System of Environmental Economic Accounting

Accounting for Mineral and Energy Assets

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United Nations

Outline

- Asset accounts and their applications
- Structure and scope of asset accounts
- Physical mineral and energy accounts
- Monetary mineral and energy accounts
- Exercises!

System of Environmental Economic Accounting

Asset accounts and their applications

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What do we mean by assets in the SEEA?

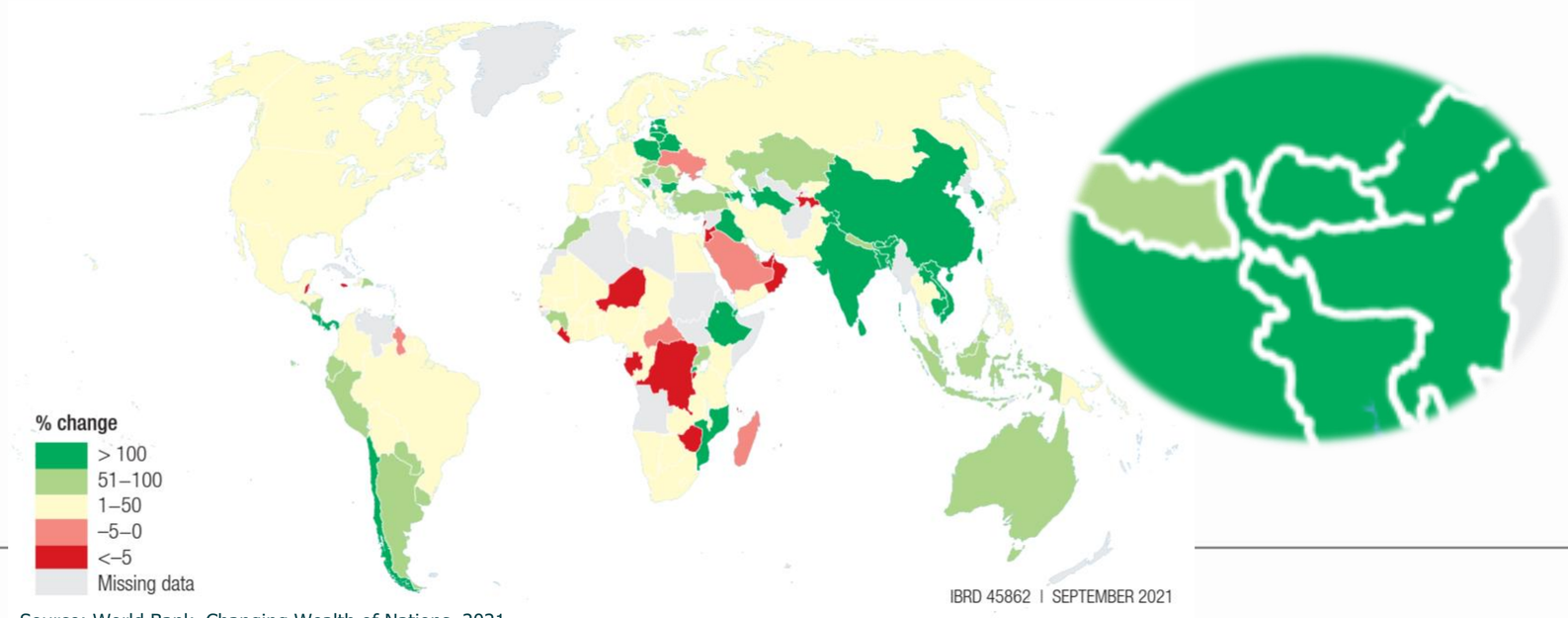
- In the SEEA: “Environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity.”
- In other words:
  - The environment provides value to society and the economy—environmental assets provide these benefits
  - The SEEA measures assets in both physical and monetary terms

Asset accounts: applications

- Measuring your assets allows you to monitor and manage them
  - >What is the contribution of natural assets to national wealth?
  - >Are we maintaining total wealth over time (produced, natural, human)?
  - >Are we substituting produced assets for natural assets?
- Measuring natural capital and the wealth from natural capital complements measurements of GDP

