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Steinbeis Innovation Center
Logistics and Sustainability

“CARBON AND WATER FOOTPRINT” LEARNING MODULE

NOTES FOR TRAINERS/TEACHERS

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NOTES FOR TRAINERS/TEACHERS

LEARNING MODULE CONTEXT

The learning module relating to the topic of “carbon and water footprint” is aligned to the contents of the occupational profile position “Environmental protection” in the general training plan for vocational education and training in the occupation of freight forwarding and logistics services clerk.

The avoidance of environmental pollution caused by the company within the occupational sphere of influence is considered and explored within the scope of the occupational profile position “Environmental protection”. The contents of this thematic area are possible instances of environmental pollution caused by the company providing training and environmental protection regulations that are applicable to the company. Opportunities for efficient and environmentally friendly use of energy and materials as well as strategies for waste avoidance and disposal can also be explored within the scope of this occupational profile position.

The focus of the learning module is based on the playful familiarisation with the concepts of “virtual water” and "footprint". Another issue that is the addressed is calculation of a carbon footprint in accordance with the DIN EN 16258 standard, which applies to the transport and logistics sector.

CONTENTS OF THE LEARNING MODULE

People have always used and consumed natural resources to meet their needs whilst at the same time producing waste products that are harmful to the environment. Against this background and in order to secure a livelihood for future generations, an attempt is made to identify the impacts of private and business behaviour on the environment. There is a reason why a basic principle of management states: "If you can't measure it, you can't control it."

In order to protect the environment, political institutions have been stipulating maximum levels, reduction targets and threshold values for a number of decades. The transport and logistics sector is also measured on the basis of values of this nature. It has also embraced the notion of "green logistics" and pursues the objective of creating logistics processes that are friendlier to the environment and have less impact on resources.

In the transport and logistics sector, the ecological dimension of sustainability is primarily measured via greenhouse gas (GHG) accounting. Greenhouse gases are released throughout the whole of the logistics chain. According to the Kyoto Protocol, a distinction is drawn between six different greenhouse gases. These are methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and carbon dioxide (CO_2). In the interest of better comparability, these emissions are expressed in so-called CO_2 equivalents. The "Global Warming Potential" (GWP) of the respective gas is used to convert the different greenhouse gas emissions into CO_2. The higher this potential, the greater the contribution made to global warming by the greenhouse gas will be.

Since March 2013, the DIN EN 16258 standard has stipulated a uniform way of calculating and declaring energy consumption and greenhouse gas emissions from transport services. A distinction is drawn in the calculation between direct and indirect emission. Every instance of transportation of goods or persons generates direct greenhouse gases. The extent of the emission depends on the type of vehicle, the load weight, the transport distance, and fuel consumption. Indirect emissions, on the other hand, have already been produced via such processes as the generation of electricity and manufacture of fuel. These procedures also require energy and therefore release greenhouse gases. When considering emissions created by logistics services, therefore, a differentiation is made between the following three process sections:

Figure: Process sections for the calculation of GHG emissions from transport services in accordance with DIN EN 16258

Like every European Standard (EN) or German Industry Standard (Deutsche Industrie Norm, DIN), DIN EN 16258 is not legally binding. However, even though implementation is voluntary, its application is becoming ever more relevant against a background of rising political and social pressure. In November 2018, for example, the German Federal Government published its Climate Protection Report for the year just ending. This report indicates that Germany will fail to meet its climate protection target for the year 2020 if further measures aimed at reducing greenhouse gas emissions are not instigated. The declared aim for 2020 is to achieve a fall of at least 40 per cent in national greenhouse gas emissions as compared to the year 1990. This figure represents an overall decrease of around 500 million tonnes of CO_2 equivalents. The transport sector in particular, however, has not thus far succeeded in reducing its emission by the expected amount. Instead of contributing reductions of between seven and ten million tonnes of CO_2 equivalents, the branch has at most achieved a decrease of 1.6 million tonnes of CO_2 equivalents. The challenge that transport and logistics service providers face in terms of reducing emissions is being exacerbated by rising competitive pressure at two levels. On the one hand, companies are seeking to operate in a cost-efficient manner in order to secure their own market share. On the other hand, however, competitors are beginning to set new standards with regard to transparent reporting. The question that thus arises is how long it will take before the European standard becomes an International Standard (ISO) and greenhouse gas accounting becomes mandatory.

