Open Risk White Paper

Sustainable Public Procurement

Part I: Emissions Attribution

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Summary

Public Procurement represents a major opportunity to catalyze the transition of economies towards more sustainable patterns but faces important challenges. We review mechanisms that can help address key pain points through the use of open standards, open data and open source tools. In the first part we frame the overall task of Sustainable Public Procurement as an instance of portfolio management. We outline three distinct information processing pillars that are relevant in this context. We focus here on the task of measuring and attributing greenhouse gas emissions to an existing procurement portfolio.

Further Resources

- The Open Risk Manual is an open online repository of information for risk management developed and maintained by Open Risk.
- The Open Risk Academy offers a range of online courses around risk and sustainable portfolio management, which utilize the latest in interactive eLearning tools.
- The Open Source Repository contains a variety of open source tools and resources.
- More content: Open Risk White Papers and Open Risk Blog

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Motivation

Motivation

> *"It is not so much that humanity is trying to sustain the natural world, but rather that humanity is trying to sustain itself. It is us that will have to "go" unless we can put the world around us in reasonable order. The precariousness of nature is our peril, our fragility."* - Amartya Sen

Governments spend a large portion of their budget provisioning products, services and infrastructure development from the private sector. The OECD estimates that an average of 30% of general government expenditure goes to public procurement in OECD countries and public procurement represents circa 12% of economic output. Every year in the EU, over 250 000 public authorities spend around EUR 2 trillion (around 13,6% of GDP) on the purchase of services, works and supplies. Within the broader public sector the role of local governments is particularly relevant, as it is predicted that by 2050 about 64% of the developing world and 86% of the developed world will be urbanized.

From new roads to tablets for pupils or equipment for hospitals, public authorities are the main buyers in many key sectors such as energy, transport, infrastructure, waste management, social protection, health, defense and education services. This significant economic activity creates a leverage mechanism that can be used to pursue strategic sustainability objectives. Besides the sheer size of public sector expenditure (and corresponding footprint), the objectives and incentives of the public sector position it better to implement sustainability policies compared to purely monetary-profit maximizing businesses.

Incorporating sustainability considerations into public procurement decision-making processes has already become a declared objective in many jurisdictions. Over the last decade there has been significant stock-taking around two particular vectors of anthropogenic change in the biosphere: climate change and biodiversity loss, both fundamental risk factors and threat multipliers. This recognition increasingly spurs the development of policies, legal frameworks and technological and market initiatives.

In European context the European Climate Law writes into law the goals set out in the European Sustainable Deal for Europe's economy and society to become climate-neutral by 2050. The law also sets the intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. Some European countries have set more ambitious targets (2045) for climate neutrality.

Central governments but also local authorities (municipalities) can use their purchasing power to create and sustain demand for new technologies (so called market-pull), and/or guarantee demand for products and services of lower environmental impact.

Green Public Procurement is defined as a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle. This is compared to goods, services and works (with the same utility) that would otherwise be procured irrespective of environmental impact. A number of governments have already adopted GPP criteria and practices (such as tenders with *life-cycle costing*) that incorporate, for example, the neglected costs of GHG emissions.

In practice sustainable public procurement involves making comparisons and evaluations that integrate *both* economic / financial and sustainability criteria (non-price criteria). Acting in parallel with government and/or international regulations such practices incentivize the provision of low-emission solutions and trigger innovation in technology and/or business models through the creation of so called *lead markets*.

Yet reaching long-term sustainability is a complex, multifaceted challenge that faces inertia, vested interests and genuine gaps in capabilities [1]. There is a backlog of missing tools, methodologies, standards, practices and conventions that can help overcome obstacles and accelerate the sustainability transition. This gap applies across the board, both private and public sectors. When combined with the political and economic challenges du jour, it provides an excuse for de-prioritization and further delays.

Reducing costs and improving efficiency via open standards, interoperability, open data, open source code and knowledge sharing can help overcome some of the handicaps. With this bigger picture as backdrop, in this White Paper we explore sustainable public procurement and more specifically Green Public Procurement as a portfolio management task.

We sketch the types of information processing tools that this entails and we discuss a conceptual framework for managing the GHG emissions of procurement activity using techniques as already pioneered in other sectors. As we go along, we enumerate the types of data and software infrastructure that would facilitate implementing sustainable portfolio management processes in local government procurement.

In a previous (more generally applicable) white paper [2] we setup an analytic framework that synthesized a number of existing methodologies and frameworks that are going under the term *Sustainable Finance*. This included *GHG accounting* (inventory) concepts deriving from the GHG Protocol work[3, 4], and *attribution* and *allocation* approaches that have been proposed in the context of recent banking and insurance sector initiatives, see e.g.,[5, 6]. The aim there was to identify and develop a precise common language (including an encompassing mathematical formulation which we skip here) that captures the interlocked variables, indicators and targets in a consistent manner.

Here we want to translate these concepts in the concrete context of Sustainable Public Procurement (SPP), with a focus on GHG emissions. This removes some of the abstraction and introduces details from public procurement practices. The discussion remains somewhat generic, yet links to software implementation provide leads towards specific implementation.

The structure of the paper is as follows:

- In section we review relevant background material. In particular we go into the measurement of Greenhouse Gas (GHG) emissions as the essential new information in GPP context.
- In section we discuss Sustainable Portfolio Management as an integrated practice, outline the main activities involved and their information technical requirements.
- In section we discuss the basics of GHG accounting as they apply in a local government procurement context. This involves the attribution of emissions to procurement contracts on an individual and then portfolio basis. Our focus is highlighting what are informative portfolio views. We discuss the attribution of direct emissions and the challenge of attributing indirect emissions. We discuss standard GHG accounting (inventory) approaches of measuring direct emissions as exemplified e.g., by the IPCC methodologies.
- In section we highlight interesting and relevant open data standards and open source projects in the evolving landscape of tools that can facilitate the implementation of sustainable procurement.