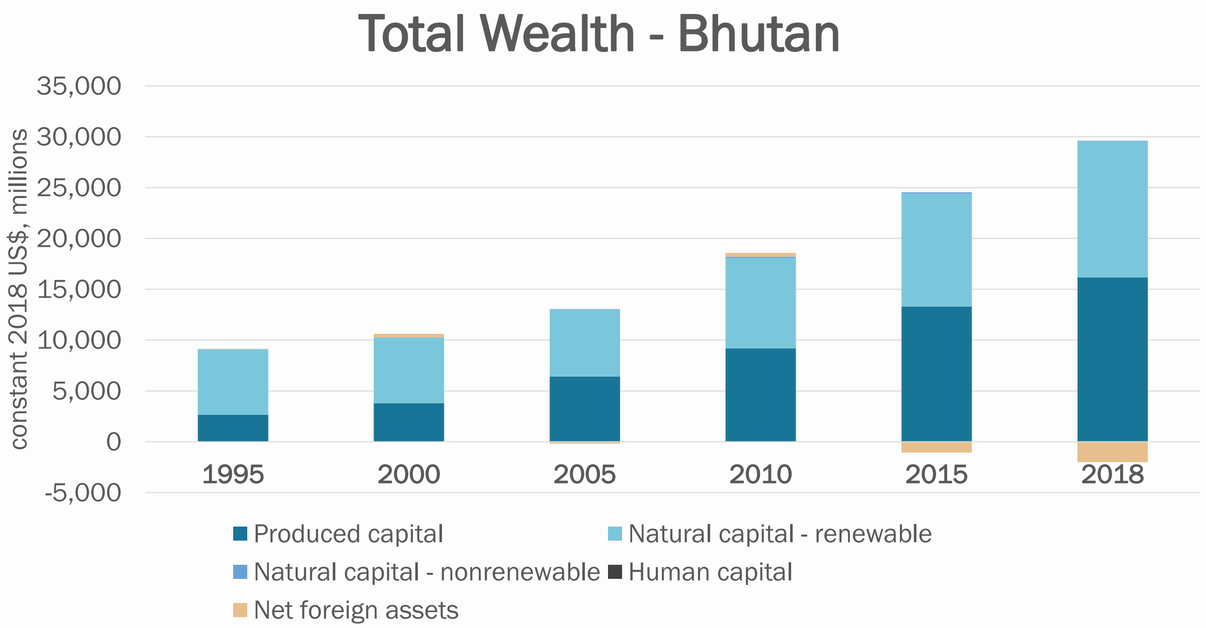
Asset accounts: applications

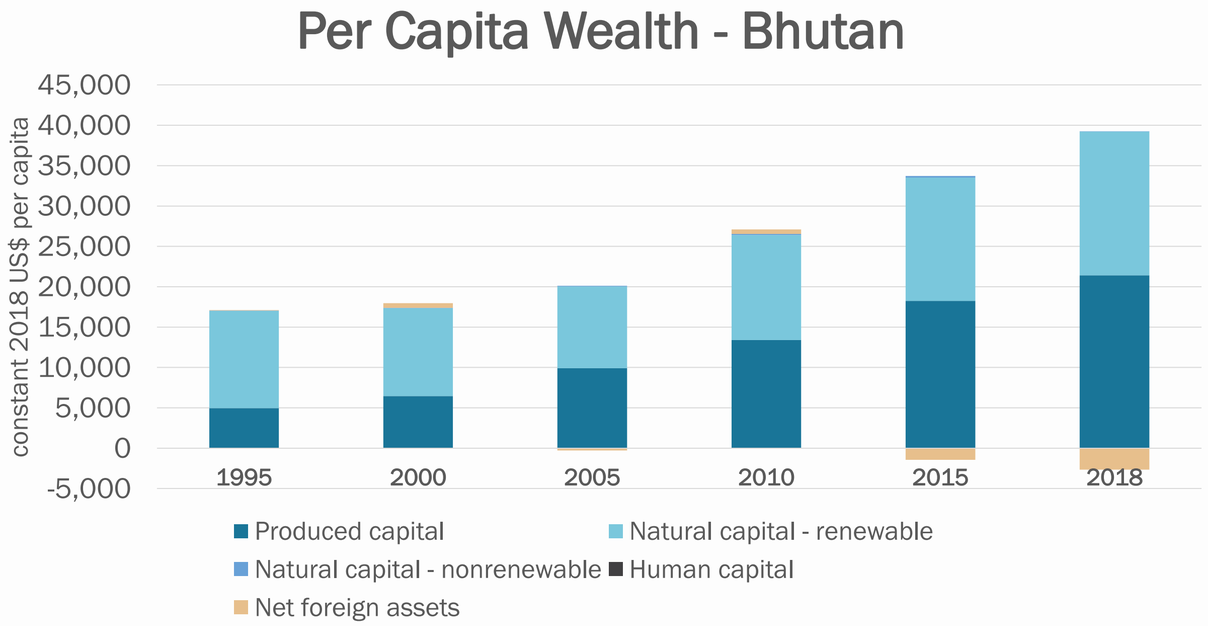
- Example of wealth accounting (using asset accounts): The Changing Wealth of Nations
- Measures nations' wealth, taking into account human, produced and natural capital, noting where assets are being managed sustainably or unsustainably
- 2021 finding: Wealth has remained relatively stagnant in some places, but has increased in others.



Source: World Bank, Changing Wealth of Nations, 2021

Asset accounts: applications





Note: Renewable includes forest timber, forest ecosystem services, mangroves, fisheries, protected areas, and crop and pastureland. Nonrenewable refers to subsoil assets (oil, gas, coal, metals and minerals).

Note: Human capital estimates not available for Bhutan. At the moment, renewable energy resources are not included for all countries.

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Source: World Bank, Changing Wealth of Nations, 2021

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Structure and scope of asset accounts