Alongside company fields of activity in the transport and logistics sector, greenhouse gas emissions also represent an important benchmark for sustainable behaviour in people's private lives. A person's carbon footprint expresses the quantity of greenhouse gas emissions that have been caused by their specific actions. This is a single-dimensional approach towards ecological accounting, which enables individual emissions to be calculated via observation of private spheres of life (e.g. diet, mobility, or consumer goods). The outcome of the calculation is designated as being a person's individual carbon footprint. Someone who lives in a climate friendlier way will produce a smaller carbon footprint.

As well as looking at pollution to the resource of "air", the intention is also to focus on a further natural resource in the form of "water". Although the transport and logistics sector is only able to exert an indirect influence on consumption of the resource of water, the need for water is of enormous significance in the manufacturing process of the products to be transported. The amount of water required for the complete production process is also measured via a unit which has been specially derived for the purpose – "virtual water". "Virtual water" refers to the total quantity of water which is evaporated, consumed, or polluted during the process of manufacturing a product or creating a service. Around 15,500 litres of water are, for example, consumed during the process of producing a kilo of beef. In this case, the water consumed is made up of the water directly drunk by the animals and of the water indirectly used to grow the feed. The "virtual water" model acts as a kind of aid to render the influence of this resource both measurable and comparable. "Virtual water" is also split up in a way similar to the division into process sections made when measuring greenhouse gas emissions. The three colours green, blue and grey are used, each colour representing the type of water consumed.

Rainwater
that is stored in the ground and absorbed by plants.

Groundwater
or water from rivers and lakes that is used in the manufacture of a product but can no longer be returned.

Contaminated water
(from the manufacturing process) that would be required for dilution to restore the water quality of the contaminated water.

Figure: Types of "virtual water"

The different colours of the "virtual water" provide information on the degree of damage to the environment caused by the consumption of the water. From an ecological perspective, it is desirable to consume as high a proportion as possible of green water. Blue water is particularly used for industrial manufacturing processes and in households. It also includes water needed to irrigate agricultural land, which is subsequently converted by plants or else evaporates. This means that such water is also removed from the natural water cycle. Planting corn, for example, involves using 77 per cent green water. The corresponding figure for tomatoes is 50 per cent. These numbers are arrived at by taking regional circumstances into account. Spain, the main cultivation area for tomatoes, does not have sufficient rainwater to irrigate the tomatoes naturally. The virtual water footprint thus states which quantity of which type of water is lost during the process of manufacturing a product.

As well as creating water footprints for individual products, it is also possible to develop a virtual water footprint for companies or for entire countries. This footprint takes account of the quantity of water needed to produce goods. Such water may be derived directly from local resources or be taken indirectly from the water resources of countries of origin. Germany's annual virtual water footprint, for example, comprises 92 billion cubic metres of water used for the domestic production of goods and 106 billion cubic metres of water consumed for goods that are produced abroad and then imported.

In conclusion, it should be noted that both the water and the carbon footprint are useful concepts in terms of recording the complex correlations of water consumption and emission of greenhouse gases. They make it possible to draw a comparison between different options for action. The conclusions and consequences of such a comparison must, however, be arrived at individually and in accordance with the management principle referred to above: "We can measure it and can therefore control it."

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SUMMARY OF THE "CARBON FOOTPRINT CALCULATION IN ACCORDANCE WITH DIN EN 16258" LEARNING MODULE

Classification under training regulation: Environmental protection

Topic: Carbon water footprint

Type of learning task: Basic learning task

Learning venues: Workplace, company, or classroom

Learning arrangements: Individual work

Target competencies:

- The trainees calculate the energy consumption and greenhouse gas emissions of transport services in accordance with DIN EN 16258.
- The trainees evaluate transport services on the basis of their calculation in accordance with DIN EN 16258.
- The trainees explore the benefits and drawbacks of the calculation of energy consumption and greenhouse gas emissions in accordance with DIN EN 16258 for their company.

Brief description and module context:

The trainees begin by using an information text to look closely at the DIN EN 16258 standard. In their own words, they then explain the specialist abbreviations that are used. Learners are then tasked with two sample assignments relating to the calculation of energy consumption and greenhouse gas emissions in accordance with DIN EN 16258. Their first assignment is to understand these calculations. As the task progresses, the trainees work independently to produce four calculations relating to energy consumption and greenhouse emissions at different transport companies. They evaluate these companies based on the results of their calculations. The trainees conclude by considering the practicality and usefulness of energy consumption and greenhouse gas emissions calculations in accordance with DIN EN 16258 for their company.