Other technical components not covered here

Not covered in this paper and left for future documentation are important other technical dimensions of SPP. An important such aspect of sustainable public procurement is the *forward-looking setup of targets*, the allocation of so-called *carbon budgets*, the steering of procurement activities but also the monitoring of alignment with declared targets. These are non-trivial tasks, both conceptually and technically, and rely on re-using effectively and correctly climate science and expert-based sectoral analyses and data sets. These forward-looking procurement management tasks differ substantially, both conceptually and in terms of the required information technology from the GHG inventory attribution task we discuss here. Yet they need to be performed in tandem and consistently. In a subsequent paper we will elaborate on topics such as science-based targets, scenario analysis, limit frameworks, "Sustainable" Kraljic Portfolio Matrices and other tools that can help guide the development of more sustainable procurement portfolios.

Ultimately portfolio-wide policies resolve and materialize through the execution of individual procurement contracts. The tools and models relevant at the *contract level*, when engaging in new procurement activity, form yet another pillar in the overall technical landscape. Individual *project-oriented analysis* as exemplified e.g., by the GHG Protocol for Projects[4] and how the procurement life-cycle dots connect together will be the subject of another white paper.

This work forms part of the documentation of the Equinox software platform [20], [21] where many of the above considerations are implemented (See more in Sec.)

Background

The multiple faces of sustainable procurement

The concept of *Sustainable Public Procurement* (SPP), similarly to other novel terms such as *Sustainable Finance* is not yet fully crystallized. The translation of sustainability goals [7] to low-level indicators that can be embedded, tracked and managed in the wide-variety of existing public procurement contexts is still a work-in-progress. The diverse scope of sustainable procurement activities is indicated by the multitude of policy dimensions[8] that come under the umbrella SPP, including policies such as:

- Green Public Procurement (reduced environmental impact, defined broadly of which GHG emission is core consideration)
- Bio-Based Public Procurement (wood-based construction, bio-energy etc.)
- Social Procurement (Adopting ILO criteria for social benefit)

- Social Return On Investment (embedding social considerations, e.g. job opportunities for job seekers)
- Innovation-Oriented Public Procurement (early adoption of innovative solutions)
- Sustainable Food Procurement (preference for local smallholder farmers)
- Circular Economy Procurement (conditions on raw materials, reuse and life span)

Greenhouse gas emissions are but a subset of the many other environmental impacts (other air pollution, soil contamination, water use and pollution, habitat destruction, biodiversity loss from deforestation etc). We will focus on the sequel exclusively on GHG emissions as part of the broader GPP pillar but will use the SPP terminology interchangeably. Some higher-level aspects of GHG emissions oriented portfolio management concept do apply to other SPP areas but the low-level inputs will be different.

The GHG Emissions challenge

In the Paris Agreement signed in 2015, an overwhelming majority of the world population, expressed as 196 countries, agreed to set long-term goals to reduce national GHG emissions and adapt to the impacts of climate change. The recent Glasgow Climate Pact (GCP) [9] expressed alarm and utmost concern that human activities have already caused around 1.1 °C of warming to date, that impacts are already being felt in every region, and that *carbon budgets* consistent with achieving the Paris Agreement temperature goal are now small and being rapidly depleted. To mitigate the worst effects and adapt to the inevitable climate change reality, sovereign and sub-sovereign authorities must (among others) update their overall procurement processes. The first step in this journey is the measurement of emissions.

Measuring actual GHG emissions

In the simplest form, SPP means integrating sustainability related indicators into the various stages of the procurement process as variables that can influence outcomes. In the concrete context of GHG emissions linked to a city's procurement activities this information would take the form of an *inventory* (list or catalog) of emissions associated with procurement activities. Early initiatives such as IPCC [10] and the GHG Protocol [4] have set measurement standards for GHG emissions with specialized frameworks for compiling *GHG Inventories*.

The physical basis of measuring GHG emissions hinges on *identifying* sources and sinks of greenhouse gases linked to procurement related activities and *quantifying* the impact of each. Emission sources or sinks can be classified and grouped in various ways. From a physical mechanisms perspective, GHG emissions are produced by (bio)chemical processes that take place while various substances are in contact with the atmosphere. Emissions subsequently diffuse and mix immediately. Alternative emission mechanisms can be *leaks* of previously generated and stored gases, and changing land-use that modifies the role of vegetation in its natural carbon emission and absorption cycle.

The relevant chemical processes can be classified as either i) *fuel combustion*, where the primary aim is energy generation and ii) *industrial process* emissions, where the primary activity is a chemical or mechanical transformation process. Further, combustion can be classified as either *stationary*, where the combustion process takes place in a geographically fixed facility or mobile combustion, where combustion happens in transit (e.g., in the context of transport of people or goods using cars, ships or planes). The precise taxonomy for classifying sources varies slightly by framework (e.g., [11],[3]). An example categorization might be:

- Stationary Combustion: combustion of fuels in stationary equipment such as boilers, furnaces, burners, turbines, heaters, incinerators, engines, flares, etc.
- Mobile Combustion: combustion of fuels in transportation devices such as automobiles, trucks, buses, trains, airplanes, boats, ships, barges, vessels, etc.
- Electricity Use.
- (Industrial) Process Emissions: emissions from physical or chemical processes such as CO2 from the calcination step in cement manufacturing, CO2 from catalytic cracking in petrochemical processing, PFC emissions from aluminum smelting, etc.
- Fugitive Emissions: intentional and unintentional releases such as equipment leaks from joints, seals, packing, gaskets, as well as fugitive emissions from coal piles, wastewater treatment, pits, cooling towers, gas processing facilities, etc.

As a separate category, *carbon sinks* are processes that absorb GHG gases. Carbon sinks are an important and distinct consideration. There is a remaining natural terrestrial carbon sink that can absorb GO2 which is finite but substantial. It is further affected by economic activities such as changes in land management practices or fertilization effects leading to increased vegetation and soil carbon [12].

In practical application the above categories form a collection of emission sources (and sinks). The ascribed environmental impact of procurement activities derives directly from the association of contracts with such sources or sinks.