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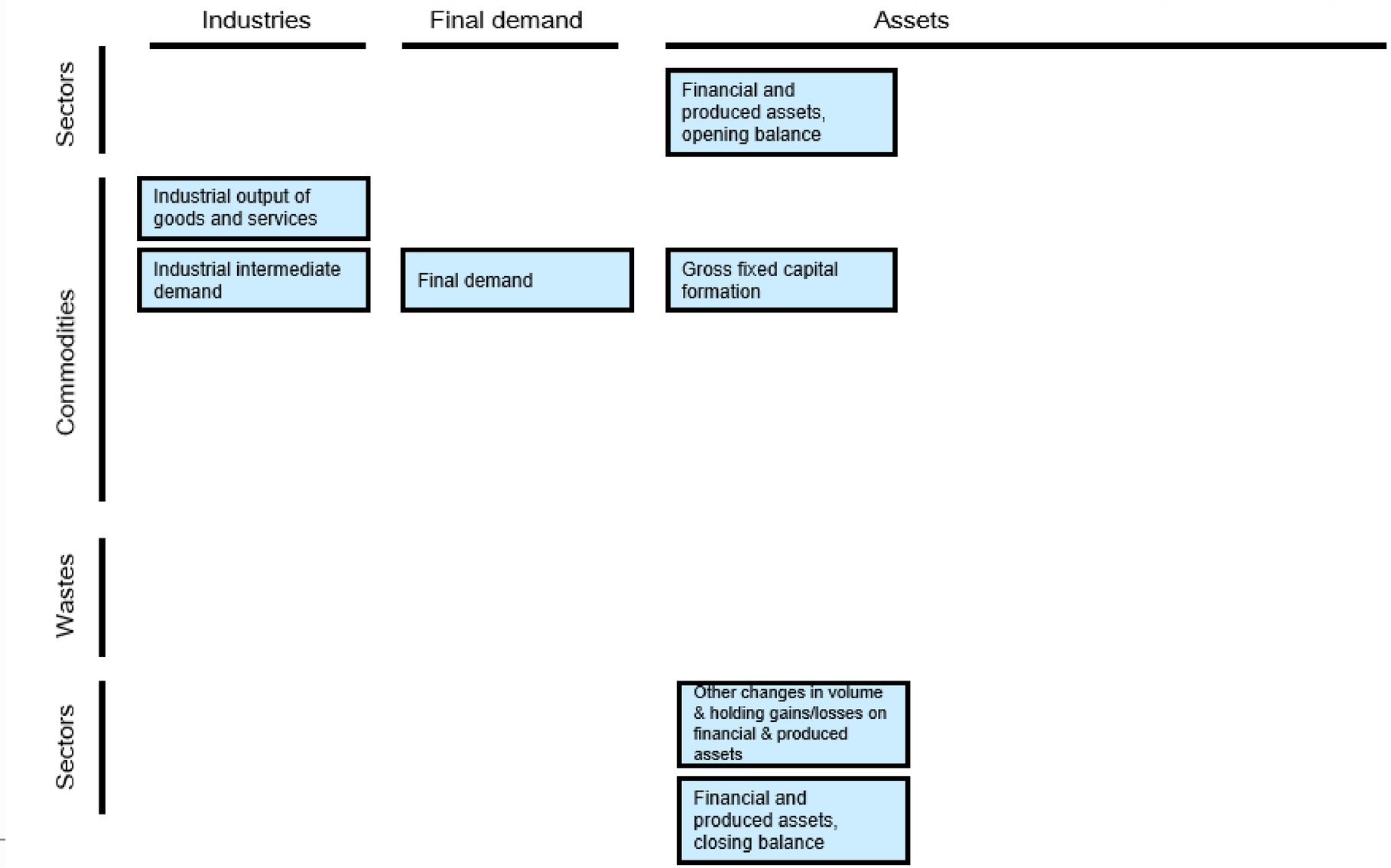
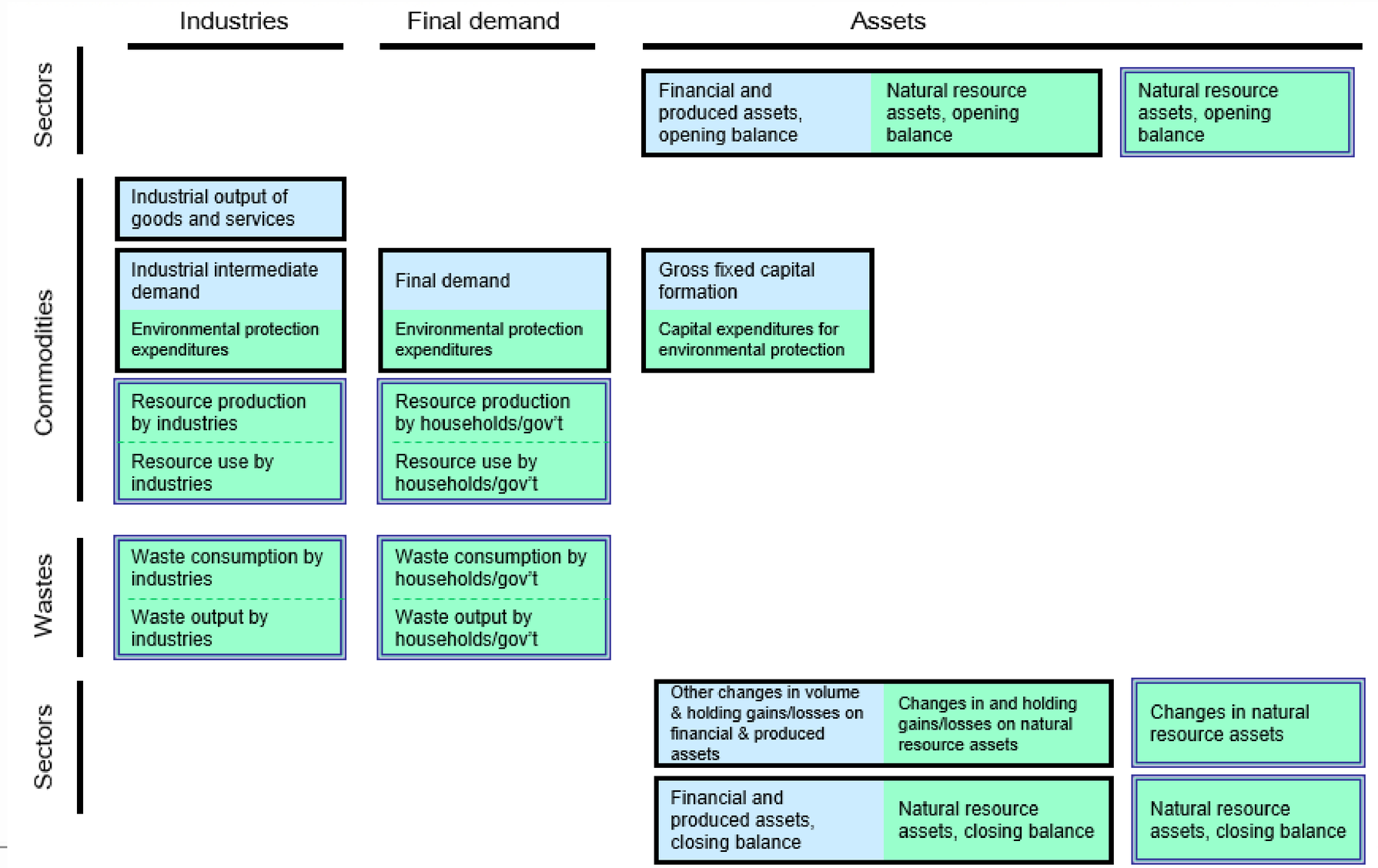
SNA view of assets