This module serves as the basis for tackling a further module on the topic of "Water and carbon footprint". The focus of the following module is based on a playful familiarisation with the concepts of the water and carbon footprint.

Contents and tasks:

- Theoretical analysis of DIN EN 16258
- Description of specialist terminology (e.g. greenhouse gases, CO_2 equivalents, direct and indirect emissions, calculation approach based on consumption and distance)
- Performance and evaluation of energy consumption and greenhouse gas emission calculations in accordance with DIN EN 16258
- Practice-oriented reflection on the energy consumption and greenhouse gas emission calculations

Materials required:

- Pocket calculator
- PC with Internet access
- Copy of DIN EN 16258 if available

LEARNING PHASES	SEQUENCE OF ACTIVITIES FOR LEARNERS	EXPLANATION OF LEARNING METHODS AND TECHNIQUES	NOTES ON RESOURCES
ALL LEARNING PHASES ARE WELL-SUITED TO BE WORKED ON INDIVIDUALLY			
INTRODUCTORY PHASE	Before the trainees are able to undertake their own calculations of energy consumption and greenhouse gas emissions, they begin by using an information text to look closely at the DIN EN 16258 standard. They then use their own words to explain relevant abbreviations.	The trainees are provided with a text on the calculation of greenhouse gas emissions using DIN EN 16258 and with the DSLV Guide (*see Material 1*)*. The trainees are provided with a template for the individual definition of relevant abbreviations *(see Material 2)**.	During this phase, it would be useful for trainees to have access to a computer with an Internet connection so that any necessary research can be carried out. The trainees can also be issued with a copy of DIN EN 16258 if the company has one at hand.
DEVELOPMENT PHASE	Once the trainees have undertaken a theoretical analysis of DIN EN 16258, they use the understanding of various sample calculations that they have obtained to draw up a fundamental scheme for the calculation of the energy consumption and greenhouse gas emissions of transport services. The trainees then use selected approaches described in DIN EN 16258 and various calculation and text-based tasks to link up their results with the contents described in the information text.	The trainees are provided with examples of calculations in accordance with DIN EN 16258 *(see Material 3)**. The trainees are provided with tables of energy and emission factors and with tables of key consumption indicators per tonne kilometre for specific energy consumption by lorries and container transport *(see Material 4)**.	During this phase, it would be useful for trainees to have access to a computer with an Internet connection so that any necessary research can be carried out. A pocket calculator should also be available to the trainees during this phase. At this point, the trainees should be provided with the correct answers to the calculation tasks so that they can check their own work independently *(see Annex)**.
REFLECTION PHASE	After they have performed their own energy consumption and greenhouse gas emission calculations, the trainees reflect upon DIN EN 16258 in a practice-oriented way.	This practical reflection on the energy consumption and greenhouse gas emission calculations is encouraged by giving the trainees key questions to consider *(see Notes 1 & 2)**.	

** see notes for trainees*

ANNEX TO THE "CARBON FOOTPRINT CALCULATION IN ACCORDANCE WITH DIN EN 16258" LEARNING MODULE

ANSWERS TO THE CALCULATIONS:

LORRY

1) **Identification of parameters for the calculation**

Type of goods:	Bulk cargo
Class of lorry:	Articulated lorry 24–40 tonnes
Consumption data:	0.027 litres/1,000 km *(see Table 2, "Level" column since the route does not contain any significant climb)*
Transport distance:	430 km
Transport weight:	12 tonnes

Calculation of energy consumption

F [litres] = W [t] x D [km] x E [litres/1,000 km] = 12 t x 430 km x 0.027 litres/1,000 km = 139.32 l

2) **Tank-to-wheel energy consumption**

Formula: $E_T = F \times e_T$

$E_T = 139.32\ \text{l} \times 35.7\ \text{MJ/l} = 4{,}974\ \text{MJ}$

Well-to-wheel energy consumption

Formula: $E_W = F \times e_W$

$E_W = 139.32\ \text{l} \times 44.4\ \text{MJ/l} = 6{,}186\ \text{MJ}$

Tank-to-wheel greenhouse gas emissions

Formula: $G_T = F \times g_T$

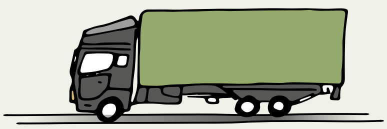
$G_T = 139.32\ \text{l} \times 2.49\ \text{kg}\ CO_2e/\text{l} = 347\ \text{kg}\ CO_2e$

Well-to-wheel greenhouse gas emissions

Formula: $G_W = F \times g_W$

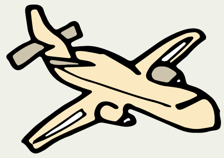
$G_W = 139.32\ \text{l} \times 3.15\ \text{kg}\ CO_2e/\text{l} = 439\ \text{kg}\ CO_2e$

3) **This is a distance-based calculation approach as details on the specific energy consumption are not available.**



AIRCRAFT

The respective energy and emission factors are provided in Table 1.
Please note: the correct unit for kerosene consumption is kilogrammes rather than litres.