An important further sub-categorization that is relevant in practice concerns the *fuel type* that is involved in energy production (diesel, gasoline, natural gas, coal etc.). For each material source or sink, there are *seven GHG gases* mandated under the Kyoto Protocol to be included in GHG inventories, under the United Nations Framework Convention on Climate Change (UNFCCC). These are:

- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Hydrofluorocarbons (HFC's)
- Perfluorocarbons (PFC's)
- Sulphur hexafluoride (SF6)
- Nitrogen trifluoride (NF3)

GHG emissions of the above gas types are generally measured in tonnes. The unit **tCO2** denotes *one tonne of CO2 gas*. Larger emission amounts use *unit prefixes* (e.g.,MtCO2) to denote multiples of tonnes (kilo for a thousand, mega for a million etc.). A simplifying tool for managing emissions across the seven Kyoto Protocol gas species is the concept of *CO2 Equivalents*. The CO2 equivalent is the amount of CO2 that would cause the same *integrated radiative forcing*, a measure for the strength of Climate Change drivers, over a given time horizon as an emitted amount of another GHG or mixture of GHGs. The CO2 equivalent is an adopted yardstick or *unit of measurement* to indicate the Global Warming Potential (GWP) of each greenhouse gas, expressed in terms of the GWP of one unit CO2. GWP's can be used to evaluate different greenhouse gases against a common basis, in this way somewhat simplifying the accounting that must take place.

A given amount of procured economic activity will in general involve a range of technologies and each may produce a range of gas emissions of different type. For a given set of GHG species (e.g., CO2, N2O and CH4) associated with a particular technology (e.g., the use of a diesel engine) the accounting equation sums the total GHG Emissions as the sum-product of an *Emissions Factor* (see below) for each gas and technology, times the *Economic Activity Indicator*, converted to CO2 equivalent. This simplification is in wide use and we adopt it here as well[1]

It is good to keep in mind that the many other aspects of sustainable procurement may not allow such concise summaries of impact. Technologies and standards that can help manage the combinatorial complexity of real modern economies are therefore an important consideration.

The physical measurement basis of GPP

Procurement activities are linked to sources and sinks of diverse gas emissions. Gas emissions are measured using physical units (e.g., tonnes). Global warming potentials create a common yardstick expressed in CO2 equivalent tonnes. The central task of sustainable procurement is to ensure that the anticipated (ex-ante) and realized (ex-post) emissions linked to procurement contracts are within the purchasing authority's targets. ♡

Challenges and Opportunities in SPP

While the conceptual task as sketched above seems at least well defined, accelerating the adoption of SPP stumbles on a number of challenges. For many organizations sustainable public procurement comes as a new and multi-dimensional *constraint*. A list of challenges towards a climate neutral and circular procurement systems for local government would include the following observations [13, 14].

[1] Note that more specific methodologies may be relevant for critical sectors (energy, transport etc).

- The optional nature, lack of prioritization and organizational focus have an impact. Varying political preferences may play a role, as employees of public contracting agencies may be political appointments.
- A cross-cutting issue is the availability, suitability, flexibility and cost of data and related information technology tools.
- Some data must be requested or be supplied by/to market actors and counterparties.
- Implementations can be challenged by their legal complexity, complex policies, added time needed for implementing, lack of credible information for verification etc.
- Purchasers may have limited knowledge and skills around sustainability.
- Difficult to aggregate consistently impacts on the scale of the organization. Mapping climate-related metrics and other environmental impacts to public sector procurement activities not straightforward.
- No consensus or uniform frameworks on sustainable indicators and environmental criteria. Sustainability related risks, while clear and rising, are still incompletely understood and measured.
- Lack of cooperation between various authorities.

A vivid illustration of the novel challenges thrown when pursuing the SPP agenda are the so-called *Scope 3 (or indirect) GHG emissions*. For proper accounting and attribution of responsibility and to avoid pathologies such as *carbon leakage* one requires, in principle, information about the entire network of economic relations (upstream and downstream supply chains). This is a significantly more comprehensive analytic task than what is customary the case in most public and private sectors settings.

Digging deeper into possible root causes that can delay or accelerate adopting of SPP the authors in [8] analyzed data from surveys to identify whether and how much it is *organizational abilities*, *motivation* or *opportunities* that might affect the implementation of SPP. The picture according to this review is rather complex. The presence of *opportunities* was found to affect green public procurement, innovation-oriented public procurement and circular economy procurement but not other types of sustainable public procurement. Opportunity in this context refers to the possibilities available to procurment managers to embrace SPP in their procurement projects. It is argued that an organization open the to development of new ideas and learning something new (thus, exhibiting organizational learning capacity) is likely to achieve faster progress.

While creating an environment that provides opportunities for change is ultimately a governance issue, *chance favors the prepared mind*: leveraging open standards and open source methodologies can have significant positive impact by *removing frictions* from the adoption and refinement of SPP *when* the organizational environment is conducive.

A second strand of opportunities comes from the broader initiatives around sustainability. The context and objectives of the public sector are unique, but in both practical and conceptual issues there are deep linkages with efforts towards sustainability in the private sector. Diverse entities from the private sector: corporations active in different sectors, accounting organization, different strands of the financial system: banks, insurance, institutional investors etc. are all actively developing methodologies and infrastructures to meet the same collective sustainability challenge. There is, e.g., a growing number of public methodologies, open data sources and open source tools that help with accounting and managing GHG emissions in the context of procurements or similar financial activities [15],[16],[6],[5],[17]. These frameworks and tools span a range of online databases, and software and there is an increasing drive to build more enabling infrastructures. We will review in Sec. some representative projects.

Sustainable Procurement Challenges and Opportunities

- There are substantial challenges hindering the adoption of SPP, linked to both novel dimensions (e.g. the need to address supply chains) and a combination of lack of capability, motivation and opportunity to affect change.
- Yet there is common *ground truth*, in terms of e.g., reference data inputs, scientifically determined technology transition scenarios [19], portfolio and risk management frameworks with many other private sector initiatives.
- Open data, standards and open source tools can remove technical frictions and help focus on the harder behavioral challenges.