Source: Statistics Canada

SEEA view of assets



Source: Statistics Canada

Environmental assets in the SEEA

1	**Mineral and energy resources**
1.1	Oil resources
1.2	Natural gas resources
1.3	Coal and peat resources
1.4	Non-metallic mineral resources (excluding coal and peat resources)
1.5	Metallic mineral resources
2	**Land**
3	**Soil resources**
4	**Timber resources**
4.1	Cultivated timber resources
4.2	Natural timber resources
5	**Aquatic resources**
5.1	Cultivated aquatic resources
5.2	Natural aquatic resources
6	**Other biological resources** (excluding timber resources and aquatic resources)
7	**Water resources**
7.1	Surface water
7.2	Groundwater
7.3	Soil water

Structure of an asset account

- Similar to a balance sheet
- Explains the development of the stock from the beginning to the end of the accounting period
- Basic identity: **closing stock always equal to opening stock plus changes over the period**

Identity of the asset accounts:

Opening stock

\+ Additions to stocs

\- Reductions in stocks

= Closing stock

Asset account for limestone
Class A Commercial Recoverable Resources

	Million tonnes
Opening stock	1200
+ Additions to stock	
Upward reappraisals	+ 200
- Reductions in stocks	
Extractions of limestone	- 50
= Closing stock	1350

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Mineral and energy asset accounts

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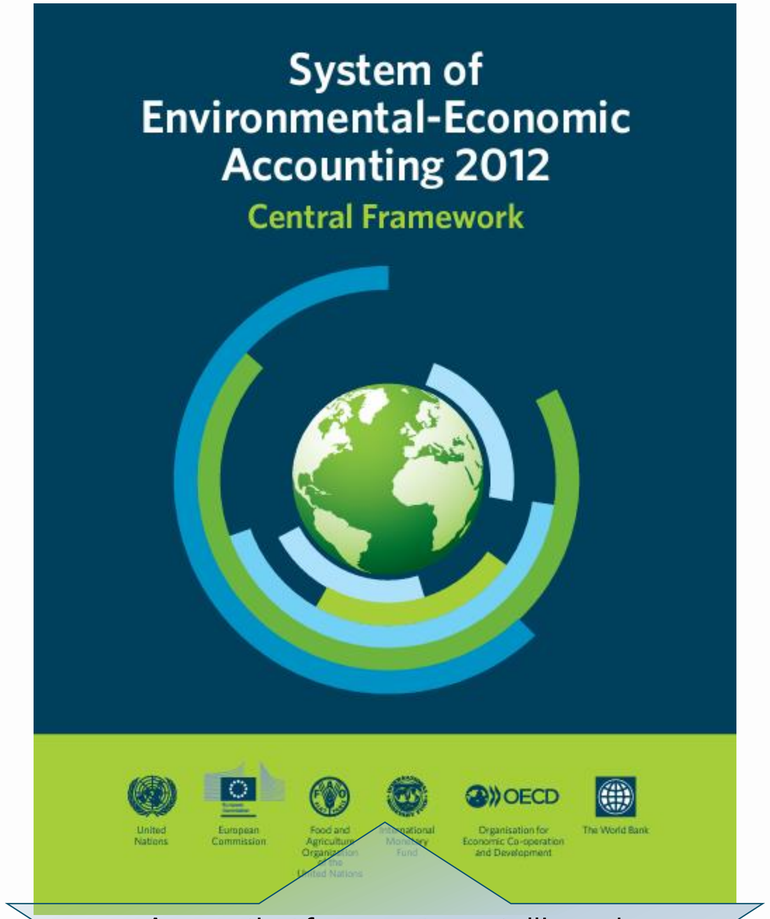
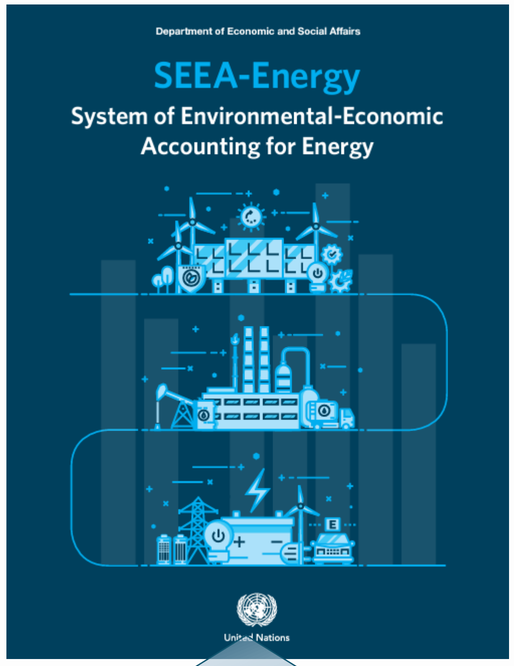
Use of mineral and energy asset accounts

- Sustainability/stewardship issue: Mineral and energy resources cannot be renewed on any human timescale
- Can help understand specific issues such as:
  - >Operating life of existing mineral and energy resources
  - >Future requirements for energy imports OR opportunities for energy exports
  - >National energy security
- Monetary accounts:
  - >Provides a more complete set of production costs of extracting industries, e.g. depletion-adjusted value-added measures
  - >Help determine gov't taxation and royalty settings