4) Tank-to-wheel energy consumption

Formula: $E_T = F \times e_T$

$E_T = 117$ kg x 44.1 MJ/kg = 5,160 MJ

Well-to-wheel energy consumption

Formula: $E_W = F \times e_W$

$E_W = 117$ kg x 52.5 MJ/kg = 6,143 MJ

Tank-to-wheel greenhouse gas emissions

Formula: $G_T = F \times g_T$

$G_T = 117$ kg x 3.18 kg CO_2e/kg = 372 kg CO_2e

Well-to-wheel greenhouse gas emissions

Formula: $G_W = F \times g_W$

$G_W = 117$ kg x 3.88 kg CO_2e/kg = 454 kg CO_2e

GOODS TRAIN

5) Tank-to-wheel energy consumption

Formula: $E_T = F \times e_T$

$E_T = 4{,}850$ kWh x 3.6 MJ/kWh = 17,460 MJ

Well-to-wheel energy consumption

Formula: $E_W = F \times e_W$

$E_W = 4{,}850$ kWh x 11.1 MJ/kWh = 53,835 MJ

Tank-to-wheel greenhouse gas emissions

Formula: $G_T = F \times g_T$

$G_T = 4{,}850$ kWh x 0 kg CO_2e/kWh = 0.0 kg CO_2e

Well-to-wheel greenhouse gas emissions

Formula: $G_W = F \times g_W$

$G_W = 4{,}850$ kWh x 0.574 kg CO_2e/kWh = 2,784 kg CO_2e

6) Tank-to-wheel energy consumption

Formula: $E_T = F \times e_T$

$E_T = 4{,}850$ kWh x 3.6 MJ/kWh = 17,460 MJ

Well-to-wheel energy consumption

Formula: $E_W = F \times e_W$

$E_W = 4{,}850$ kWh x 4.0 MJ/kWh = 19,400 MJ

Tank-to-wheel greenhouse gas emissions

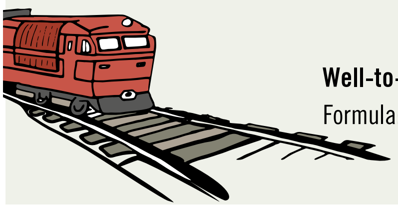
Formula: $G_T = F \times g_T$

$G_T = 4{,}850$ kWh x 0 kg CO_2e/kWh = 0.0 kg CO_2e

Well-to-wheel greenhouse gas emissions

Formula: $G_W = F \times gW$

$G_W = 4{,}850$ kWh x 0.004 kg CO_2e/kWh = 19.4 kg CO_2e



The values for the well-to-wheel sections in Sweden are clearly much lower. This means that there are significant differences in the electricity supply between Germany and Sweden, although consumption of electricity does not vary. Despite the same level of consumption (4,850 kWh), 34,435 MJ less were needed for energy provision in Sweden and 2,764.5 kg less CO_2 equivalents were emitted. The reason for this is that all traction current in Sweden is produced using hydropower.

BIODIESEL

8) **Tank-to-wheel energy consumption**

Formula: $E_T = F \times e_T$

$E_T = 207.89 \text{ l} \times 32.8 \text{ MJ/l} = 6{,}819 \text{ MJ}$

Well-to-wheel energy consumption

Formula: $E_W = F \times e_W$

$E_W = 207.89 \text{ l} \times 68.5 \text{ MJ/l} = 14{,}240 \text{ MJ}$

Tank-to-wheel greenhouse gas emissions

Formula: $G_T = F \times g_T$

$G_T = 207.89 \text{ l} \times 0 \text{ kg } CO_2\text{e/l} = 0 \text{ kg } CO_2\text{e}$

Well-to-wheel greenhouse gas emissions

Formula: $G_W = F \times g_W$

$G_W = 207.89 \text{ l} \times 1.92 \text{ kg } CO_2\text{e/l} = 399 \text{ kg } CO_2\text{e}$