♡

Sustainable Portfolio Management

In this section we explore the concept of sustainable procurement from the perspective of *Portfolio Management*. Using the thought framework and terminology of portfolio management in not the standard approach in the procurement world. The prevalent description of procurement processes adopts the language of *contract management*. This language offers a granular and pragmatic, *contract specific view* that traces end-to-end the procurement activities along their typical life-cycle:

- The Pre-Award Stage: Identifying procurement needs and objectives, impacts in terms of value for money or environmental impact, determine suitable types of contract, draft terms and conditions, specifications and evaluation criteria, perform market research and analysis, engage with suppliers, select procurement approaches, prepare tender documentation stipulating contract provisions, cancellation conditions, performance and termination provisions etc.
- The Award Stage: Execute the tendering process, evaluate against defined criteria, negotiate outstanding issues, reach final agreement etc.
- The Post-Award Stage: Perform contract management, monitor compliance with contract terms and conditions, track KPI's, pursue possible modifications or amendments etc.
- Closeout: Assess the fulfillment of contractual obligations.

The portfolio dimension is more explicitly in Kraljic's *purchasing portfolio model* that has also been extended in the public sector context [22]. Kraljic's approach introduces a *portfolio segmentation matrix* that classifies products on the basis of two dimensions:

- an external dimension (capturing Supply Risk or Complexity) that considers factors regarding suppliers and the supply market more broadly,
- an internal dimension (Importance of Purchase) that relates to the importance and value impact of a given product or service.

Each dimension is assessed against a number of variables where an overall classification score (low or high) is established. The classification is mostly expert-based (qualitative). The result is a 2x2 matrix and a classification in four categories: Non-critical, Leverage, Bottleneck, and Strategic items. In this approach the overall procurement portfolio can be segmented into procurement categories or codes as follows:

- Strategic Codes: High supply risk, high impact
- Bottleneck Codes: High supply risk, low impact
- Leverage Codes (low hanging fruit): Low supply risk, high impact
- Non-critical Codes: Low supply risk, low impact

We leave the discussion of Kraljic's matrix for a subsequent paper in the series. It is more relevant in the context of forward-looking scenarios and individual procurement criteria rather than attributing impact to the current portfolio. Our working assumption here is that all procurement categories that have material impact are included in the portfolio management activities.

Procurement Portfolio Concept

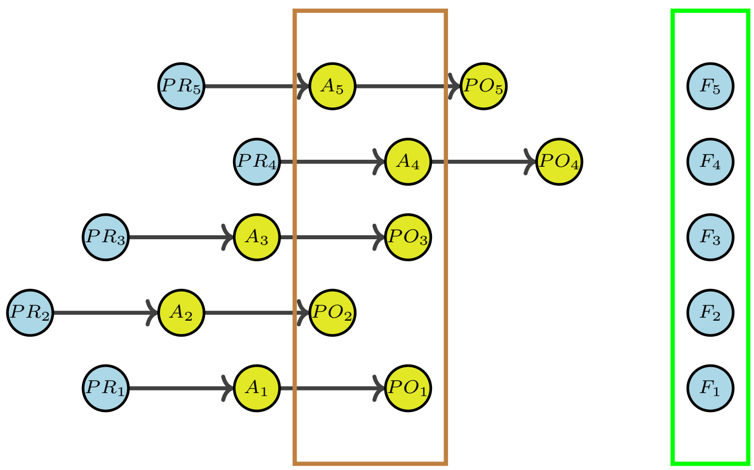
The analysis of the *Procurement Portfolio* helps establish:

- what and how much is purchased
- from who, where and how
- studies of key supply markets
- risk analysis

- sustainability metrics

Such analysis is an important part of procurement best-practices[23]. A procurement portfolio forms through the documentation of the distinct contracting activities of a procurement agent, as they go on establishing relations with counterparties, market purchases etc. Obviously such a portfolio exists irrespectively of whether it is explicitly managed as such. A *contracts database* is maybe the most visible manifestation of a procurement portfolio that is treated as such. Such a database registers relevant documentation and attached data sets on an ongoing basis. This facility is responsible for recording contracts and play an important role in monitoring impacts, both in terms of documenting the estimated impact (at the time of selection and contract award) and the actual impact, after the contract is fulfilled.

Sustainable Procurement Portfolio Management denotes the set of principles, tools, processes etc. that underpin the management of procurements while incorporating the desired sustainability constraints. In comparison to the horizontal, chronological view of contract management we discussed above, portfolio management activities are better visualized by introducing a vertical axis that spans all concurrent procurement activities.



The horizontal *contract lifetime* view where different procurement activities proceed from the pre-award (PR) phase to the award (A) and post award phase (PO) versus the vertical *portfolio snapshot view* (the green box) that encompasses all activities occurring during a certain time window. Expressed in these visual terms, sustainable portfolio management is the set of policies, and steering actions that will transform the procurement portfolio so that on a future date (indicated by the green box), and a collection of new procurement contracts (F) present at that time, the portfolio sustainability attributes fall within a desired target range.

Portfolio management as sketched here is not synonymous with the entirety of procurement management activities. It is rather the *subset* of relevant tasks and functions apply a holistic view on the procurement process. Activities that are typically bundled under portfolio management would be as follows:

- *Portfolio Monitoring* of all contracts that are in the post-award stage. This activity provides performance information to help assess the current state of the portfolio. Such information must cover both the financial and sustainability dimensions (). This task involves among others data collection, data processing and creation of reports. It supports any external (sustainability) *reporting* requirements of the purchasing authority.

- Guide the shape of *new procurement* projects. Use current and past portfolio information to inform the pre-award stages of future procurement so as to shape the *future procurement portfolio.* This is achieved in a number of ways:

  - Perform Scenario Analysis. Formulate portfolio-wide baseline scenarios and forecast the impact of adjusted procurement criteria and policies. Perform *stress testing* and sensitivity exercises.

  - Set Portfolio Limits, allocate budgets and monitor compliance.

  - Improve the Portfolio Structure. For example reduce *concentration risk*, whether to particular suppliers, supply chains, product categories etc.

– Perform overall *procurement activities optimization*, including developing internal measures for holistic evaluation of risk/return.

The portfolio management pillar we focus in this paper (emissions attribution) falls under the first group of activities (portfolio monitoring).