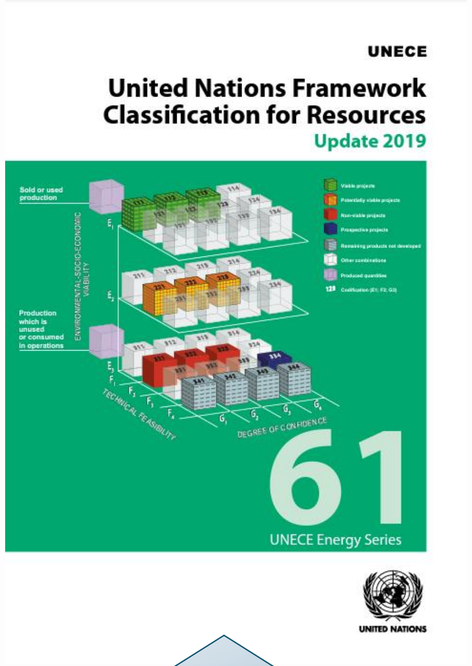
Resources for SEEA mineral and energy accounts



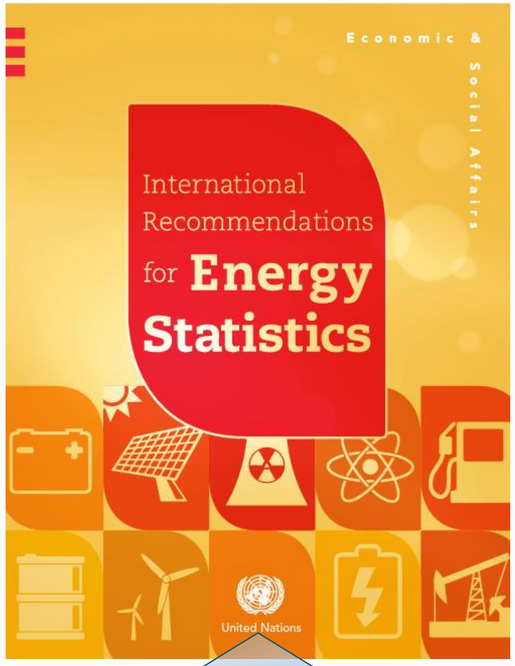
Accounting for energy, metallic and non-metallic minerals, e.g. dolomite, limestone, gypsum, talc, quartzite, iron-ore



Accounting for minerals/energy for energy purposes (e.g. coal)

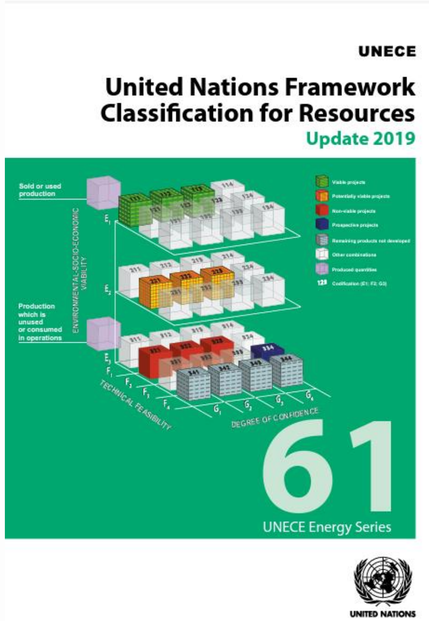


Scheme for classifying resources, including mineral and energy



Basic energy statistics

Mineral and energy resources in the SEEA



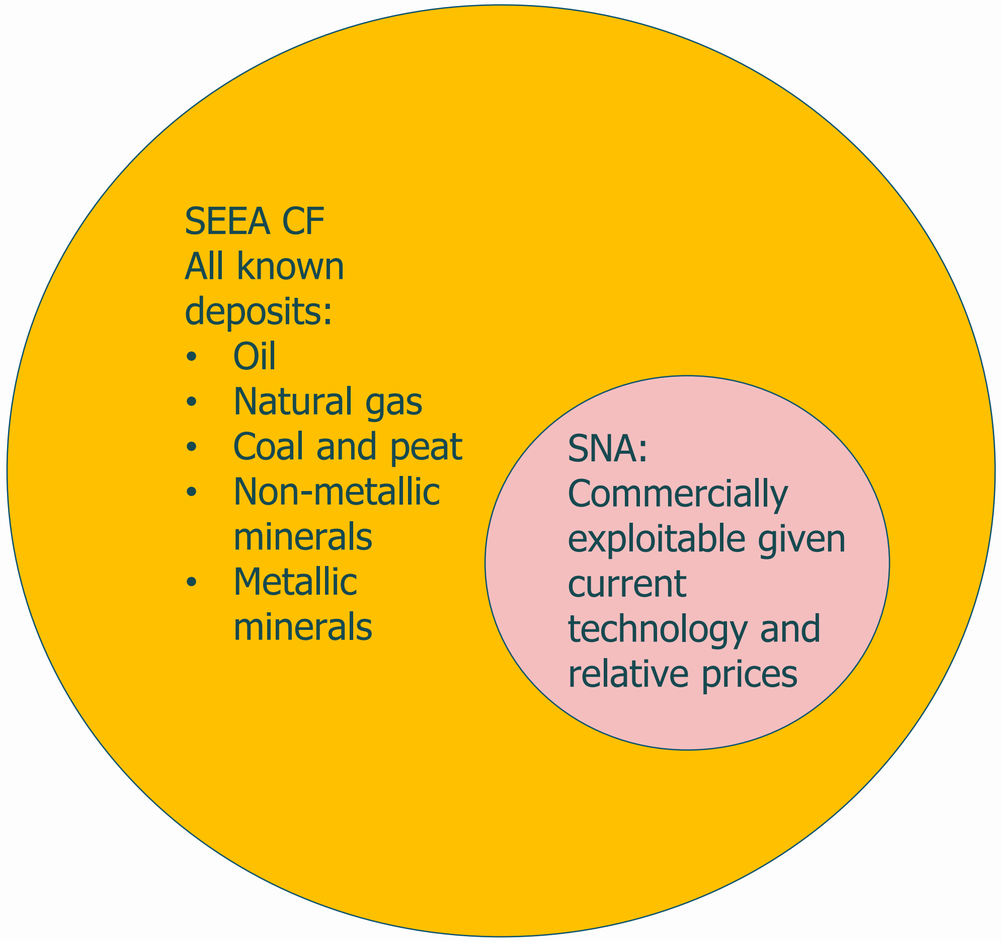
- **Known** deposits of oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals
- These deposits are classified based on the maturity of the projects.
- In particular, the classification of deposits is based on three criteria affecting their extraction:
  - >Economic and social viability: are there favourable economic and social conditions to establish the commercial viability?
  - >Field project status and feasibility: maturity of studies/commitments
  - >Geological knowledge: level of certainty of geologic knowledge