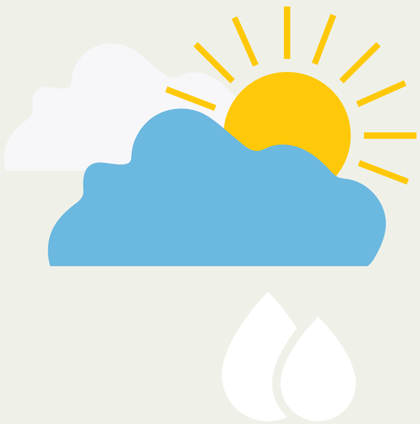
9)

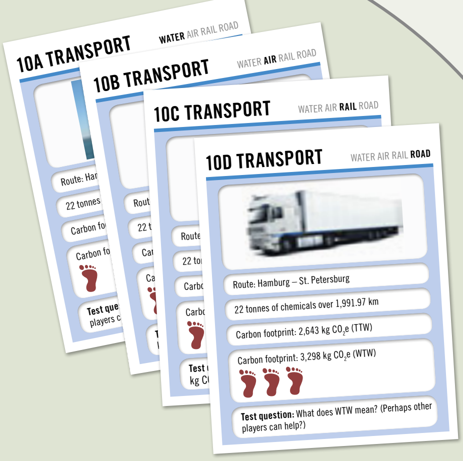
	Diesel from Germany	Biodiesel	Comment
E_T	6,819 MJ	6,819 MJ	Remained the same. 1 litre of biodiesel replaces around 0.92 litres of diesel > if the litre consumption is slightly higher, the same amount of energy is consumed given the same route and the same conditions.
E_W	8,480 MJ	14,240 MJ	Much higher energy consumption than in the case of biodiesel. This is because energy provision is included in the calculation, and the production of biodiesel requires more energy. This is readily apparent from the energy factor in Table 1.
G_T	476 kg CO_2e	0 kg CO_2e	Reduced to 0 in the case of biodiesel. This is because no CO_2 equivalents are emitted in the energy conversion.
G_W	602 kg CO_2e	399 kg CO_2e	Reduced by 44 per cent to 399 kg in the case of biodiesel. This is because energy provision is added into the calculation in the well-to-wheel section. CO_2 equivalents are emitted, even in the case of biodiesel.

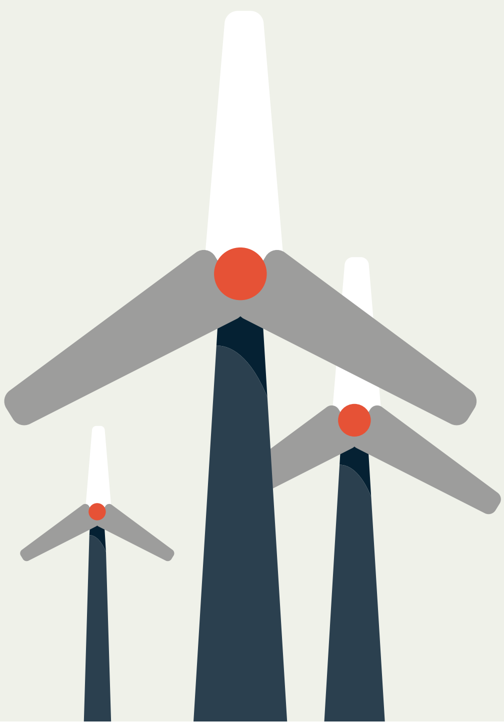
10) **Open-ended task;**

> Possible arguments:

- Better carbon footprint in respect of consumption (benefit)
- Considerable use of land including deployment of pesticides (drawback)




10A TRANSPORT
WATER AIR RAIL ROAD
10B TRANSPORT
WATER AIR RAIL ROAD
10C TRANSPORT
WATER AIR RAIL ROAD
10D TRANSPORT
WATER AIR RAIL ROAD
Route: Hamburg – St. Petersburg
22 tonnes of chemicals over 1,991.97 km
Carbon footprint: 2,643 kg CO_2e (TTW)
Carbon footprint: 3,298 kg CO_2e (WTW)
Test question: What does WTW mean? (Perhaps other players can help?)