Management Objectives and Strategies

Ultimately authorities need to answer the question: is the region or city more prosperous and sustainable today compared to a year ago, where prosperity means enhanced citizen quality of life that preserves natural capital. For the contracting authority the procurement portfolio forms a subset of its overall sustainability footprint. Depending on any other sustainability oriented initiatives, the procurement portfolio footprint may need to be managed consistently with other direct or indirect impacts. Note also that the SPP mandate is effectively *augmenting* but also possibly colliding with other objectives.

Our narrow task here is to think how management objectives translate into concrete information flows as those needs to be supported by the technical infrastructure. A working hypothesis towards that end is to assume that the portfolio manager will operate under a cascaded *environmental impact budget* that is applicable over a period of time. Given that constraint, they are required to use the available tools and levers towards optimizing procurement activities.

Cities may manage local government emissions via their direct procurement choices as well as developing building and energy-efficiency codes or rules that can lead to changes within city-wide supply-chains that effectively decrease GHG emissions [24]. For example they may pursue preferentially procurement that modifies the technology mix used, help adjust (rebalance) supply chains etc. Cost-benefit analysis to evaluate procurement activities from a sustainability angle may also be a requirement.

The Procurement Ecosystem

To circumscribe the information universe that is involved in pursuing the procurement mandate it is useful to first acknowledge the diverse economic agents involved in procurement:

- The *procurement manager* (buyer), acting on behalf of the public organization or contracting authority with the SPP mandate. Theoretically this implies access to all *own* procurement related data but reality might be less charitable.
- The *contractors*, providers (sellers) of goods, works or services with various sustainability profiles. Their relationship with the purchasing authority provides in principle additional private data (which might costly to produce).
- The *upstream supply chain* of the contractor, which depending on the sector, may also play a significant role in the sustainability profile of the procurement activities. Data for supply chains will be increasingly harder and costlier to collect, the further away from the contractor.
- The *downstream final users* of the procured services in cases where those involve additional environmental impacts. Again data might be hard to collect.
- Controllers, regulators and other stakeholders (e.g., citizens, civic society etc.) that are interested in compliance, transparency etc. These agent will typically require access to data.

The relevance of the upstream and potentially downstream supply chain is what distinguishes and complicates SPP from ordinary procurement as it requires information flows that may not be readily available.

Portfolio Information Layers

The above ecosystem of economic agents forms a set of information layers and data exchanges that provide the raw material and factual basis for any SPP activities. A broad classification of the distinct information layers that provide data for portfolio monitoring tasks would be as follows:

- **The contract data**: Those are the legally binding procurement contracts. They may reference physical assets, technologies, processes, activities etc. and of course the associated financial data. They provide snapshots of the current state of the procurement portfolio

- **The physical assets layer**: This concerns identifiable physical artifacts (buildings, vehicles, land etc.) involved (referenced) in procurement activities - to the extend they have sustainability implications. Physical assets will have (in general) a *spatial profile* which may be important to manage along geospatial data dimension.
- **The technology process layer**: Processes such as physical or chemical transformations are ultimately what produces environmental impact. Information about such processes (and associated emission factor etc.) will be a critical input.

The technology process layer makes heavy use of external reference data. An example of such dataset is the Emissions Factor Database (EFDB). It is a database of various emission factor parameters that can be used in the calculation of anthropogenic emissions by sources and removals by sinks. The EFDB at present contains the IPCC default data and data from peer-reviewed journals and other publications including National Inventory Reports (NIRs). Indicatively, the EFDB database contains circa 18 000 distinct activity / factor entries.

Additional Data Infrastructure and Analytics / Measurement Tools

Besides the above *primary data*, SPP management tasks will call for a number of additional data infrastructure and analytics tools:

- *Historical Data*: Those might be internal and/or external and can help track and record over time the development of procurement and sustainability metrics at contract, counterparty, regional, sectoral etc. levels. This helps establish baselines, understand volatility risk factors.
- *Scenario Analysis and Stress Testing*: This will typically use external sectoral forecasts for various risk horizons (short, mid, long-term) but may also be internally developed scenarios. Portfolio-wide policies and targets will be informed by such analysis.
- *Quality Assurance Data*: Backtesting, verification and validation of past inputs and assumptions, outputs and eventual performance.

In practical implementations of tools (databases) these distinct types of data sources become individual data schemas.

Illustrative Data Schemas

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In the Equinox platform different information layers translate into distinct data models. The app with most expansive data schemas is the Portfolio app. An indicative (not complete) list of data models:

- The Asset schema that captures physical attributes of any assets mentioned in the contract (optional geolocation capability).
- The Contractor schema captures a business profile of the contractor.
- The Emission Source schema that holds emissions related data.
- The Primary Effect schema. In line with GHG Protocol this would be used to enable comparative analysis (versus baseline).
- The Project schema. This is the high-level container for any distinct procurement pursuit (project).
- The Project Activity schema. This captures the economic activity being pursued by the procurement. Together with the emission source data it leads to an impact calculation.

These can be combined to construct different databases and reports as required.

GHG Emissions Attribution

Given the context of an existing procurement portfolio and associated data flows the task now is to assess its sustainability profile which here is assumed to be equivalent to the GHG emissions profile. Calculating a GHG emissions *baseline* snapshot for the current procurement portfolio is the first step of any portfolio management activity. This GHG inventory helps prioritize actions and policies as it highlights *emissions concentration*. The inventory is also the baseline against which to measure future progress. *GHG Accounting* (also named Carbon Footprinting) is a quantification process that aims to integrate a number of analytic approaches towards an objective enumeration of GHG emissions (and absorption). In alternative but equivalent terminology this is named a portfolio-wide GHG emissions *attribution*.

Each procurement contract is characterized by a number of technical and physical characteristics (the technology used, its production capacity etc.) that determine applicable emission factors and production volumes. Calculating a GHG inventory requires compilation of these figures portfolio-wide. Access to such data can be a barrier that either prohibits completing the inventory or reduces data quality in the procurement portfolio overview it produces. In general a procurement manager will have easiest access to so-called Scope 1 data, that is data relating to GHG emissions from activities that the contractor controls directly . If the procurement portfolio being managed involves substantial indirect (Scope 3) emissions, the data must be provided through supply chain counterparties or some other means. This raises the bar as to cost, availability, consistency, completeness and other data quality criteria. A fallback solution is to rely on sectoral statistics (macro data).