Mineral and energy resources in the SEEA

		Corresponding UNFC-2009 project categories		
		E	F	G
	SEEA Class	Economic and social viability	Field project status and feasibility	Geological knowledge
Known deposits	Class A: Commercially recoverable resources[a]	E1. Extraction and sale have been confirmed to be economically viable	F1. Feasibility of extraction by a defined development project or mining operation has been confirmed	Quantities associated with a known deposit that can be estimated with a high (G1), moderate (G2) or low (G3) level of confidence
	Class B: Potentially commercially recoverable resources[b]	E2. Extraction and sale are expected to become economically viable in the foreseeable future[c]	F2.1 Project activities are ongoing to justify development in the foreseeable future	
			F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay	
	Class C: Non-commercial and other known deposits[d]	E3. Extraction and sale are not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay	
			F2.3 There are no current plans to develop or to acquire additional data at the time owing to limited potential	
			F4. No development project or mining operation has been identified	

Scope of deposits

- Mineral and energy deposits include all stocks that ***may*** provide benefits to humanity, even if they may not have a present market value
  - >i.e. all known deposits of the energy/mineral resource ***that could potentially become products***
  - >Includes resources with no current economic value, but excludes resources where there's no expectation of economic viability
- This means that the scope is broader compared to the System of National Accounts



System of Environmental Economic Accounting

Physical mineral and energy asset accounts

United Nations

Basic physical asset account

	Type of mineral and energy resource (Class A: Commercially recoverable resources)				
	Oil resources (thousands of barrels)	Natural gas resources (cubic metres)	Coal and peat resources (thousands of tonnes)	Non-metallic minerals (tonnes)	Metallic minerals (thousands of tonnes)
Opening stock of mineral and energy resources	800	1 200	600	150	60
Additions to stock					
Discoveries					20
Upward reappraisals		200		40	
Reclassifications					
Total additions to stock		200		40	20
Reductions in stock					
Extractions	40	50	60	10	4
Catastrophic losses					
Downward reappraisals			60		
Reclassifications					
Total reductions in stock	40	50	120	10	4
Closing stock of mineral and energy resources	760	1 350	480	180	76

Note: Different physical units (e.g., tonnes, cubic metres and barrels) will be used for different types of resources.

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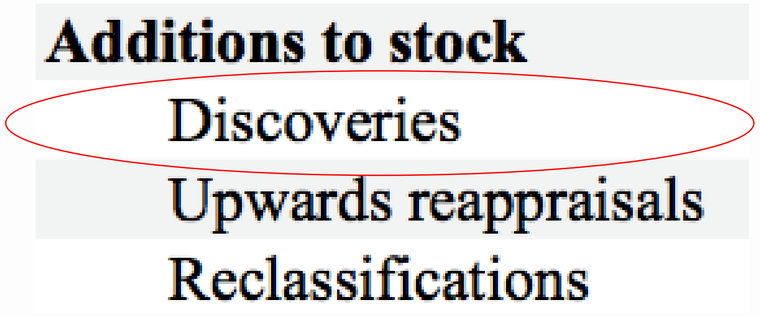
Discoveries

- When new quantities of energy resources are **discovered through exploration** activities in an accounting period the new quantities should be recorded as **additions to the opening stock**.
- Depending on the characteristics of the new discoveries and the development of the related projects for extraction the discoveries should be accounted for as either Class A, B or C.
- When quantities of *potential deposits* become known to a higher degree of confidence and thereby become *known resources*, the increase is treated as discoveries.



Extractions

- Quantity of resource physically removed from the deposit, excluding mining overburden
- Quantity before any refinement or processing of the resources
- Estimates should technically include estimates of illegal extraction (either by residents or non-residents)

Reductions in stock
Extractions
Catastrophic losses
Downwards reappraisals
Reclassifications

Reappraisals

- Reappraisals pertain to the estimated available stock of specific **known** deposits. Reappraisals occur with **changes in the geological information, technology or prices**.
- Reappraisals are typically associated with a move of resources between class A, B and C.
- A common reason for **upward reappraisals** of the quantity of energy resources is **price increases**. When energy prices go up it becomes more profitable to extract resources and an upward reappraisal of the physical quantities may take place.
- In contrast **downward reappraisals** of the quantities may take place when energy prices are going down.

