Expanding the Metrics

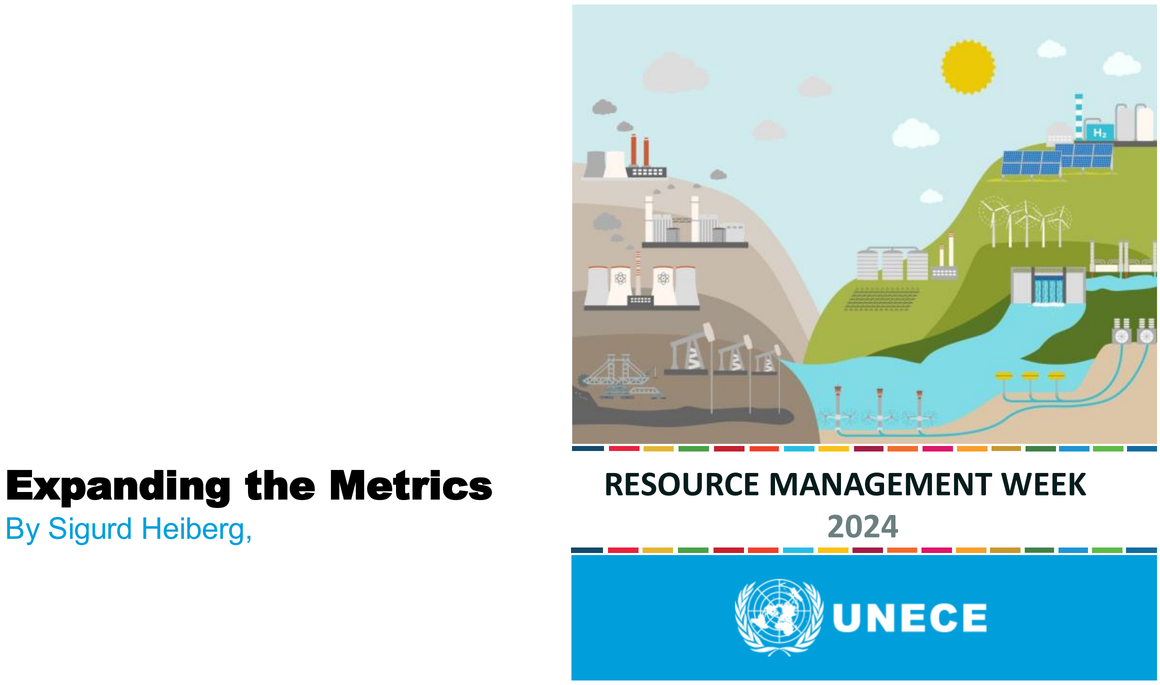

Figure 1

At its 13th session in 2022, the Expert Group noted that the work on commercial applications of UNFC has revealed a need to adjust the formal definition of UNFC to include metrics that projects carry beyond sources and products, e.g., emissions, costs, revenues, energy requirements, other input factors etc. The Expert Group agreed on the use of the metrics that decisions require, both in the form of scalars and as time series (Figure 2). (UNECE, 2022)

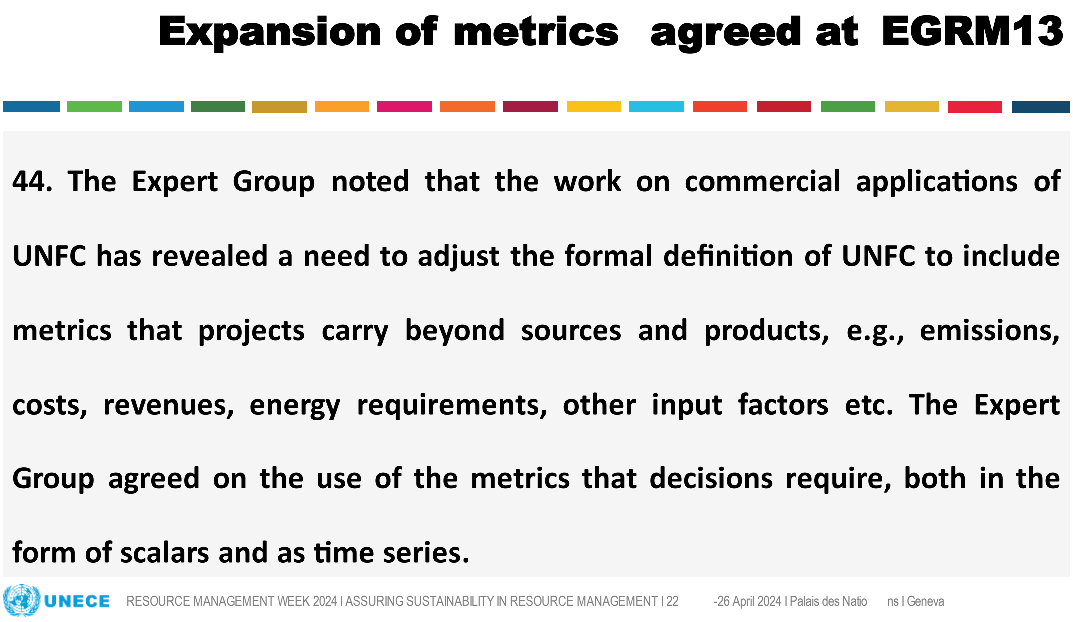

Figure 2

These requirements vary between users and decisions, but some are common across governments, industries and capital allocators.

The UN is uniquely positioned to provide negotiated common metrics through the resolve of ECOSOC to promote the UNFC and UNRMS. These have strong international governance provided by the Bureau of the EGRM representing the EGRM, elected as it is by the UNECE member States and overseen by the Intergovernmental Committee on Sustainable Energy which in turn is overseen by the UNECE Executive Committee and finally by The UN Economic and Social Council.

