European Commission

ENTEC

Energy Transition Expertise Centre

Terms of Reference Competitiveness of System Integration Elements

Terms of Reference - Competitiveness

Consortium Leader

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1 Initial request of the EC

1.1 Status quo

1.1.1 Background information on Competitiveness Progress Report

Since 2020, as per the Energy Union Governance Regulation[1], the European Commission publishes an annual Report to assess whether clean energy technology development is on track to deliver the EU's long-term energy and climate goals and to map the competitiveness of the EU clean energy industry[2].

As competitiveness is a complex and multifaceted concept which cannot be defined by a single indicator[3], the Competitiveness Progress Report (CPR) proposes a set of widely accepted indicators capturing the entire energy system (generation, transmission and consumption) and analysed at three levels (technology, value chain, and global market). [Table 1]

As of 2022, the CPR will build on the Clean Energy Technology Observatory (CETO), and Administrative Arrangement (AA) between JRC and DG R&I, in close cooperation with DG ENER. CETO will provide the evidence-based repository needed to support, amongst other deliverables, the report. As part of CETO, the JRC will publish annual in-depth technology development and competitiveness reports on a wide number of relevant technologies and systems.

CETO will produce annually a series of reports on the technologies listed below (either individually or in clusters) addressing the following main themes: technology maturity status, development and trends (2030 –2050 and beyond); value chain analysis and global market and EU positioning.

- Advanced biofuels;
- Batteries;
- Bioenergy (solid biomass and biogas for heat and power and for intermediate carriers);
- Carbon Capture Utilisation and Storage;
- Concentrated Solar Power and Heat;
- Geothermal Heat and Power;
- Heat Pumps;
- Hydropower & pumped Hydropower Storage;
- Novel Electricity and Heat Storage Technologies;
- Ocean energy;
- Photovoltaics
- Renewable fuels of non-biological origin (other);
- Renewable hydrogen;
- Solar fuels (direct);
- Wind (offshore and onshore).

Out of the above list, the CPR will present key findings on technologies selected according to the following criteria:

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1 Article 35 (m) of Regulation (EU) 2018/1999

2 2020 edition: Progress report on competitiveness COM(2020)953 | Clean energy transition - technologies and innovations report, accompanying the report on progress of clean energy competitiveness SWD (2020) 953. 2021 edition: Progress report on the competitiveness of clean energy technologies COM(2021)952 | Staff Working Document(2021)307 parts 1-5.

3 For the purpose of the report, competitiveness in the clean energy sector is defined as the capacity to produce affordable, reliable and accessible clean energy through clean energy technologies; use clean energy productively; and compete in energy and energy technology markets, with the overall aim of bringing benefits to the EU economy and people.

- Criteria 1: technologies with the largest potential in terms of contribution to the 2030 energy and climate targets
- Criteria 2: key technologies highlighted in EU energy and climate policy

Table 1: Indicators underpinning the competitiveness progress report

Part 1: Macro section	**Part 2: Technology-specific section**		
Macro-economic analysis (aggregated, per MS and per clean technology)	1. Technology analysis Current situation and outlook	2. Value chain analysis of the energy technology sector	3. Global market analysis
Energy and resource Trends - Primary and final energy intensity and final energy consumption - Share of RES and targets - Trade balance including energy import dependency [electricity, fuel, carbon] [EU and per MS] - Carbon pricing [EU vs world's biggest economies] - Industrial electricity and gas prices - Turnover share in energy (clean, Fossil Fuel) sector (vs whole EU economy)	**Capacity installed, generation/production** (today and in 2050)	**Turnover**	**Trade (imports, exports)**
COVID-19 - Impact of COVID-19 and recovery	**Cost/Levelised Cost of Electricity (LCoE)**[4] (today and in 2050)	**Gross value added growth** Annual, % change	**Global market leaders vs. EU market leaders** (market share)
Human Capital - Employment in clean energy and share in energy sector [EU vs RoW] - Skills and training aspects - Gender statistics - Labour Productivity - Energy Poverty - Impact on "conventional fuels" employment	**Public R&I funding (MS and EU)**	**Number of companies in the supply chain, incl. EU market leaders**	**Resource efficiency and dependence**[5]
Research and Innovation Trends - Public and Private R&I investments - Patenting and High-Value patents EU and per MS	(Suggested additions and changes) **Private R&I funding** (venture capital (value and number of deals) (incl. sources backing) VC), energy companies)	**Employment in value chain segment**	

[4] And – if available - Levelised Cost of Storage (LCoS).
[5] Segments of the value chain that depend on critical raw materials.

