products, has just proved to be naïve.”*

With this analysis, the recommendation for countries starting with e-waste policies is **not** to incorporate prevention-oriented design measures in the waste management oriented legislation but preferably in generic eco-design and product related policies. Besides keeping focus on the necessary waste management requirements, (“one policy for one main goal”) according to [Huisman \(2013\)](#), eco-design requires a careful balancing act, preferably as early as possible in the early product-creation stages. What is good for recycling may not be so good, for example, for materials selection or energy consumption ([Bakker et al., 2012](#)). In practice, a lot of creativity is required to achieve long-term societal goals and higher levels of sustainability: more functionality with fewer materials, more quality, products that last, instead of “fast-food electronics,” and further dematerialization ([Bakker et al., 2014](#)). It is likely that such creativity is actually hampered by static legislative requirements and long compliance checklists, rather than being supported. To improve product design, it is suggested that it is more effectively supported to some degree by having more procedural elements, life cycle assessments, eco-design checklists, and marketing of green products in annual environmental reports of producers. However, more relevant for the long term is to have eco-design structurally embedded in the **inside core of the product creation**

and integration process and permanently resident in corporate culture and management bonus systems internally, rather than in external legal compliance layers.

Design for recycling activities can take shape in very simple forms, like following specific design strategies and rules. Secondly, they can also be based on actual dismantling (or shredder tests when prototypes) and previous designs or warranty goods are available. Thirdly, they can be based on more advanced simulations in cases where it is difficult to determine separation characteristics or when more complex compositions and connections are at stake, or in the case that it is simply too expensive to destroy valuable new products.

- As an example of the first approach, a both effective and economically attractive design strategy is to simplify the product architecture, limit the number of screws used by just sketching where materials are incompatible and having a troublesome connection. When done properly, this leads to better liberation and lower assembly costs at the same time, see for example [Bakker et al. \(2012\)](#). A drawback here is that very general design rules are not targeting the specifics and heterogeneous nature of many electronic products, which requires making different design compromises in a tailored way. See [Stevels \(2007\)](#) for a compilation of many different cases.
- As an example of the second approach, the GREENELEC project ([Balkenende et al., 2014](#)) conducted a range of redesign tests for LED lamps, LED TVs, and medical displays based on extensive analysis and actual shredder tests. Various design guidelines are derived to improve the selection of materials, the connections between these materials and the liberation of the electronic components. The project displayed various actual product improvements that after redesigning made it into the market.
- Regarding the third approach, one of the lessons of [Balkenende et al. \(2014\)](#) is that more detailed recycling tests and process simulations may provide valuable design information. One important constraint here is the availability of information from the electronics industry regarding product chemical content. For improving designs, the position of the materials by Full Material Declaration and Bill of Materials data is crucial. Commonly, the combined information of material composition and exact location is not available. Such information should become more widely available than what is observed nowadays to increase transparency on product content, as well as to improve product designs and to enable more advanced recycling assessments.

5.8.2 Green public procurement

A design feedback possibility that is not always considered is green public procurement (GPP):

- How can green procurement and government asset management contribute?

Authorities are an important buyer of electronics and commonly of office IT equipment in particular. For emerging and established countries, a relevant eco-design and Design for Recycling incentive may also come from green purchasing. For the EU a GPP handbook exists ([European Commission, 2016](#)), which includes primarily energy requirements for IT equipment.

The area of green procurement has been explored substantially in the United States. The EPEAT program ([Green Electronics Council, 2018](#)) is used by government procurement programs worldwide and focuses more on electronics products. The criteria include more than design for recycling considerations only, with product longevity, substance management and reuse, repair, and recycling aspects covered as well. From a practical point of view, the US government online procurement tool provides a useful overview of products available as well as the government practices, requirements, and case studies ([SFTool, 2018](#)).

Finally, since authorities are also a generator of discarded e-waste, paying attention to proper collection and treatment of the own discarded assets and in some cases using these for collection and recycling pilots in the case of starting countries makes sense. Here, there is also an important risk mitigation element to be noted. It is detrimental for the development of national e-waste policies when illegal trade and substandard recycling of own government assets is exposed to the general public.

5.8.3 Information to recyclers

- What product information do recyclers need?

In the European Union still only attempts are made to arrange for the information flow from producers to recyclers on new items placed on the market under the scope of the EU WEEE Directive – Article 15 (European Parliament and Council, 2012). Ideally, a feedback loop is created to inform recyclers when and where to expect troublesome designs, specific substances and components of concern, and more general recycling and preparation for reuse information. For this purpose, as an example the I4R platform has been created (I4R platform, 2018) in Europe. Per collection category the platform provides example products and information about which substances and components potentially have hazardous content and need to be selectively removed. The information however is very generic for the main product groups and does not contain detailed product dismantling data, nor repair nor composition information, nor information about changes in product compositions over time. Therefore, the actual usefulness of the information for everyday recycling practices remains to be seen. It is recommended to recyclers in emerging and established countries to investigate these developments for own financial planning and technical adaptation of recycling processes for the future products. One possibility to do this in the recycling industry itself is to conduct dedicated treatment trials, by sorting out the youngest products, which are always present in limited shares in the return streams, and analyze the material composition to determine the value, concentrations of key substances, and newly appearing materials that may hinder the existing recycling processes in the future.

5.9 CONCLUSIONS

The national e-waste development approach as presented in Chapters 2–5 has many advantages for setting up efficient take-back systems. The most important benefits of the proposed **comprehensive and à la carte** e-waste development cycle are described by six keywords, which are to be kept in mind when dealing with complex matters of e-waste:

- **Focused** and goal oriented: Due to the complexity of the e-waste problem, the development goals differ per country and change over time. The iterative approach allows focus on the respective goals.
- **Fact based**: An independent fact-based approach allows for more neutral decision-making processes, which is crucial since interventions are affecting many different stakeholders and economic interests and provide for more eco-efficient e-waste system development.
- **Flexible**: Setting up and operating a take-back and treatment system is a complex operation in which there is a lot of “learning along the way.” Simultaneously, external developments like new technical and

scientific progress and market price changes have a big impact. Therefore, take-back systems require more “organic” and iterative development compared to existing linear manuals and guidance documents available so far.

- **Faster and feasible:** By not attempting to fix everything in one round, a faster and more tailor-made process supports timely implementation under widely varying contexts. It also improves the feasibility by concentrating scarce resources to the most pressing issues.
- **Forward looking:** Applying the iterative approach of the e-waste development cycle provides perspective plus preparation time to achieve further reaching goals to be tackled in the next development round.

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