The metrics are prepared by project teams. This information is integrated into what entities need both as aggregation of project metrics for operations and as transformation into entity metrics honouring the legal rights that entities hold for participating in projects including in the cash flows. Finally, it is assessed by jurisdictions for their use. Host countries and the EU may do more than a direct aggregation of operator's project metrics, given that they are able to see global constraints, missing information, and common mistakes in reporting. (Figure 3)

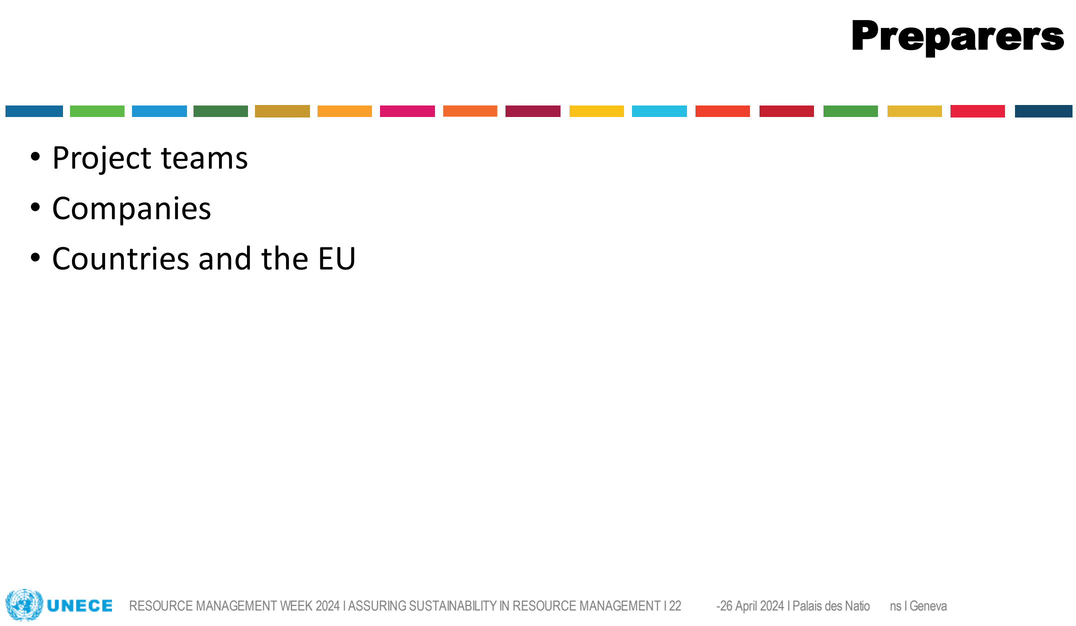

Figure 3

The main uses and users of metrics that projects carry are shown in Figure 4 and explained in the report "Informed Dialogue and Decisions for Sustainable Development – Adoption of the United Nations Framework Classification for Resources" (UNECE, 2024).

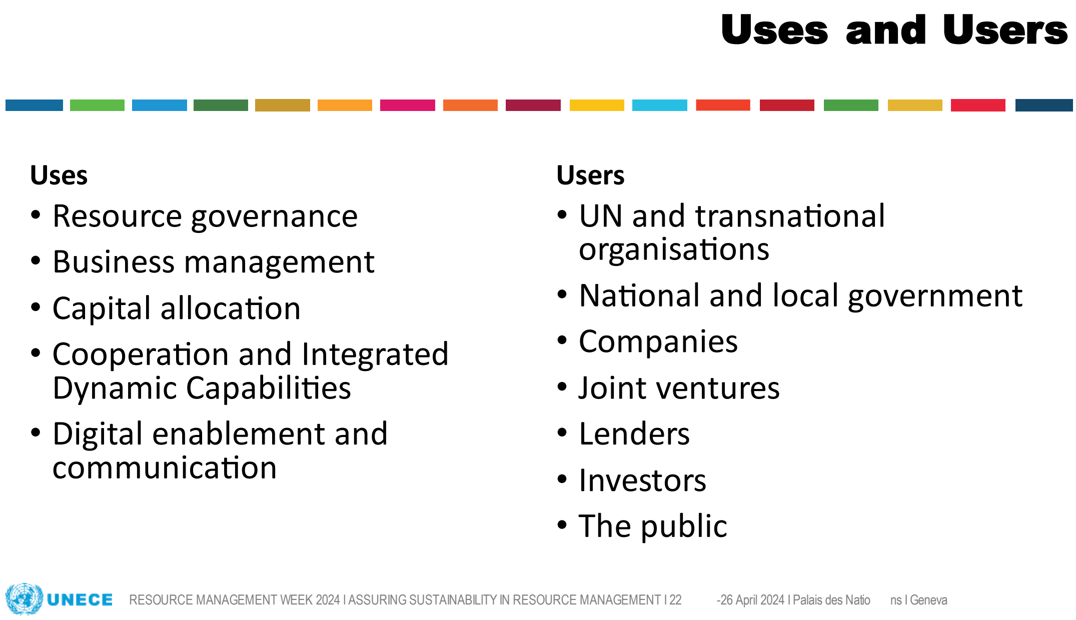

Figure 4

Importantly, today's situation with the requirements to meet the goals of Agenda 2030 and mitigate climate change requires all hands on deck. It is not enough for each partner in this public-private partnership between government, industry and capital allocators to excel within their domain. They must excel as a partnership exploiting and respecting each other's capabilities and interests. For this the UN holds the required convening power and must deliver.