Measured Emissions

GHG emission (or absorption) can in principle be measured directly, locally, where the emission takes place, using a sensor near the emitting source. Emissions may be measured through systems that monitor the concentration of GHGs and output flow rate [11]. For example in chemical processes a *stoichiometric ratio* may used to determine the amount of carbon dioxide (CO2) released per unit of carbonate input, and can be expressed as the molecular weight of CO2 divided by the molecular weight of carbonate. Direct measurement may be relevant for major facilities using *Continuous Emissions Monitoring Systems* (CEMS), such as power plants, industrial facilities with large stationary combustion units, or landfills with landfill gas collection systems. In certain cases it may possible to directly detect certain GHG emissions from satellite data [25].

While measured emissions offers the most accurate and unbiased approach (and in a plausible future of IoT devices and sensors may be ubiquitous), direct measurement will in general not be practical or even available as an emissions attribution approach. For this reason practical GHG accounting frameworks envision instead a *menu of possibilities* that are collectively termed *inferred* emissions.

Inferred Emissions

All non-directly measured emissions are inferred or deduced from proxy *activity* data that are converted to emissions following typically linear equations (more activity leads proportionally to more emissions). *Activity Data* are the quantitative measures of the level of economic activity that results in GHG Emissions. Activities producing emissions will in general be associated with some type of independently verifiable economic measure (e.g. meals served, kilometers traveled, housing units built etc.) *Primary* activity data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, mass balance, stoichiometry, or other methods for obtaining data from specific activities that happen the procurement supply chain. *Secondary* activity data include industry-average-data (e.g., from published databases, government statistics, literature studies, and industry associations), financial data, proxy data, and other generic data. Different activities get quantified in different ways. The associated units depend on the type of activity. For example:

- Kilowatt-hours of electricity used.
- Quantity of fuel used.
- Output of a production process (numbers of widgets, volumes or weight of substance etc).
- Hours some equipment is operated.
- Distance traveled by a vehicle.
- Floor area of a building.
- Revenue from some service provision.
- Value of contracts providing a defined service.

There is a hierarchy of recognized GHG measurement methodologies that, in the IPCC nomenclature [10] are called Tier 1, Tier 2 and Tier 3 methodologies. Tier 1 uses default (generic) data and simple equations, while Tiers 2 and 3 are each more demanding in terms of complexity and data requirements. Tier 1 methods are meant to be the simplest to use, rely on globally available sources of activity data estimates. Tier 2 methods generally apply emission and stock-change factors that are based on country or region specific data while Tier 3 involves the most specific activity data and emission factors. The hierarchy of specificity from highest to lowest depends on the context. For a manufactured product it may look like:

- Product-level: GHG emissions for the product of interest.
- Production line-level: GHG emissions and/or activity data for the production lines that produce the product of interest.
- Facility level: GHG emissions and/or activity data for the facilities or operations that produce the product of interest.
- Business unit level: GHG emissions and/or activity data for the business units that produce the product of interest.
- Corporate-level: GHG emissions and/or activity data for the entire corporation.
- Sectoral-level: GHG emissions based on sector averages.

Importantly, different data input options may get assigned different *Data Quality* scores as they embed varying degrees of uncertainty. This way a portfolio report may provide indicators about the reliability of the various analyses.

Emission Factors

GHG Emission Factors linked to activities are *the* central organizing concept in GHG emissions management. They encapsulate the rate at which an economic activity produces emissions. Emission Factors are essentially *technology dependent physical parameters* Emission and they are the tangible representation of the *technology mix* available to an economy. Verified emission factors expressed per physical activity (e.g., tCO2eq/MWh) are issued or approved by a credible independent body such as the International Energy Agency (IEA).

For calculating absolute emissions, activity data are multiplied by a corresponding GHG Emission Factor to derive the GHG emissions associated with a process or an operation. When multiple alternatives exist for the same economic activity they encapsulate concrete possibilities for decarbonization. A sustainability transition path (in simplified terms) implies a rebalancing of economic activity between different emissions factors. Technological innovation in this spreadsheet type representation of the economy is the potential of *materializing new factors* that do not exist in the current portfolio.

Emission factors are by convention positive for produced emissions and negative for sequestered (removed) emissions (sinks). Land-use categories may also have removal factors i.e., the amount of CO2 removed from the atmosphere per unit of activity data (often expressed in hectares). Corresponding to the categorization of activities, there are various categorizations of emission factors: physical emission factors are emission factors associated with a lower-level physical activities. For manufacturing activities that involve material / chemical transformations GHG emissions will be captured by corresponding material or product emissions factors.

Indirect Emissions from Procurement

The GHG Protocol has introduced the important concept of emission *scopes* [3]. While all emissions are measured with one of the methods discussed in the previous section, an important distinction comes from the fact that they might be linked to different economic agents. Each contract in the procurement portfolio has emissions associated with its operations that can be categorized as either *direct or indirect emissions* [26]:

- *Scope 1*: **Direct GHG emissions** are those that occur from *sources owned or controlled by the contractor*. For example emissions from combustion in owned or controlled buildings, plants, vehicles, etc or emissions from sources located within the contractor GHG inventory boundary.
- *Scope 2*: **Indirect GHG emissions** are emissions from the generation of purchased or acquired electricity, steam, heating, or cooling *consumed by the contractor*. Scope 2 emissions physically occur at the facility where the electricity, steam, heating, or cooling is generated. Depending on the energy mix applicable to the grid or grids the contractor operates this will determine the applicable emission factor.

- *Scope 3 Upstream*: All **other indirect GHG emissions** (not included in Scope 2) that occur in the upstream supply chain of the contractor (for example, from production or extraction of purchased materials). Also called embodied emissions.

- *Scope 3 Downstream*: All **other indirect GHG emissions** (not included in Scope 2) that occur in the downstream utilization of the product or service that is being procured.