Part 1: Macro section	Part 2: Technology-specific section	
The EU Climate Tech Landscape [vs major economies] - Venture Capital and Innovation Funding in Climate Tech (and energy domain) + digital domain depending on availability - New generation funding solutions - Innovation ecosystem actors - Tech transfer and commercialisation	**Patenting trends** (incl. high value patents)	**Energy intensity/ labour producti-vity**
NEW: - **Sustainability and circularity challenges** of clean energy technologies; **(critical) raw material dependency** of the EU clean energy sector and impacts on the EU competitiveness	**Level of scientific publications** (Suggested additions and changes: *Share of EU publications among the top 10% most cited in the field; participation in co-operation and networks in the other EU MSs; participation in new clean energy networks/alliances, etc.)*	**Community production** Annual production values
NEW: - The role of systemic change (e.g. the digitalisation of energy) on the clean energy transition from a social and economic point of view.		
NEW: - The global clean energy competitive landscape		

Source: own composition, based on information from the EC

1.2 Output of ENTEC

To ensure continuity with the 2020 and 2021 editions, the CPR 2022 will build on the same set of competitiveness indicators as in 2021, and at the same time it will:

- further improve and consolidate the evidence-based methodology (both in Part I and Part II as per the Table 1)
- cover new emerging areas, depending on data availability

The above-mentioned points will be elaborated in the framework of either an exploratory or in-depth EnTEC study. The exploratory study will describe but not analyse the SIA, as their definition, scope and delineation to each other is the prerequisite of an in-depth study.

1.2.1 Competitiveness at the macro level (EU Clean Energy Sector)

On a macro-economic level, the focus is on factors that influence the competitiveness of clean energy technology in the EU and is not yet captured by the existing approach. Thus, the key question is: **is there anything missing with respect to the indicators on "overall competitiveness of the EU clean energy sector?"** Some factors at the macro level are part of the

monetary and fiscal policies, education policies, general market access for foreign investors, general access and availability of (scarce) resources. For example:

- investments and subsidies into clean energy technologies – incl. RoI, risks factors,
- skilled professionals, labour productivity, technology knowledge, productivity and GVA,
- economic analysis of the clean energy competitiveness: e.g., influence of rising energy prices, influence of foreign industrial policies.
  Sustainability and circularity challenges of the EU clean energy sector/clean energy technologies; **(critical) raw material dependency** of the EU clean energy sector and impacts on the EU competitiveness

To understand how relevant these factors are for the energy transition, the EC would also like to understand what is the impact/support of these aspects or factors on goals of the EGD package (Fit for 55).

1.2.2 System Integration Areas (SIA)

The Clean Energy Technology System Integration, and more specifically, this ToR includes an option to assess the maturity status and development trends for technical integration of clean energy technologies/solutions in the energy system.

The reference framework is the Communication on EU Strategy on **Energy System Integration.** The analysis could cover the following optional technology fields:

- **building-related clean energy technologies**;
- **digital infrastructure for smart energy system**;
- **industrial and district heat & cold management**;
- **off-grid energy systems**
- **transmission- and distribution-related technologies**;
- **smart cities**;
- **innovative energy carriers and energy supply for transport needs**.

In addition to these seven identified SIA, many other energy system integration areas could be treated in such report, such as integrated housing ecosystem (focus on skills and interaction between professionals, like construction workers, installers, architects), etc. However, the seven SIA seem to present a broad scope of technologies and applications, which will already provide a good sense of the required indicators, and evaluation of the need to develop further the concept of SIA for the next revisions of the competitiveness reports.