The metrics have been used for as long as projects have been managed and appear in numerous requirements and guidelines. They also appear in the EU Critical Raw Materials Act. Figure 5 shows the 4 paragraphs where UNFC is referenced directly and the 22 where project-based metrics are required or implicit. In addition, there are the Annexes and references to other EU legislation.

The overview shows that the CRMA is looking for information at the country and EU level primarily with some information at the company level and to a much lesser extent at the project level.

The traditional metrics of classification, the quantities of source material and the estimated total quantities of future production known as reserves and resources are of course required. More prevalent are the requirements for forecasted quantities in time that the UNFC is designed to carry. Some of the concerns are:

- Time schedule of access, exploration, and development processes.
- Production as a function of time.
- Time forecasts of environmental and social impacts
- Economic impact here shown as cash flows.

Cash flows are not requested directly, but economic impact is and that is derived from estimated cash flows that projects carry.

CRMA §	Title	Unit			Established scalars		Extended metrics				
		Country/ECE	Company	Project	Source quantity	Total life cycle production	Access-Exploration-development timing	Production forecast	Environment impact forecast	Social impact forecast	Cash flow
1	Subject matter and objectives	x						x			
3	List of strategic raw materials	x						x			
4	List of critical raw materials	x						x			
4a	Strategic projects - benchmarks	x						x			
5	Criteria for recognition of strategic projects	x		x		x	x		x		
6	**Application and recognition – UNFC classification**	x	x	x	x	x	x	x	x	x	x
7	Reporting and information obligations for Strategic Projects	x		x		x	x		x	x	x
11	Environmental assessment and authorisations								x		
12	Planning	x			x				x		
16	Facilitating off-take agreements							x			x
18	**National exploration programmes using UNFC**	x			x						
19	Monitoring and stress testing	x						x			
20	**Information obligations for monitoring - UNFC**	x	x					x			
21	Reporting strategic stocks	x	x		x						
22	Coordination of strategic stocks	x	x			x		x			
23	Company risk preparedness		x		x			x			
25	National measures on circularity	x				x					
26	**Recovery of critical raw materials from extractive waste – UNFC Classification**		x		x						
29	Recognised schemes (environmental footprint)	x							x		
30	Environmental footprint declaration	x							x		x
35	International cooperation and strategic partnerships	x	x	x	x	x	x	x	x	x	x
42	Monitoring progress	x	x					x			
	Annexes – UNFC metrics apply										

Figure 5

The EU should be commended for enacting its Critical Raw Materials Act with such rigor and in record time. The metrics in Figure 5 refers to the needs described in the Act.

Figure 6 (UNECE, 2018)reminds us of the seven industries and four applications the UNFC is designed to serve. They are all based on projects that in the real world as in UNFC follow the chain of establishing technical feasibility from first concepts through provision of access, exploration, development design, development, production, modification and decommissioning. This is done while navigating the contingencies with respect to environmental, social/strategic and economic impact.

The decisions to be prepared and taken with respect to operations and the meeting of the contingencies must be good decisions and good decisions require good information, in this case on metrics that projects carry.

While traditional use of classifications reveal total quantities and the degree of confidence in estimating them, the need for forecasts in the management of resources at the national and supra national level, in business management, in capital allocation and in forging together strong, integrative and dynamic partnerships between them is evident. Forecasts are more complex to report with respect to uncertainty. The backup below sketches some of the reasons and points to possible solutions. Importantly however, which metrics matter and should be standardised in the UNFC are not decided in any way now, but for the EGRM to address in the coming months.

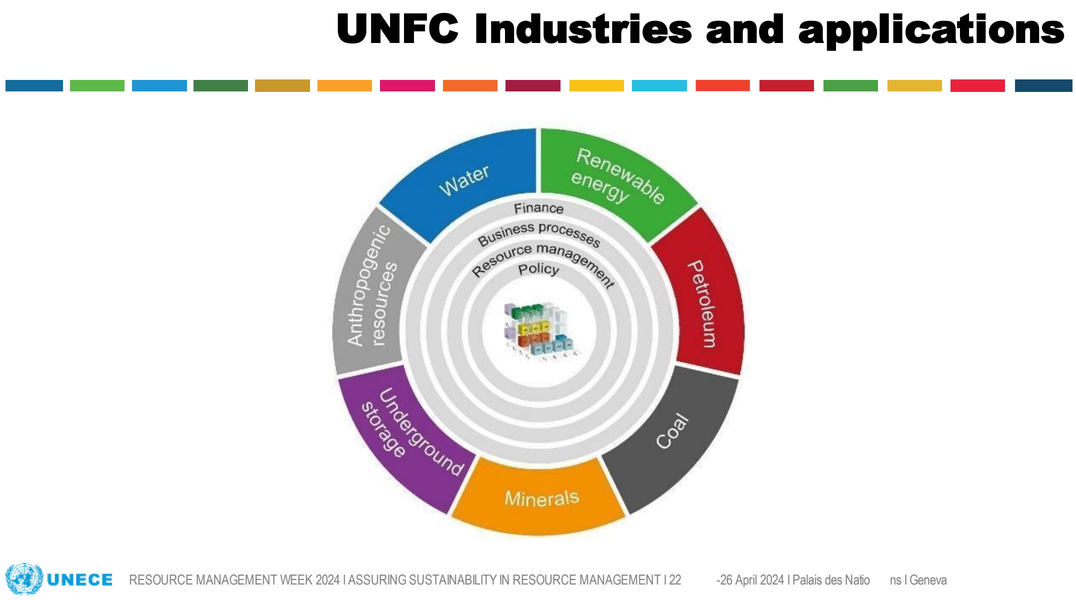

Figure 6

Backup

As UNFC is a classification of projects, the UNFC may well prove suitable for other industries than the ones shown in Figure 6. By having one classification that covers multiple industries, the UNFC facilitates aggregation across industries, providing a solution to the uncovered needs of analysing the performance of business combinations and diversified public and private portfolios.