Specific terminologies for indirect emissions include:

- *Life cycle emission factors* that capture emissions that occur at every stage of a material/product's life, from raw material acquisition or generation of natural resource to end of life. In energy use context, emissions that occur from combusting the fuel and all other emissions that occur in the life cycle of the fuel, such as emissions from extraction, processing, and transportation

- *Cradle-to-gate (or upstream) emission factors* that include all emissions that occur in the life cycle of a material/product up to the point of sale by the producer.

Environmentally-Extended Input Output Data

Life cycle and cradle-to-gate type emissions data can be estimated at the macro level using e.g., official statistics data and acknowledged EEIO tables providing region or sector-specific average emission factors expressed per economic activity (e.g., tCO2eq/€ of revenue or tCO2eq/€ of contracts). Environmentally extended input-output (EEIO) tables and models have become a powerful element in supporting information-based environmental and economic policies. They provide insights into the value of economic transactions between different sectors in an economy, including final output by tracking all exchanges. Monetary IO tables can be extended with environment-related information for each sector, such as its emissions, primary (natural) resource use, and other external effects per sector. The challenge is that the granularity by which one can currently track economic exchanges in such a holistic way is limited to high-level sector and product classifications.

Procurement Emission Intensities versus Emissions Factors

Absolute GHG emissions are *extensive* variables measured, e.g., in tonnes of gas emissions. There are various types of *intensities* that can be defined by suitably normalizing (dividing) absolute emissions using other variables. A **Physical Emissions Intensity** can be obtained by normalizing absolute emissions by an other extensive variable that expresses a non-monetary metric (e.g., amount of school meals served). In the simplest case a physical emissions intensity will reflect a weighted average of the emissions factors we already discussed.

Emissions can also be normalized using economic indicators in which case they are frequently named *carbon intensities*. Managing procurement portfolios using physical emission intensities focuses on the *tangible results of procurement* as opposed to any economic figures. While the terms carbon intensity and emissions factor are sometimes used without distinction it is useful to keep in mind that the former is a top-down aggregate metric while the later is a bottom-up component.

Portfolio Monitoring

The following steps create a hypothetical attributed emissions baseline using contract size, product category (CPV) and indirect, EEIO derived emission factors.

- Defining the procurement portfolio boundaries (what is in scope) and the corresponding contracts that will be tracked. All procurement contracts in scope are grouped as part of a Procurement Portfolio linked to a purchasing authority. This aggregation allows the systematic analysis of both historical and current activities.

- Collecting and collating activity data for each contract in the procurement portfolio, e.g., amounts of energy production or consumption. All procurements pursued by a purchasing organization are modeled as a Procurement Project. Whether this concerns works or supplies of services, procurements always have a defined environmental impact. The type of project is captured via its CPV (Common Procurement Vocabulary) sector.

- Utilizing the CPV code of a contract and a mapping of products and services to NACE sectors one can leverage EEIO databases and attribute GHG emissions to select components of the procurement portfolio (subject to a number a number of conceptual uncertainties).

- Calculating individual and aggregate emissions by applying factors to activity data.

The result of this workflow is a list of emissions contributions from procurement contracts and a total sum of emissions attributed to the entire procurement portfolio. In practice GHG attribution methodologies will also support defining *subsets* of emissions defined by filtering on various characteristics.

Portfolio Reporting Views

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Segmenting the procurement portfolio along various dimensions provides deeper insights over a potentially large and therefore difficult to inspect catalog of procurement portfolio elements. Conceptually this can be expressed as filtering a catalog of indexed emissions contributions.

- By Emissions Scope. The decomposition by emissions scope is an important dimension from a procurement management perspective because it determines responsibility (attributability of emissions) and the ability to influence transition pathways via various incentives or other tools. E.g. it is important to know if a contractor is directly responsible for emissions (and therefore able to influence them) or subject to the profile of upstream suppliers.
- By Economic Sector. Segmenting the inventory by *economic activity sector* (product) is also an important slice because activities and emission factors will in general be more homogeneous within sectors and the dynamics of transition pathways will follow sectoral paths. Any sector classification can be used for that purpose (NACE, CPV, etc.) One potential difficulty is if entities and contracts are active across multiple (sub)sectors.
- By Geography. When the procurement portfolio concerns an extended geographical perimeter the concept of a *spatially defined GHG inventory* becomes relevant. Administrative city boundaries can be represented on a map and various contracts, technologies, emissions profiles and financial information can be added as overlays. A geospatial catalog means that each source or sink is linked to a defined geography. Geographical segmentation is also necessary to address different local technology conditions (e.g., electricity produced by different type power plants).

Explaining Period-on-Period Portfolio Developments

One of the most effective types of portfolio management reports is explaining period-on-period developments. Given a new period of analysis (and thus in general a modified portfolio footprint) the task is to explain how this was obtained from the previous period footprint.In other words, what causal factors link the past with the present. That explanatory approach (sometimes called waterfall analysis) will broadly speaking be in terms of identifying the changing procurement volumes (values of contracts) and the changing technology mix. Such an analysis can be performed for the aggregate portfolio but also any of the segmentations mentioned above.

Open Standards and Open Source Tools

The conceptual discussion of the previous sections can be translated into concrete digital infrastructure and implementations in a wide range of possible configurations. The range of options depends on the needs, the resources available, pre-existing infrastructure and the knowledge and ambition in this direction. A defining aspect is the degree to which the infrastructure will build on interoperable open standards and open source code (versus proprietary implementations).

In this section we review some initiatives and relevant projects. The selection is nowhere near being a comprehensive catalog, the intention is to provide a flavor of the range of possibilities that currently exist. We start with some foundational initiatives:

Minimal Interoperability Mechanisms (MIM)

The broader thrust of *digital transformation* across private and public sector means that cities and regional authorities already have to face the complexities of a burgeoning IT landscape with countless systems collecting and processing data.

Minimal interoperability mechanisms (MIMs) is a concept that has emerged to enable a sufficient level of interoperability for data, systems, and services, specifically in the context of so-called *smart city* solutions.

By facilitating a minimal level of interoperability between different technology stacks, MIMs aim to pave the way for the development of a cohesive market and collaboration centered around solutions, services, and data. For example, MIM2 Data Models aim to support cities and communities to use consistent and machine-understandable definitions of all the entities about which data is being captured in a data ecosystem. The governance around MIMs is by OASC (the Open & Agile Smart Cities & Communities).