1.2.3 Suggested Approach

EnTEC is expected to perform a 6 months' in-depth study using a two-step approach:

1) [Indicator based]
2) Methodology development on how to perform the analysis [including to the extent possible indicators of table 1 and development of new indicators to assess competitiveness]
3) Data collection and reporting based on the developed methodology

2 Approach

2.1 Task 1: Scoping of System Integration Areas & methodological framework for elaborating SIA

With the increasing transformation of the energy system towards a sustainable and low-carbon/carbon-free energy system, the necessity to integrate energy services and usages across all sectors has become more important. In line with further technological developments in different applications, the degree and areas of integration are changing and growing over time. Hence, in a first step we elaborate an analytical framework that helps identifying and scoping areas where system integration becomes relevant, for example between

- households and industries, e.g., waste heat in the heating sector used for DHC in households
- efficiency and renewable in heating or transportation, e.g., integrated building envelopes or digital solutions and appropriate heating systems or energy generation,
- different industries such as IT- and energy industry (digital services), automotive industry (storage solutions)
- between heating & cooling and the power or mobility sector
- actors from industries, communities and private citizens or generators and consumers e.g., as flexibility providers for the energy system

In a second step, we elaborate an analysis framework that outlines how we proceed when conceptualizing indicators and depicting the competitiveness of the topics identified.

For each SIA – option we appoint a **SIA Lead**, having the required technical background and network to carry out the scoping, design the general and detailed concept and collect the data. The seven identified SIA options are:

SIA 1: Building-related clean energy technologies;

SIA 2: Digital infrastructure for smart energy system;

SIA 3: Industrial and district heat & cold management;

SIA 4: Off-grid energy systems;

SIA 5: Transmission- and distribution-related technologies;

SIA 6: Smart Cities;

SIA 7: Innovative energy carriers and energy supply for transport needs.

Objective:

- general scoping of the SIA in the inception phase (until/during kick-off). Identification of areas or elements (SIA) that are crucial for system integration and are not yet included in these ToRs;
- design the common methodological framework to be used for the SIA design, indicators elaboration (concept), and data collection. This general framework will be adapted and detailed for each SIA (under Task2);
- scoping each SIA, which interacts with other areas or energy system component(s), to include all relevant components along the supply chain. The scoping will form the basis for the detailed design and indicators identification;

Approach:

We suggest to apply a three-step approach:

- general scoping
- methodology design
- scoping of the SIAs and elaborating an analytical framework for each SIA

Output:

- scoping and general concept of SIA (during inception phase);
- methodological framework for all SIA and detailed scoping for each SIA (to apply under Task 3)

2.1.1 Task 1.1: General scoping of the SIA

In the starting/inception phase of the project, a general high-level scoping will take place. A general guidance on this will be provided in advance to the project kick-off meeting. The kick-off meeting will include a brainstorming session to identify areas or elements (SIA) that are crucial for system integration {but not yet included}. The suggested SIAs are options that might be analysed in detail if a clear definition, scope and delineation of the SIA from others is feasible.

{In case an important SIA is identified and validated by the finalisation of the kick-off's minutes, **one additional potential area** of system integration (SIA) will be selected in addition to those already identified, based on its potential significance for the energy transition, i.e., potential contribution to decarbonisation of the energy system, but also the way it complements the seven identified SIA.}

2.1.2 Task 1.2: Designing a common methodological framework

- Elaborate a common methodological framework for the scoping, design and indicator identification to be used for each SIA. It will provide the general guidance on the way to scope a SIA (e.g., on the way to describe the elements/components, and their interactions), to design an SIA (e.g., on the way to identify areas where indicators are needed), and to identify and describe the indicators (e.g., on the way to describe data sources). This framework is required to ensure coherence between all SIA descriptions, considering they are all different in concept.
- Conduct a final workshop to set the common methodological framework; participants will be SIA leads and possibly team experts of the topics (SIA). The workshop aims to elaborate and validate the common methodological framework.

This common methodological framework will guide the SIA to properly identify the elements to be analysed, keeping in mind the competitiveness angle and the climate political agenda. It should help identify the main elements to consider, from a more general (overview) to a particular view (specific elements to consider). It will also ensure that the justifications and logic behind those selections will be clearly developed, especially liaising with the contribution to the climate policies.

It will also ensure that each SIA addresses "cross-cutting issues", such as behavioural aspects and (critical) raw materials in a comprehensive way, complementing the macroeconomic indicators.