The metrics that matter are the metrics that affect decisions. Some typical users are:

- The UN in managing its dialogues and negotiations to reach agreements on measures to achieve the ambitions embedded in the SDG's, UNRMS and to mitigate climate change.
- Governments who need standard metrics for their resource management and national econometric analyses.
- Corporations who work in several industries and jurisdictions and who need common metrics for managing these.
- Capital allocators who manage their investments as well as the opportunities and risks associated with them through diversified portfolios over different assets, entities and jurisdictions while assessing each investment carefully.
- …and more

Most, if not all projects go through the phases of exploration, design, development, production and decommissioning with respect to technical feasibility, each with characteristic decisions to be supported by the metrics. See Figure 7.

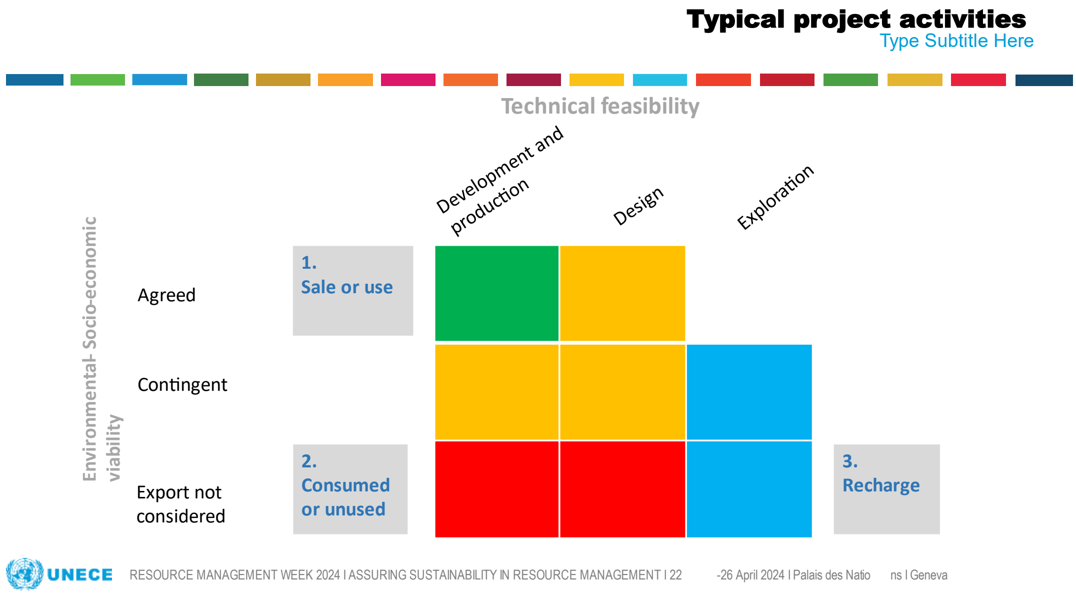

Figure 7

The projects will need to be viable with respect to environmental-socio-economic conditions. Project production may be committed as indicated in green, contingent as indicated in yellow or not considered for export as shown in red. The projects in red are either found unsuitable for realisation, not well enough known to allow consideration of future production or be production that will be consumed in operations or not used as is the case with for instance fuel and flare in oil and gas operations and mine tailings.

The metrics are bound by three reference points at which forecasts are estimated and later accounted for. They are:

1. The point of sale, or as in household economies such as home solar – delivery points where there are no sales.
2. The point where production to be consumed in operations or not used is to be observed.
3. The point of inflows to the project in the form of recharge as in the cases of renewable energy, groundwater or anthropogenic resources.

The reference points facilitate analyses where outflows from one project may be the recharge for another, thus linking projects in the way they are linked in the physical circular economy.

The metrics that projects carry are not measured, but estimated with the exception of the quantities measured at the reference points and in the financial accounts. Estimates must be accompanied by an assessment of the degree of confidence in them.

The EGRM is well placed to facilitate negotiations with champion governments, industries, and capital allocators to identify common metrics and how to specify them. The UN is here to continue this process which has already been carried out for sources and products. For this it is necessary to move a bit closer to the UNFC. The traditional cube is shown in Figure 8 (UNECE, 2019).