FIWARE

While MIM's are about interoperable data models, FIWARE is an Open Source framework of *software platform components* that are using a common API based around Context Data Management. Context Data Management implies a real time framework where sensors and other devices collect data and a *broker* platform, like the FIWARE Orion Broker, which mediates between data producers (e.g. sensors) and context consumer applications (any applications that take advantage of the information provided by the sensors). In the GPP context such infrastructure would provide the raw, low-level, emissions measurement information. This would have to be suitably aggregated (e.g. over devices and/or observation periods) before it can be used for contract monitoring purposes.

Public Procurement Data Spaces (PPDS)

Yet a different aspect of infrastructure is covered by the EU Data Spaces initiative. The European Commission's public procurement data initiative aims to harness the power of data available throughout the EU by promoting the Public Procurement Data Space (PPDS)[18]. The PPDS aims to cut red tape for public buyers and Member States when complying with various reporting obligations, for example on innovative, green and social procurement. Specifically it aims to help:

- create a platform at EU level to access public procurement data scattered so far at EU, national and regional level
- improve data quality, availability and completeness, through close cooperation between the Commission and Member States and the introduction of the *eForms*, which will allow public buyers to provide information in a more structured way
- enable that data can be combined with analytics toolset including advanced technologies in the form of Machine Learning (ML) and Natural Language Processing

eForms

eForms is since 2023 the new notification standard for public procurement procedures in the EU. It is particularly relevant for the ease, quality and flexibility with which one can import contract data into a portfolio management process. The eForms SDK is a collection of resources, models and schemas providing the foundation for building eForms applications. The regulation on Public Procurement that introduced eForms has been drafted, proposed, adopted and published in October 2019, then amended and the amended version published in November 2023.

eForms is part of the Single Market Strategy of the European Commission and will help collect, manage and analyze procurement related data; this will populate a meaningful source of information for Member States to support their initiatives on Public Procurement Governance improvement with amplified efficiency, transparency and integrity. Some aspects that the eForms Regulation is intended to address, are:

- increased information accuracy
- forms simplification
- extended flexibility (e.g. ability to adapt labels to regional preferences, enforce the use of some optional fields)
- closer consistency (among forms and with other documents based on the same standards),
- intensified flexibility with specifications at *Lots* level
- improved governance with identified sellers and buyers, as well as a limited number of policy related information
- balanced transparency-competition aspects with justified private information

- simplified process for Corrigenda publications
- use of a procedure identifier for a better Business Opportunities identification

Open Contracting Data Standard

Somewhat analogous to eForms, but with a broader jurisdictional scope, the Open Contracting Data Standard (OCDS) enables disclosure of data and documents at all stages of the contracting process by defining a common data model. It was created to support organizations to increase contracting transparency, and allow deeper analysis of contracting data by a wide range of users.

SDMX

There are various other non-procurement related open standards that can be used for specific purposes. For example, SDMX, which stands for Statistical Data and Metadata eXchange, is an ISO standard designed to: describe statistical data and metadata, normalise their exchange, and improve their efficient sharing across statistical and similar organisations. SDMX is sponsored by eight international organisations including the Bank for International Settlements (BIS), European Central Bank (ECB), Eurostat (Statistical Office of the European Union), International Labour Organization (ILO), International Monetary Fund (IMF), Organisation for Economic Cooperation and Development (OECD), United Nations Statistical Division (UNSD), and World Bank. While SDMX is used primarily as a dissemination format for statistical data produce by statistical agencies it can be leveraged wherever similar datasets (timeseries etc.) need to be exchanged between independent agents.

Open Sustainable Technology

Next, it is worthwhile mentioning the Open Sustainable Technology initiative. This is an effort to collect and catalog the large and growing number of specialized (domain specific) *open source models, tools and infrastructure* that can contribute towards the sustainability transition.

Last but not least, a description of our Equinox platform that can be tailored to support a diverse set of sustainable procurement workflows.

Equinox

Equinox is both a database and a web application front-end. It works together with tailored data schemas to provide a flexible and powerful Sustainable Finance platform. A key design is to adhere to and implement any regulatory and best-practice initiatives and recommendations. Running an equinox *instance* creates a local (e.g., within an intranet) web server that can then be accessed via any regular web browser. With some additional installation and configuration steps an instance can be also be made available online (cloud servers). Usage can be completely open or via registration. For a running demo instance of equinox one can check out a demo server: Sustainability.Town

In a series of posts we have used Equinox to explore the role of Open Data and Open Source in enabling Green Public Procurement (GPP).

- Part 1 - Overview of the Public Procurement TED dataset
- Part 2 - Identification of Entities involved in procurement
- Part 3 - Attribution of GHG Emissions using the CPV classification
- Part 4 - Green Public Procurement as a Sustainable Portfolio Management

The functionality of Equinox focuses on implementing sustainability related workflows as specified by public standards. This is made possible by a modular structure that re-uses common blocks. An indicative list of applications implemented as proof-of-principle:

- Energy Accounting and in Particular Scope 2 Accounting and Reporting (Electricity)
- Green Public Procurement (GPP) portfolio management (the focus of this paper)
- GHG Accounting Protocol for Projects

- The PCAF coalition's approach to accounting and reporting *mortgage portfolio* GHG emissions
- The PCAF coalition's approach to accounting and reporting *project finance* GHG emissions
- The *Equator Principles* for Project Finance
- The European Banking Authority's Criteria for Credit Risk Assessment of Project Finance under the *Standardized approach for Specialized Lending*

The Open Source Equinox Platform

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Equinox is a versatile, open source, cloud native framework that supports sustainable public procurement using entirely modern approaches and technologies.
In the context of the EU Datathon 2022 the platform has being enhanced to support sustainable (green) practices on a procurement procurement portfolio basis.
It is built using the popular Python language which allows easy integration of machine learning and statistical algorithms.
The platform provides geospatial functionality to allow more intuitive geographical oriented workflows. To this effect it imports geometries from open geodata.
Equinox is still under development.
The repository is available here and both technical and user manuals are being developed and are publicly accessible.
A demo endpoint is live at sustainability.town

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