2.1.3 Task 1.3: Scoping the SIA and designing their general concept

- Literature review on system integration and interactions, globally and for each identified SIA;
- Matrix-approach to identify interacting elements that connect different systems and sectors relevant for the energy transition. Each SIA lead will conduct his own analysis based on the common methodological framework, and internal workshops will be organised to exchange views and practices, and define a common approach. If needed, discussions in working groups will be organised, to develop the scoping concepts, i.e., entire scoping of each SIA covering the

main connecting elements to other SIAs and relevant energy system components. Such elements could be:

- infrastructure;
- intermediates, materials, resources or references useful per SIA such as technical components;
- institutional aspects (co-operations, networks, policies) impacting the SIA;
- knowledge and skills.

In case that during the scoping process of SIAs a clear definition, scope and delineation of the SIA is note feasible, the study will become an exploratory study and Task 3 will not be elaborated.

2.2 Task 2: Identification of further indicators on a macro level

Based on the existing approach and outline of the analysis on the competitiveness of the EU in clean energy technologies, we examine whether further indicators should be added, such as risk aspects on a macro- or meso-level (sector), e.g., geopolitical aspects, dependencies, impacts on sustainability or EGD, pace of recovery, human capital and qualifications, value-added, global research and innovation, and the global funding landscape.

Objective:

- Concept of macro competitiveness and indicators in addition to those of the existing approach (and areas);
- Data for a limited number of indicators (e.g., three, to be defined at the kick-off meeting).

Approach:

- In a first step, we identify relevant features to depict the overall competitiveness of the EU at macro-economic level – and verify if there is anything missing with respect to the indicators with regard to "overall competitiveness of the EU clean energy sector";
- In a second step, we check, collect and analyse the respective data.

Output:

- General concept and additional macro indicators
- Data sources and report

REM: If no new macro indicators are deemed relevant, we will justify how the current CPR report addresses all SIA in a comprehensive and exhaustive way.

2.2.1 Task 2.1: Elaboration of concept

The main steps will be:

- conduct **analysis of reports and studies** that look into different analyses and approaches to outline competitiveness,
- compare results of literature with the existing concept of macro-economic competitiveness indicators of CPR
- based on the SIA scoping, evaluate to which extent the SIA concepts are bringing new macro considerations that should be monitored, due to their impact on competitiveness.
- **elaborate a general concept** of competitiveness applied to the clean energy technology and derive key macro indicators and compare it to the existing concept. This concept accounts for the main drivers of competitiveness on a macro-level, e.g., including factors affecting returns

on investment, investment or operation risks, such as energy prices, foreign industrial and trade policies, geopolitical aspects,
- conduct an internal **workshop** to discuss approaches of competitiveness analyses, and outline analytical frameworks (theories or concepts),
- suggest **further indicators** with their respective data sources, paying special attention to the indicators marked as "NEW" in Table 1 of the macro-economic part.

Additional suggestions to be further investigated in the 2023 report will be discussed during the Task 2 activities.

2.2.2 Task 2.2: Data collection and analysis

The main steps will be:

- Check data availability, eventually adjust concepts (probably interactive process), decide which data will be collected
- Collect the respective data and reporting

2.3 Task 3: SIA detailed concept and indicators

Each SIA lead will have the responsibility of his own topic, and will lead the required tasks, while the Project Manager will ensure coherence and common approaches between all SIA (as defined in Task 1).

Objective of Task 3:

- Elaborated and detailed methodology to assess the EU's competitiveness of each SIA;
- Data collection and analysis.

Two-step approach for each SIA:

- Elaboration of indicators, including:
  - Adjustment of the methodological framework to specific aspects of the SIA;
  - Identification of relevant indicators. A maximum of 5 to 10 specific indicators will be defined per SIA;
- Collection of the data:
  - Collect the data for the indicators;
  - Analyse the data;
  - Draft the SIA-specific report section.

Output of Task 3:

- Detailed concept and identification of indicators (methodology)
- Data sources, data collection and report on competitiveness of EU compared to relevant countries and regions

2.3.1 Task 3.1: Elaboration of SIA indicators/concepts to assess competitiveness

Approach to derive indicators:

1) Apply and fine-tune the methodological framework of Task 1 to the specific SIA, through

- literature review and expert interviews to identify potential technological components, detail the interactions with other sectors and energy system components, identify organisational or regulatory issues that are relevant to foster competitiveness of this SIA;
- describe current situation (knowledge and indicators) and outline "ideal" situation, i.e., a strong competitiveness of EU and derive indicators;
- describe the (set of) indicators and verify their expressiveness and applicability; conduct expert talks and interviews where required, group discussions or workshops;

2) while it should be aligned to the common methodological framework (across all SIA), the detailed concept and underlying methodology should be specific and adapted to each specific SIA, to ensure an appropriate coverage of all SIA components;

3) check data availability, quality and sources;

4) adjust methodology according to data availability. This will be an iterative process between Tasks 3.1 and 3.2.

