THE IMPACT OF ENERGY AVAILABILITY
ON CITY TRAFFIC AND DEVELOPMENT

I. Historic development

Throughout European history, the city, and especially the city center, has been and still remains the intellectual, economic and cultural center of a region. Aside from this, the cities are markets for employment, goods, information and entertainment. In the past the surface area of cities was limited by the trip length of the available transport medium. The trip length, in turn, depends in each case on the type of drive available. In early history, human or animal power was the only type of drive. Since legs were the only mode of transport for the masses, cities were limited to a circle of 4 kilometers diameter or to a surface area of 12.5 square kilometers, as, for example, Rome at the time of Caesar, where every point in the city could still be reached on foot. One lived and worked at the same place. Energy was not required to cope with traffic.

It was only with the beginning of industrialization at the start of the 19th Century, that the conditions changed, first through the introduction of the horse-drawn tram, later the coal-powered railway. The inhabitants moved into densely built-up residential areas near suburban railways. A division of the "living" and "working" functions took place. For instance, London's old city lost 80% of its inhabitants between 1850 and 1910. Due to this outward drift and migration of the rural population, large conurbations developed in the old form extending ribbon-like along the suburban railways.

At the turn of the century, both travelling speed and trip length increased due to the introduction of electric drive. Aside from this, emission free electric drive made traffic
in tunnels possible which signalled the birth of the subways. Cities were opened up effectively with overground S-Bahn systems and underground subways, even though high investment costs were necessary. The cities further expanded along the axes of the rail rapid transit systems. Because of the large concentration of passengers in a train, the amount of energy used is relatively small; energy in transportation is based on coal as primary source energy.

With the development of the car, the growth of the cities changed, first slowly and then later with increasing rapidity. The ribbonlike expansions became spread-out areas. First the omnibus and then later the car opened up the spaces between the rail corridors and as a result of their travelling speeds and therefore extended trip length have extended the cities further. Energy consumption per person transported is getting larger because:

a) modes of transport are getting more and more individual and smaller and
b) trip length is getting ever larger.

As a basis for transportation, oil has taken over from coal as primary energy source. And this brings us to today's problems, which are the result of the car in our cities and in our society.

II. Analysis of defects

It is not intended here to damn the car, which in any case would serve no purpose. One cannot imagine our society without cars, as they offer the people many advantages. The car, however, has not only advantages but also disadvantages, which caused a basic structural change with numerous negative effects in our cities. These negative
effects have to be recognised, so that they can be tempered or removed altogether.

What are the problems that concern us today?
- Due to the division of "living" and "working" additional traffic has been created.
- At the same time, due to urban expansion, trip lengths have increased.
- Due to the large number of commuters, traffic problems have been created in peak hours.
- The car promotes dissociation of social structure, which means that people with lower wages remain living in the city centers and the ones with higher wages move into the suburbs.
- Traffic noise and liability to accident make city centers uninhabitable for many people.
- The urban exodus is leading to the decline of city centers.
- The high level of energy requirement per person transported negatively affects the balance of trade to a considerable degree, especially in countries with few natural resources.
- The high cost of cars are a considerable burden on the public and private budgets.
- The attractiveness, service capabilities, travelling speed and also economic efficiency of the public modes of transport such as bus and tram are decreasing due to the infringements and competition of the car.

III. Possible solutions

It is intended at this conference to discuss the "effects of the energy shortage on city traffic and urban development".

Allow me to make a comment regarding this: Traffic and energy are only partial problems of today's urban development. The solution to these partial problems
has to be viewed in connection with the basic problem and the main target of all urban constructional planning:

To improve the quality of life of people living in a city.

Only if a secondary target positively contributes to the solution of the main target is it sensible to aim for it.

The first basic question must therefore be asked, whether an improvement of the traffic and energy problems of a city can contribute to the solution of the main target.

As can be seen from the catalogue of defects previously noted, individual means of transport affect the quality of life in a city quite considerably. Therefore reduction of this traffic is a substantial contribution towards achieving the main goal "quality of life".