Additions to stock
Discoveries
Upwards reappraisals
Reclassifications

Reductions in stock
Extractions
Catastrophic losses
Downwards reappraisals
Reclassifications

Reclassifications

- Reclassifications may occur if certain deposits are opened or closed to mining operations owing to government decisions concerning access rights
- Can also take place if a mineral/energy resource is reclassified as another type of mineral/energy resource

Additions to stock
Discoveries
Upwards reappraisals
Reclassifications

Reductions in stock
Extractions
Catastrophic losses
Downwards reappraisals
Reclassifications

Source: Philippine Statistics Authority

Catastrophic losses

- Usually very rare
- Flooding/collapsing of mines is not considered a catastrophic loss
  - > Issue of viability of extraction, not loss of resource itself
- Some exceptions when it comes to oil wells that are destroyed by fire or become unstable

Reductions in stock
Extractions
Catastrophic losses
Downwards reappraisals
Reclassifications

System of Environmental Economic Accounting

Monetary mineral and energy asset accounts

United Nations

Basic structure

- Based on availability of information on the physical stocks of resources
- Most countries do physical account first, then monetary
- Revaluations: Changes in the value of assets solely due to price changes AND any changes in value due to changes in assumptions made in valuation approaches

	Type of mineral and energy resource (Class A: Commercially recoverable resources)				
	Oil resources (thousands of barrels)	Natural gas resources (cubic metres)	Coal and peat resources (thousands of tonnes)	Non-metallic minerals (tonnes)	Metallic minerals (thousands of tonnes)
Opening stock of mineral and energy resources	800	1 200	600	150	60
Additions to stock					
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	Type of mineral and energy resource (Class A: Commercially recoverable resources)				
	Oil resources	Natural gas resources	Coal and peat resources	Non-metallic minerals	Metallic minerals
Opening value of stock of resources	24 463	19 059	41 366	1 668	6 893
Additions to value of stock					
Discoveries					1 667
Upward reappraisals		3 100		391	
Reclassifications					
Total additions to stock		3 100		391	1 667
Reductions in value of stock					
Extractions	1 234	775	4 467	98	333
Catastrophic losses					
Downward reappraisals			4 467		
Reclassifications					
Total reductions in stock	1 234	775	8 934	98	333
Revaluations	412	- 972	5 945	- 442	-4 287
Closing value of stock of resources	23 641	20 412	38 377	1 519	3 940

Scope of monetary accounts

- What makes sense to value in monetary terms?
- Measurement boundary includes all known deposits in physical terms *but* we do not want to value deposits in monetary terms if we have a lot of uncertainty
- Recommended that valuation only be undertaken for deposits in class A: Commercially recoverable resources

General valuation principles/methods

- Value at balance sheet date (e.g. end of accounting period)
- Value using market prices, if possible
  - >Market prices being amount of money that willing buyers pay to willing sellers
  - >Exchange prices/value or transaction prices—generally observable
- If no market price, need to determine price that would be applicable if a market existed.
  - >This is the case for mineral/energy resources-- we don't trade these resources on markets until they are extracted!
  - >But we want to determine their in situ value…
  - >Estimation needed--net present value (NPV) is one method for estimating market prices

Logic of NPV approach

- Provides value that a buyer would be prepared to pay for the asset in the current period
  - >Suitable for valuation of in situ resources
- In other words—what is the expected return from investment on the asset, in today's dollars (present value)
- How to get to present value?
  - >Need to discount stream of expected returns-->Assume returns earned in current period are worth more to the extractor than returns earned in future

Steps to NPV estimates

1. Estimate resource rent from sale of resources using past prices
2. Estimate the physical stock and remaining asset life assuming a rate of extraction
3. Estimate future annual flows of resource rent over the asset life
4. Discount each future annual estimate of resource rent
5. Sum the discounted estimates to arrive at NPV

1. Estimate resource rent

- Resource rent is the return attributable to the environmental asset itself—in this case the mineral/energy resource
- How to isolate value attributable to environmental asset itself from the observable information we have on price?
- Residual value method

Output (sales of extracted environmental assets at basic prices, includes all subsidies on products, excludes taxes on products)
Less Operating costs
Intermediate consumption (input costs of goods and services at purchasers' prices, including taxes on products)
Compensation of employees (input costs for labour)
Other taxes on production plus other subsidies on production
Equals **Gross operating surplus—SNA basis**[a]
Less Specific subsidies on extraction
Plus Specific taxes on extraction
Equals **Gross operating surplus—for the derivation of resource rent**
Less **User costs of produced assets**
Consumption of fixed capital (depreciation) + return to produced assets
Equals **Resource rent**
Depletion + net return to environmental assets[b]

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2. Estimate physical stock and remaining asset life

- Recommended that estimates of asset life are based on recent past rates of extraction and growth—relatively simple for non-renewable assets
- Not recommended to assume changes in future management practices, behaviors, etc.

3. Estimate future flows of resource rents

- Main estimation is to figure out an expected rate of return on produced assets (e.g. earnings attributable to use of machinery) to deduct from your output
- Recommended to assume that expected rate of return on produced assets is equal to an external rate of return, e.g. government bond rates

4. Discount each future annual estimate of resource rent

- Step needed to convert expected stream of resource rents into a current-period estimate of overall value
- Discount rate—expresses a time preference for receiving income now rather than in the future
- Discount rate in NPV can also be interpreted as an expected rate of return on non-produced assets
  - Logic: In cases of perfect competition, the discount rate and rate of return should be equal. i.e. the enterprise will only invest if the rate of return on assets aligns to its time preferences for receiving income
- In short, default is to set discount rate equal to rate of return on produced assets in step 3!

4. Sum the discounted estimates to arrive at NPV

$$V_t = \sum_{\tau=1}^{N_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}}$$

where:

V_t *= value of asset in time t*

N= asset life

RR=resource rent

N= reserve life, i.e. closing stock ÷ extraction

r_t*= discount rate*

System of Environmental Economic Accounting

Exercises

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Exercise – physical asset account

Use the following information to fill in the asset account (Class A Commercially recoverable resources) for coal resources.

1) The total amount of coal available for extraction at the beginning of the year was 20 million tonnes.

2) During the year a new coal deposit is discovered and made ready for extraction. It contains 3 million tonnes of coal

3) The geologic survey discovers that their previous estimate of the coal deposit underestimates the stock by 1.4 million tonnes.