Table 2: Overview of SIA topics

	SIA Topic	Description / draft scoping
SIA 1	**Building-related clean/smart energy technologies**	e.g., prefabricated building components, energy efficient lighting, building-integrated PV, heat pumps
SIA 2	**Digital infrastructure for smart energy system**	e.g., enabling technologies and infrastructures facilitating data access and data exchange across the energy system including smart meters, home energy management systems, smart charging and V2G, smart heating
SIA 3	**Industrial and District Heat & Cold Management**	e.g. industrial process operating at high temperature level managing internal heat recovery and temperature/parameters optimisation; 5th Generation DHC operating at very low temperature level, adapting operation to the precise needs, and optimising with the available resources (e.g various RES) while providing flexibility services
SIA 4	**Off-grid energy systems**	such as prosumers - feeding in the remaining energy (connected to the grid); off-shore not connected to the grid producing H_2 or derivates; and off-shore in general (with the more complicated grid connection)
SIA 5	**Transmission- and distribution-related technologies**	including HVDC, Superconductors, Power Electronics, LVDC & MVDC technologies, dynamic line rating, compensation devices, etc.
SIA 6	**Smart Cities**	extent, to which cities as subnational entities have local strategies for the transformation of the energy system, referring to points of SIA 1, 2, 3, 4 and other relevant matters in subnational jurisdictions, e.g. the existence of (subnational) smart city and decarbonisation plans, the use of digital technologies to enable the energy transition, such as mobility as a service platform.
SIA 7	**Innovative energy carriers and energy**	Focus on bio & e-based fuels for the aviation and shipping industry

	SIA Topic	Description / draft scoping
	Supply for transport needs	

2.3.2 Task 3.2: Data collection and analysis

Approach to collect data:

- Verify requirements for indicators (e.g., quality, range, coverage, time periods);
- Collect data (Excel-based);
- Analyse data and draft the respective report section per SIA.

2.4 Task 4: Reporting and project management

Based on the outputs of Task 1-3, a study report will be developed including the concepts, data and data sources as well as the results of the analysis of SIA competitiveness. This will be accompanied by delivering an Excel-based data-set of the results of Task 1-3.

3 Deliverables

The results of the study will be presented in the following deliverables:

Table 3: Deliverables

Deliverable number	Deliverables in-depth study	Date	Description
D1	Draft first interim output Task 1+Task 2: Draft scoping and methodology design	Mid of March 2022	Word docx
D2	First interim output Task 1+Task 2: Finalized Scoping and concept	Early April 2022	Word docx
D3	Second interim output Task 1, 2, 3: Compilation of first data (by SIA) including gap identification and first interpretation	End of April 2022	Word docx and Excel-based data-set
D4.1	Draft final report	End of May	Word docx
D4.2	Final report	Mid of June	Word docx and Excel-based data-set
Deliverable number	**Deliverable exploratory study**	**Date**	**Description**
D1	System scoping and concept	June 2022	Word docx

The deadlines of draft and interim deliverables were made under the assumption of a one-week feedback period by the Commission after delivery of the draft documents.

4 Time and work planning

Start of the project and kick-off meeting: 24 of January 2022

1st Project meeting: second half of March 2022

Decision on the scope of the study (exploratory or in-depth): April/May 2022

2nd Project meeting: second half of April 2022

3rd Project meeting: end of May 2022

Final Stakeholder Workshop: June 2022

Table 4: Start and completion date per task/ Lead, contribution

Deliverables	Start	Completion	Lead	Contribution
Project coordination	Beginning of January 2022	June 2022	Trinomics	
Task 1	January 2022	Early April 2022	ISI	SIA leads
Task 2	Mid-January 2022	End of April 2022	ISI	Trinomics
Task 3	March 2022	Mid of June 2022	SIA leads	All
Task 4	Beginning of January 2022	End of June 2022	Trinomics	All