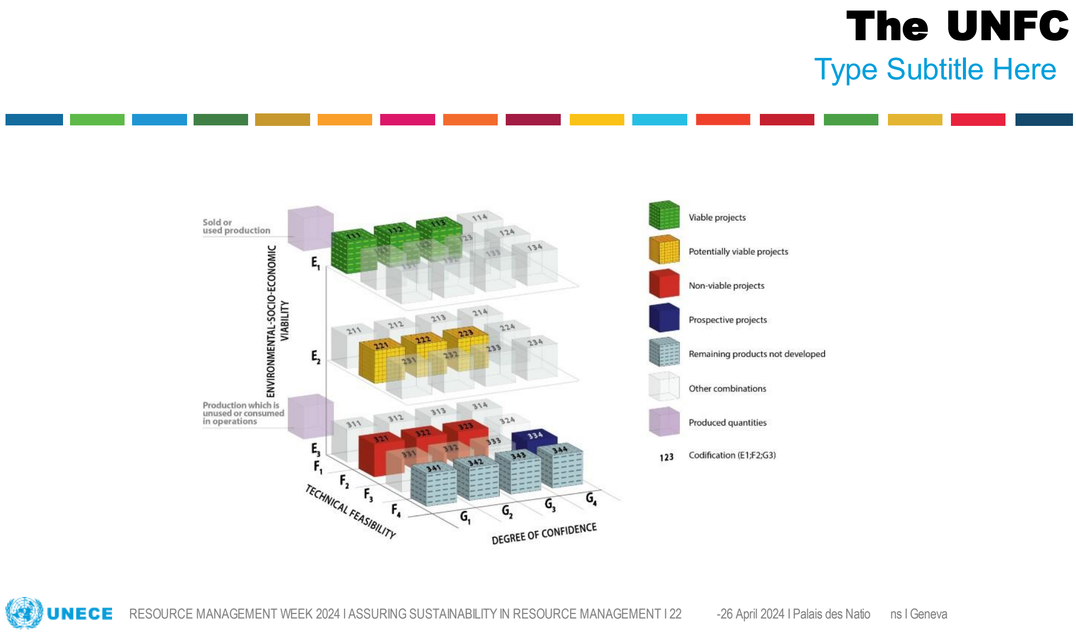

Figure 8

Since the metrics are expanded from sources and products to the metrics that projects carry and that users need, i.e the traditional G-axis quantities, the G-axis needs to be expanded to reflect the change. This is indicated in Figure 9 (UNECE, 2022).

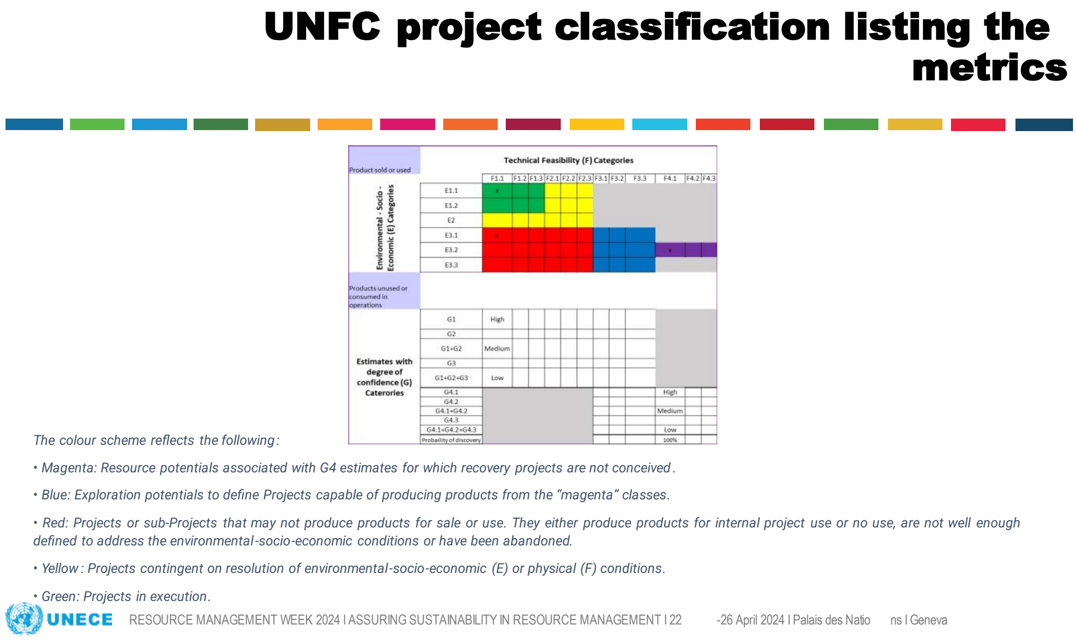

Figure 9

The projects are classified with subcategories of technical feasibility and environmental–social-economic viability. Metrics for each project class as defined by its categories should be provided in an expanded table.

The metrics are of two kinds:

- **Scalars, such as life cycle quantities**. When it comes to sources and products, these have traditionally been addressed on the G-axis. Scalars such as these can be single values or ranges, reflecting the confidence in the estimates. They lend themselves to probabilistic analyses given that the information on probability density functions, correlations and dependencies are available.
- **Vectors, better known as time forecasts**. Resource, business, and capital allocation management is done on the time scale, making these metrics indispensable. They are more complex than single values as they cannot be represented by a low-medium-high path and quantified with a probability density function. A single forecast may be high relative to the actuals in the sense that start up time is too optimistic and at the same time be low in the sense that productivity once production has built up may be too pessimistic. They are shaped by parameters that are independent of one another either completely or partially.

The importance of a metric is determined by its effect on the decisions it supports. Resource governance, and in particular proactive resource governance requires a substantial set of metrics to support decisions on opening areas for exploration, design of facilities, development, production, modification, decommissioning, infrastructure provision, revenue management etc. In the environmental-social-economic space, early prospect analyses may be combined with strategic environmental and social analyses. This is required and under government control to determine where, when and to whom access can safely be provided without undue risk of failure once operations start. Both public and private sector consequences of providing access must be assessed. There will normally be large uncertainties associated with these assessments but also significant opportunities to steer future activity patterns. Despite the uncertainties, these assessments may provide clear indications of where activities are likely to be successful, and where they are likely to fail at great cost to both the private and public sector.