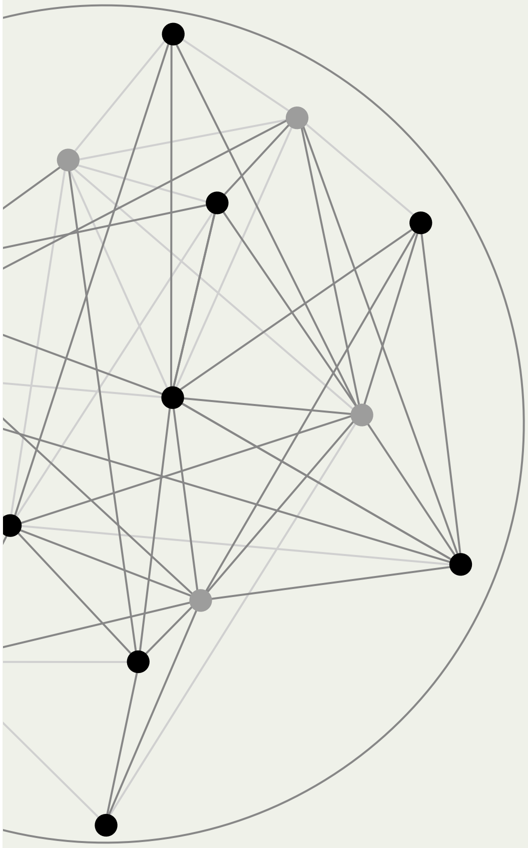
SUMMARY OF THE "THE NATURAL QUARTETS" LEARNING MODULE

Classification under training regulation:	Environmental protection
Topic:	Carbon water footprint
Type of learning task:	Link-up learning task
Learning venues:	Company or classroom
Learning arrangements:	Pairs or group work
Target competencies:	- The trainees use examples to describe the concepts of the carbon and water footprint in order to represent the ecological impacts of personal and company actions. - The trainees use the carbon and water footprint concepts to reflect on the ecological impacts of personal and company actions.
Brief description and module context:	The trainees begin by learning the rules of a quartets game that relates to the carbon and water footprint. They also become familiar with the concept of "virtual water". They then play the game "The Natural Quartets" in pairs or groups (between two and a maximum of five participants). Trainees are able to playfully familiarise themselves with the concepts of the carbon and water footprint. They use examples of everyday products and services to create links between the concepts and their own personal and working lives. The trainees finish by creating a personal "encyclopedia"", in which they record relevant terms and describe these using examples from the quartets game and from their own life experience. This module uses examples to focus on the concepts of the carbon and water footprint and facilitates play-based reflection on the ecological impacts of personal and company actions.
Contents and tasks:	- A playful familiarisation withthe concepts of the carbon and water footprint - Creation of own encyclopedia of relevant terminology relating to the concepts of the carbon and water footprint - Play-based reflection on the ecological impacts of personal and company actions
Materials required:	- PC with Internet access - Scissors

LEARNING PHASES	SEQUENCE OF ACTIVITIES FOR LEARNERS	EXPLANATION OF LEARNING METHODS AND TECHNIQUES	NOTES ON RESOURCES
ALL LEARNING PHASES ARE WELL-SUITED TO BE WORKED ON IN PAIRS OR GROUPS			
INTRODUCTORY PHASE	Before the trainees begin to play the quartets game, it is important for them to read through the rules together so that any possible queries can be jointly resolved beforehand. The trainees will also need to stipulate the time limit for the game prior to starting it. The rules contain various possible versions that allow the duration of the game to be adjusted.	The trainees are given an explanation of how to play the game. This is also included in the rules *(see Note 1)**.	It would be useful for trainees to have access to a computer with an Internet connection so that any necessary research can be carried out regarding questions that may arise.
DEVELOPMENT PHASE	The trainees play the quartets game.	When playing the game, the trainees are confronted with terminology relating to the concepts of the carbon and water footprint. Test questions encourage them to explain the backgrounds behind these concepts. They are also called upon to estimate the impact of individual everyday actions (e.g. average amount of pizza eaten or the carbon footprint created by a short-haul flight). This process gives the trainees an opportunity to think about their own consumer habits.	
REFLECTION PHASE	Once the trainees have played the quartets game, they individually record the terms learned and examples discussed in the form of an encyclopedia.	The trainees are provided with key questions to help them compile their encyclopedias *(see Note 2)**.	It would be useful for trainees to have access to a computer with an Internet connection. This will enable them to draw up their encyclopedia in an electronic format and will facilitate future additions or corrections.

** see Notes for Trainees/Students*

Figure: The Natural Quartets



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