Figure 1: Work plan and schedule

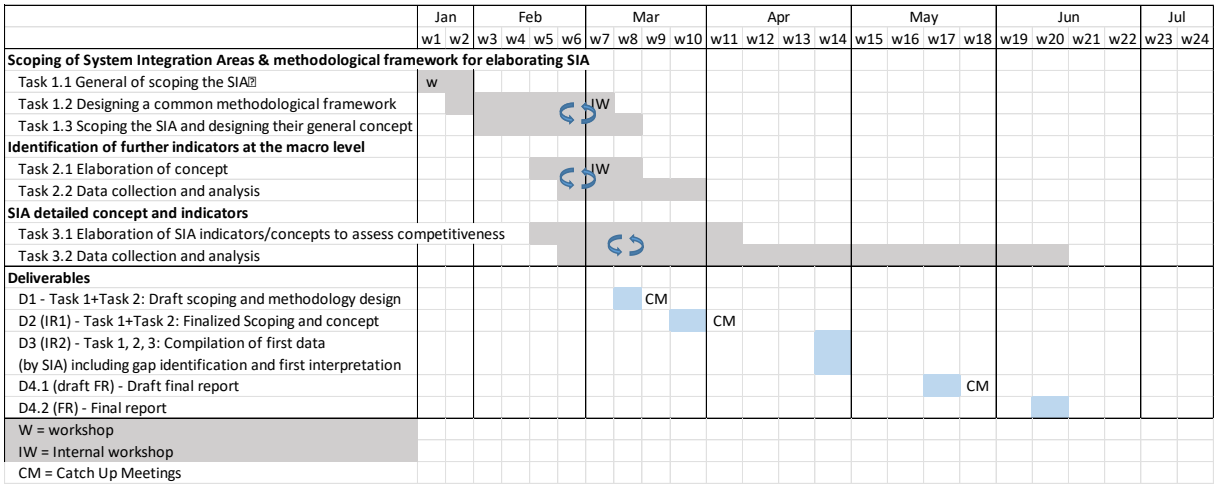

Table 5: Potential SIA lead by partner

SIA Leads	SIA Topic	LEAD	
SIA 1	**Building-related clean energy technologies**	Guidehouse	Kjell Bettgenhaeuser kjell.bettgenhaeuser@guidehouse.com
SIA 2	**Digital infrastructure for smart energy system**	ISI	Marian Klobasa Marian.Klobasa@isi.fraunhofer.de
SIA 3	**Industrial and District Heat & Cold Management**	Trinomics	Jessica Yearwood jessica.yearwood@trinomics.eu
SIA 4	**Off-grid energy systems**	ISI	Julia Panny julia.panny@isi.fraunhofer.de
SIA 5	**Transmission- and distribution-related technologies**	Trinomics	Ondrej Cerny Ondrej.Cerny@trinomics.eu
SIA 6	**Smart Cities**	IQIB (*)	Tanja Woronowicz tanja.Woronowicz@iqib.de
SIA 7	**Innovative energy carriers and energy supply for transport needs**	Trinomics	Marine Gorner Marine.Gorner@trinomics.eu

(*) IQIB is not part of the consortium

Main counterparts

	Counterparts ENER	Counterparts RTD	Counterparts JRC
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	Counterparts ENER	Counterparts RTD	Counterparts JRC
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SIA 6 – Smart Cities	Georg.houben@ec.europa.eu		Giulia.ulpiani@ec.europa.eu
SIA 7 – Innovative energy carriers and energy supply for transport needs	Giulia.serra@ec.europa.eu	Thomas.schleker@ec.europa.ec	Nigel.taylor@ec.europa.eu

5 Resources

Table 6: Planned resources exploratory study

Task/resource in depth	Resource needs in days	Share of total resources in percent
Task 1 Scoping & methodological framework	25	47%
Task 2 Identification of indicators on a macro-level	10	19%
Task 3 Coordination and alignment of institutions and SIA experts	10	19%
Task 4 Reporting and project management	8	15%
Total	**52**	**100%**

or

Table 7: Planned resources in-depth study

Task/resource in depth	Resource needs in days	Share of total resources in percent
Task 1 Scoping & methodological framework	25	10%
Task 2 Identification of indicators at the macro-level	26	10%
Task 3 SIA detailed concept and indicators	183	70%
Task 4 Reporting and project management	26	10%
Total	**260**	**100%**

6 List of tables

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