Once access is provided and exploration starts, two decisions stand out:

1. Whether or not to explore. This is usually resolved by assessing the value of the information to be collected. The success case is valued and compared against the cost of the exploration. The metrics are usually the chance that a discovery of a minimum economic quantity will be made multiplied by the value of the discovery given that it is discovered, less the exploration cost. This is then compared to the exploration cost multiplied by the probability that a minimum economic quantity will not be found. The difference is the value of acquiring the information. A decision is more likely to be made if this value is positive than if it is negative. Initially, when the first exploration efforts are made, the probabilities are strongly affected by the information acquired and with them the values of information. Although the value of an initial drillhole can be substantial relative to the cost of drilling it, the value of additional drillholes will diminish as exploration goes on. By the time the 50th hole is to be drilled, the information may increase by only a few percentage points while the costs of hole remain the same. There may be a desire in some sectors improve the precision with which resources in the ground are determined without considering the value of improving it. Eventually however, it is time to consider whether the remaining uncertainty to be reduced through exploration is significant relative to other sources of uncertainty affecting future

production. The opportunities and risks associated with this uncertainty may be better handled by proceeding to design and incorporating flexibility in it, i.e. real options that may be exercised or not to manage the opportunities and risks associated with the uncertainties.

2. Entities who have been granted access may have a choice of exploring or selling the asset acquired, either by farming out participating interests, selling shares in the entity, or selling the entity. In these scenarios, there will always be a buyer with the choice of acquiring a part of or all the asset from the seller. The metrics will also in this case be the value of information plus the value of the option to develop and produce. These values will depend on the capabilities of the seller and buyer respectively. The differences give rise to a rationale for sale and purchase. The value may also simply be the observed price that similar assets are bought or sold for in the market.

In the design phase, estimates of production performance will gradually supplement estimates of total quantities.

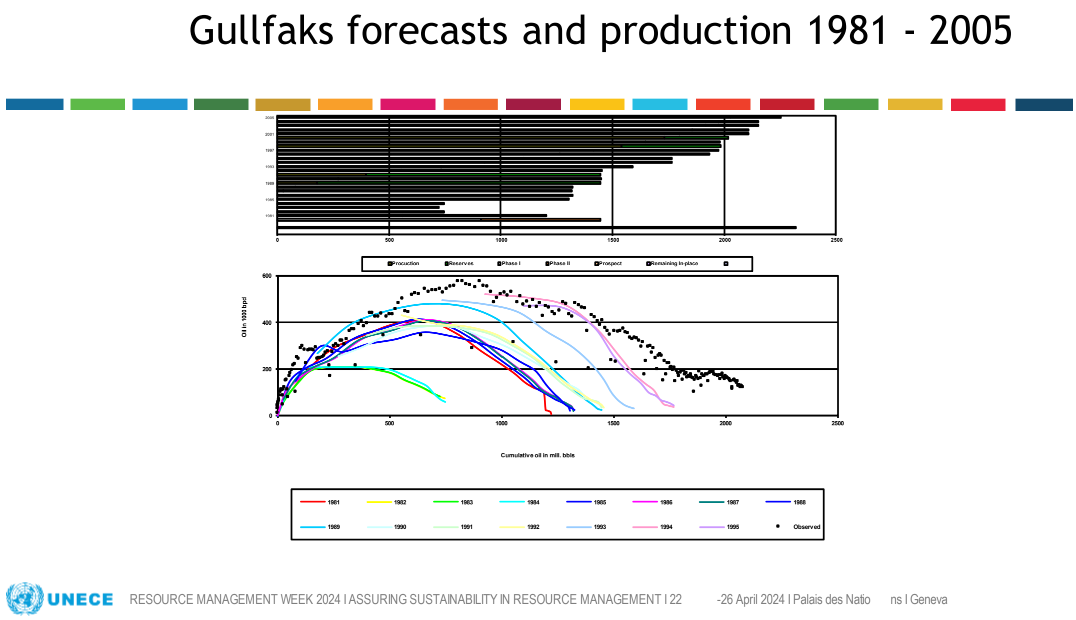

Figure 10

Figure 10 (Åm & Heiberg, 2014) shows one form of production performance from an offshore oilfield. Estimates of recoverable oil quantities are shown in the top graph. In the bottom graph estimated production rates are shown as a function of cumulative production together with the observed monthly average rates. Most projects will follow this general performance in the sense that production rates are zero at the start of production, build up to peak capacity and then decline to end when the production rates reduce to a point where operating coasts can no longer be covered by the revenues unless administrative measures such as license terms will stop production earlier. From an economic point of view, the total quantities that will be produced by the time production ends is important, but so is the production rate at which recovery takes place. The better the capacity and thus the invested capital is used over the lifetime of the project, the higher is the economic rent.

When production rate is described as a function of cumulative production there is a direct link to production rate as a function of time since the production rate is the time derivative of cumulative production. A straight-line decline of production rate against cumulative production will for instance translate to an exponentially declining production against time.

One way to estimate the uncertainty in time forecasts is shown in Figure 11 (Heiberg, Knudsen, Lund, Njå, & Ervik, 1981).