4) The extraction of coal by the mining company was 0.7 million tonnes

5) An earthquake totally destroys a mining site, which makes it uneconomically in the foreseen future to extract coal from this site. It was otherwise expected that 0.2 million tonnes of coal could have been extracted from this mining site.

6) Due to a new ambitious climate change policy, the government decides that half of the available coal resources must stay in the ground, never to be extracted. This decision applies to the coal deposits as of the beginning of the year.

Source: Statistics Netherlands

Physical asset account

Class A Commercially recoverable for coal resources.

	Coal (1000 tonnes)
Opening stock	
Additions to stocks	
Discoveries	
Upward reappraisals	
Reclassifications	
Reductions in stocks	
Extraction	
Catastrophic losses	
Downward reappraisals	
Reclassifications	
Closing stock	

Physical asset account - solution

Class A Commercially recoverable for coal resources.

	Coal (1000 tonnes)
Opening stock	20 000
Additions to stocks	
Discoveries	3 000
Upward reappraisals	1 400
Reclassifications	
Reductions in stocks	
Extraction	700
Catastrophic losses	
Downward reappraisals	10 200
Reclassifications	
Closing stock	13 500

During the year a new coal deposit is discovered and made ready for extraction. It contains 3 million tonnes of coal

The geologic survey discovers that their previous estimate of the coal deposit underestimates the stock by 1.4 million tonnes.

The extraction of coal by the mining company was 0.7 million tonnes

Due to a new ambitious climate change policy, the government decides that half of the available coal resources must stay in the ground, never to be extracted. This decision applies to the coal deposits as of the beginning of the year.

An earthquake totally destroys a mining site, which makes it uneconomically in the foreseen future to extract coal from this site. It was otherwise expected that 0.2 million tonnes of coal could have been extracted from this mining site.

Exercise – monetary asset account / NPV

See worksheet for scenario!

Estimate the following:

1) Gross operating surplus for the past accounting year
2) User costs of capital/produced assets for the past accounting year (depreciation + returns to produced assets)
3) Resource rent per tonne of coal extracted for the past accounting year
4) Asset life of the coal deposit
5) Projected stream of resource rent over the asset life (expected tonnes extracted per year x expected resource rent per tonne)
6) Discount factors for each year of the asset life (at 3% & at 11%)
7) Net present value of the coal deposit at the beginning of the accounting period
8) Interpretation: What does a discount rate of 3% vs 11% say about our time preferences?

Monetary asset account / NPV – solution #1

Estimate the following:

1) Gross operating surplus for the past accounting year

Assume extraction of 200 tonnes per year ; output price of $250/tonne ; intermediate costs of $140/tonne ; compensation of employees of $30/tonne

Output (sales of extracted environmental assets at basic pric excludes taxes on products)
Less Operating costs
Intermediate consumption (input costs of goods and se
Compensation of employees (input costs for labour)
Other taxes on production plus other subsidies on proc
Equals **Gross operating surplus—SNA basis**[a]
Less Specific subsidies on extraction
Plus Specific taxes on extraction
Equals **Gross operating surplus—for the derivation of reso**
Less **User costs of produced assets**
Consumption of fixed capital (depreciation) + return to
Equals **Resource rent**
Depletion + net return to environmental assets[b]

Output = 200 * $250

Less operating costs

Intermediate consumption = 200 * $140

Compensation of employees = 200 * $30

Other taxes plus subsidies = 200 * $0

Equals GOS = $16 000

Monetary asset account / NPV – solution #2

Estimate the following:

2) User costs of produced assets, i.e. user costs of produced capital

Produced assets are valued at $100,000. Costs of produced assets involve deprecation at a rate of 4% and a return on produced assets/capital of 6%.

Depreciation, i.e. consumption of fixed capital/produced assets	=$100 000 * .04
Plus	Plus
Returns to produced assets	=$100 000 * .06
Equals costs of produced assets	Equals $10 000

Monetary asset account / NPV – solution #3

Estimate the following:

3) Resource rent per tonne of coal extracted for the past accounting year

Gross operating surplus	=$16 000
Less	Minus
Costs of produced assets	=$10 000
Equals resource rent	Equals $6 000
	$6 000 divided by 200 equals **$30/tonne**

Monetary asset account / NPV – solution #4/5

Estimate the following:

4) Asset life

Total deposits	=1 200 tonnes
divided by	Divided by
Annual extraction	200 tonnes
Equals asset life	= **6 years**

5) Projected stream of resource rent over asset life

Tonnes extracted per year	=200 tonnes
multiplied by	Multiplied by
Expected resource rent/year/tonne	$30
	= **$6 000 per year**

Monetary asset account / NPV – solution #6

Estimate the following:

6) Discount factors for each year of the asset life (at 3% and at 11%)

$$NPV = \sum_{t=1}^{T} \frac{RR_1}{(1+r_i)^t}$$

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
@ 3%	1.03	1.0609	1.0927	1.1126	1.1592	1.1940
@11%	1.11	1.2321	1.3676	1.5181	1.6851	1.8704

Monetary asset account / NPV – solution #7

Estimate the following:

7) Net present value of the deposit at the beginning of the accounting period

Resource rent per year is $6 000

$$NPV = \sum_{t=1}^{T} \frac{RR_1}{(1+r_i)^t}$$

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	NPV
@ 3%	5 825	5 656	5 491	5 331	5 176	5 025	32 503
@11%	5 406	4 870	4 387	3 953	3 561	3 208	25 381

Monetary asset account / NPV – solution #8

Interpretation

8) What does a discount rate of 3% vs 11% say about the weight we put on future generations?

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	NPV
@ 3%	5 825	5 656	5 491	5 331	5 176	5 025	32 503
@11%	5 406	4 870	4 387	3 953	3 561	3 208	25 381

High discount rate = put less weight on the future

Low discount rate = put more weight on the future (need to safeguard assets)