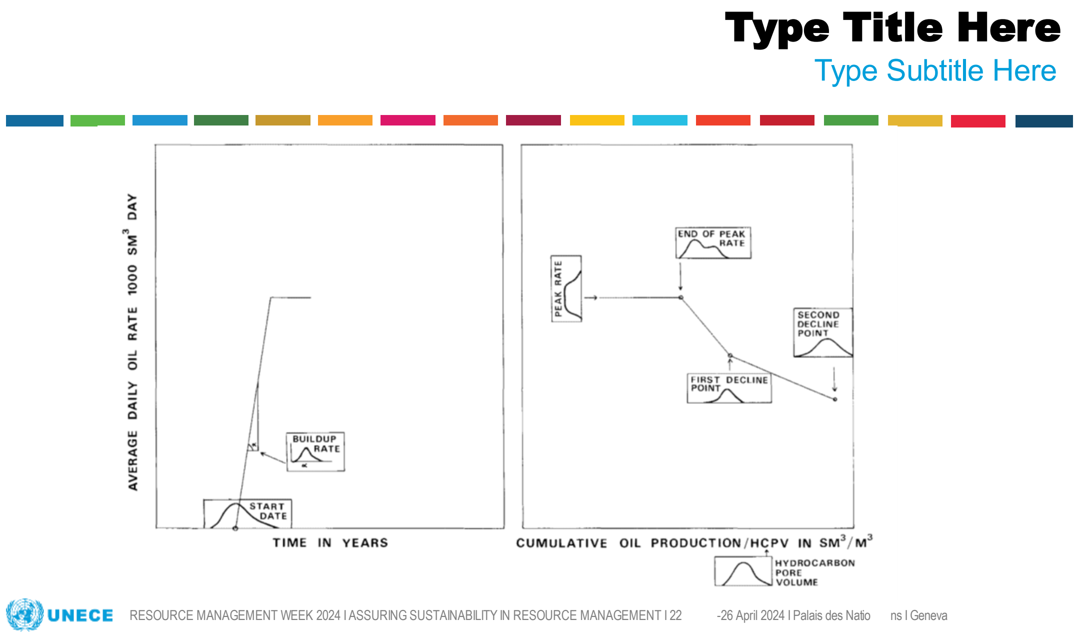

Figure 11

On the left figure, production start-up time and production build up are handled on the time axis since they are not influenced by cumulative production. They can be estimated as fixed times and rates in a deterministic approach, which is usually done. To assess the confidence in these estimates, require assessment of a range. On the right figure, the peak rate and a few points on the production performance (as many as there are reasons to address) are shown, including the cumulative production over the project lifetime, also known as reserves. Again, they can be deterministic, but to reflect the uncertainties, it is necessary to assign ranges also to them. A parametric forecast can be produced by picking one value at each control point, or by producing a swarm of forecasts, some of which will be crossing one another by working through all values in the ranges. If done using stochastic analyses, the results can be presented, not as high or low forecasts, which is impossible, but as probability density functions of scalar values of cumulative production in a given time span such as next year, another given time interval, the lifetime of the project etc, depending on the decisions to be supported. This information will govern other metrics in the environmental-socio-economic domain.

Several of the parameters of Figure 11 may be assessed from prior performances if better observations are not available.

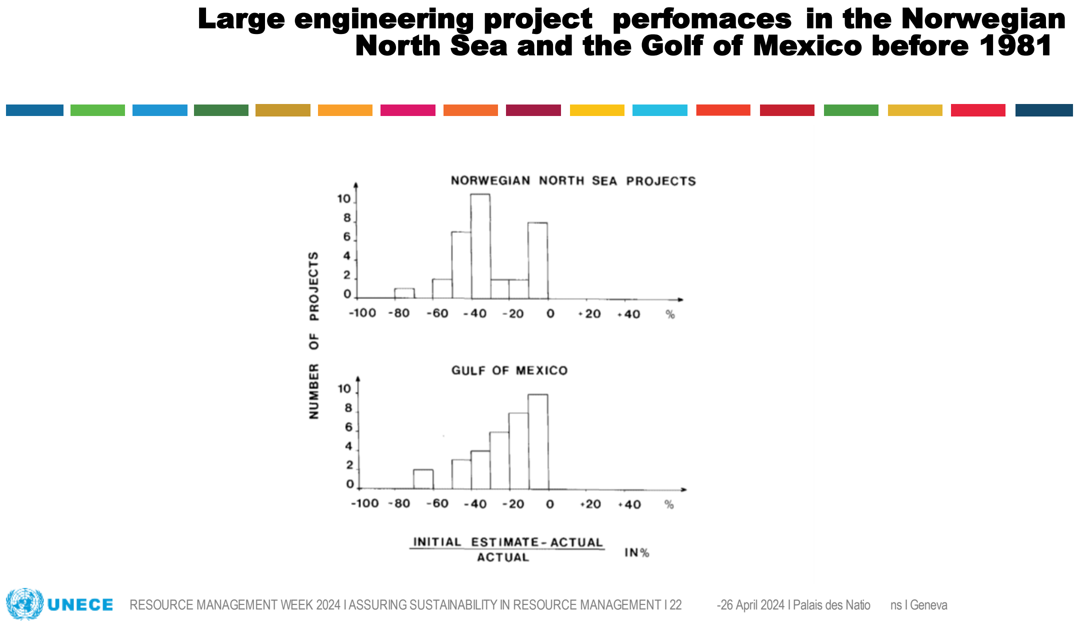

Figure 12

Going back in time, Figure 12 shows a sample of initial estimated construction times versus actual times. None of the large engineering projects examined finished on time and delays could be significant. Recognising that costs burn rates build up as construction matures the activity level increases it is reasonable to expect that an historical lookback will reveal significant cost uncertainty as well. This is not related just to petroleum development projects but is observed for large and complex engineering projects generally (Miller & Lessard, 2000). These projects are associated with significant uncertainty and risk of delays and cost overruns due to technical complexities as well as well as issues in the environmental-socio-economic domain.

Build-up rates will be affected by engineering, but here there is a strong influence also of productivity in producing the final products, which in turn is influenced by geologic detail in the area affected by build-up more than by the total lifecycle production that can be achieved.

Throughout the production cycle, the monthly average production rates shown in figure 10 may be used to assess the range of regularities expected for future production. While production rates cannot exceed capacity, they can and will at times go to zero. The probability density function for production regularity will therefore show a high probability density near capacity and a long tail towards zero. This results in an expected value to be used in planning that invariably is less that what is hoped for.

The reduction in production potential as cumulative production approaches the project life cycle may be assessed from field theory-based simulations or analogue observations. The cumulative production at the end of the project life is nothing but our friend the reserves where confidence in estimates are discussed thoroughly by EGRM and others for over a century. The probability distribution of cumulative production from extractive activities are often generous in that they tend towards log-normal distributions, affected as they are by 3 dimensional bodies, ore or hydrocarbon content and recovery factors, all factoring to yield lifecycle recovery estimates with the log values of the factors approaching normal distributions. Add to this asymmetric distribution that the economic value of the high outcomes that seldom, but sometimes occur, are quite important due to economies of scale. This causes the expected economic values to often be higher than the economic value of the expected quantities. Expected quantities are in turn often higher than the most probable estimate of quantities (due to the asymmetric distributions) that often is given as the best estimate of life cycle production.

In summary the metrics that projects carry are of vital importance to resource governance, business management and capital allocations. The UNFC Adoption Group (AG) has suggested a few examples of metrics that may benefit from having a global consensus on how to assess and report them (Figure 13) (UNECE in print, 2024).

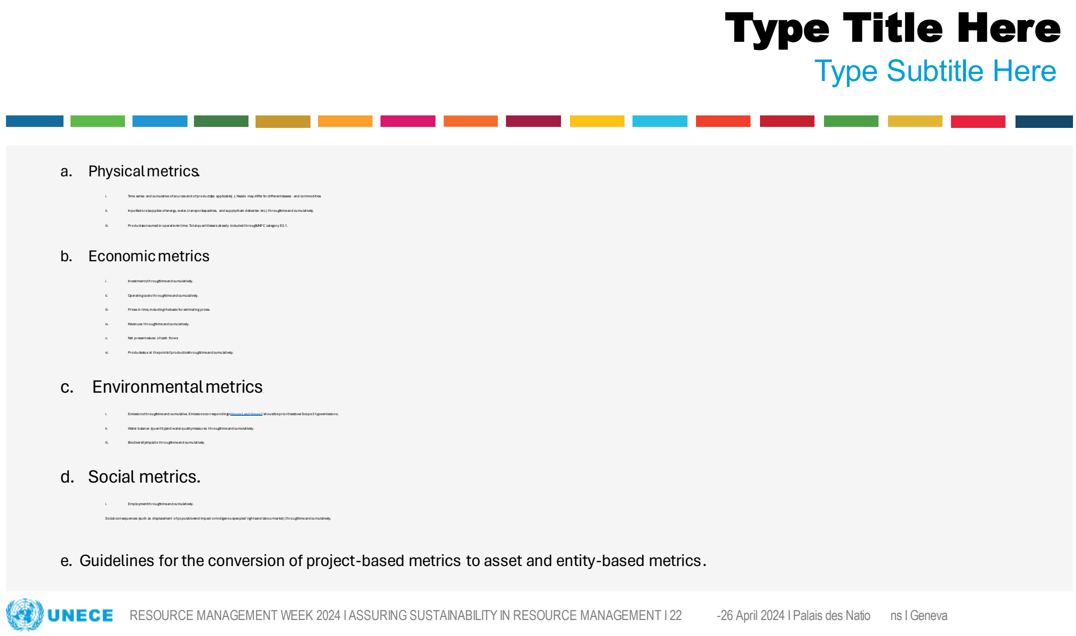

Figure 13

The AG recommends that the Bureau of the Expert Group on Resource Management develops guidelines for the use of metrics that projects carry and that users need in line with its decision at the 13th session of the Expert Group on Resource Management (EGRM13[1]).

Forward looking estimates are associated with uncertainty. To manage the opportunities and risks associated with them requires that the uncertainty in estimates is provided when this is significant for the decisions. In addition to life cycle

[1] Facilitating the inclusion of metrics with UNFC does not imply that the metrics shall be disclosed. Unless legislation requires disclosure, it is up to the owner of the information to choose what to disclose and to whom.

quantities of sources and products, the metrics of Figure13 should be considered among others. They are:

a. Physical metrics.
    i. Time series and cumulative of sources and of products (as applicable).). Needs may differ for different classes and commodities.
    ii. Input factors (supplies of energy, water, transport capacities, and supply chain deliveries etc.) through time and cumulatively.
    iii. Products consumed in operation in time. Total quantities are already included through UNFC category E3.1.
b. Economic metrics.
    i. Investments through time and cumulatively.
    ii. Operating costs through time and cumulatively.
    iii. Prices in time, including the basis for estimating prices.
    iv. Revenues through time and cumulatively.
    v. Net present values of cash flows.
    vi. Product value at the point of production through time and cumulatively.
c. Environmental metrics.
    i. Emissions through time and cumulative. Emissions corresponding to [Scope 1 and Scope 2] should be prioritised over Scope 3 type emissions.
    ii. Water balance (quantity) and water quality measures through time and cumulatively.
    iii. Biodiversity impacts through time and cumulatively.
d. Social metrics.
    i. Employment through time and cumulatively.
    ii. Social consequences (such as displacement of population and impact on indigenous peoples' rights and labour market) through time and cumulatively.
e. Guidelines for the conversion of project-based metrics to asset and entity-based metrics.

THE VIEWS EXPRESSED ARE THOSE OF SIGURD HEIBERG A ND DO NOT NECESSARILY REFLECT THE VIEWS OF THE UNITED NATIONS.

Thank you!

Sigurd Heiberg
Member of the UNFC Adoption Group and Chair of the Commercial Applications Working Group
UNECE
Date 23 I 04 I 2024, Geneva

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2024

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