The second basic question must now be asked:
How can private transport be reduced without affecting the functioning of the city?
As the development of cities up to now has resulted in a division of the functions "working - living - buying - recreation", individual means of transport cannot simply be reduced without any alternative, but must be replaced by other systems of transport. What other systems of transport are available as a replacement that, on the one hand do justice to the main target "quality of life", and on the other hand present a better solution to the secondary targets "traffic" and "energy".

Three systems present themselves for consideration:

1) Pedestrian zones
2) Bicycles
3) Public passenger transit

1. Pedestrian zones

Until the beginning of this century, the street served mainly as a market place and living area for the people. With the introduction of the car the street lost this function and the pedestrian has been pushed to the side. Aim of healthy urban development must be to give the street back its old function and to fight off the negative influence of the car. One should not, however, go to the other extreme of removing cars from our streets, but rather concepts have to be worked out for the city which will ensure a more effective functioning traffic operation. This requires:

1. arrangement of residential and traffic streets
2. the development of connected pedestrian zone networks between living, working, shopping and recreational districts
3. a new division of street cross-sections according to purpose and future task,

If the inhabitants of a city are offered a well built road network with controlled amounts of traffic, it is a considerable contribution towards minimising the negative effects of private transport and the individual will be prepared once again to used his legs as a mode of transport.

3. The bicycle

Some people today still see the bicycle as a backward, dated mode of transport.

It is however a fact that the bicycle, with regard to
energy consumption, environmental pollution, production costs, availability and travelling speeds, is without competition as a mode of transport.

The following points speak in favour of a bicycle system:

a) A bicyclist uses about 600 kilojoule/hour or 50 kilojoule/kilometer on level ground when travelling at 12 km/hour. When using a car, about 60 times the amount of energy per kilometer is used.

b) The energy used does not have to be imported, which means it does not affect the balance of payments adversely.

c) The production costs for a bicycle are low; production is possible in almost all countries as the technology is simple.

d) Travelling speed is relatively high at 12-15 km/hour; door to door transport is possible.

The purpose of a carefully aimed energy and transportation policy must be to create conditions favourable to the use of bicycles in cities; among others:

a) an unbroken network of bicycle paths connecting living, working, shopping and recreational areas.

b) If possible complete independence of the bicycle path network from private transportation.

c) Tax equality between bicyclists and car drivers.

d) Build up of a bicycle industry in developing countries.

Only when these conditions have been created, will the bicycle be accepted by the public as a method of mass transportation. However, naturally the necessary climatic and topographical conditions must exist.
3) **Public passenger transport systems**

Public passenger transport systems are often underestimated in their economic and socio-political importance. Because of this, the following significant factors are presented:

a) **Mobility:**
   - The population of a city - which after all does not only consist of car owners - is offered a reasonably priced possibility of transportation by the public passenger transport systems. This is particularly so for groups at an economic disadvantage (students, apprentices, women, old-age pensioners, disabled persons and unemployed).
   - The individual has the opportunity of choosing living and working areas to a large degree independent of each other.
   - In cases of crisis (external or internal emergency) all inhabitants have a system of transport at their disposal.

b) **Reducing the negative effects of private transportation**

A functional public passenger transport system is the precondition for a change in the modal-split, that means an increase in the share of total traffic in favour of public passenger transport, or a reduction of private transportation. Change of the modal-split in favour of public passenger transport means the following for cities:

- reduction of noise problems
- lowering of exhaust pollution
- fewer accidents and therefore a smaller burden on the economy
- reduction in requirements for traffic space
- less traffic volume on streets and therefore a greater degree of ease in attaining targets in the city as well as less interference with the omnibuses.
A spatial separation of public passenger transport from private transportation (light rail rapid transit, subways) would additionally achieve the following:

for public passenger transport systems:
- better transportation comfort, which means higher speeds, improved punctuality, a greater degree of security.

for private transportation:
- a better flow of traffic, therefore less energy consumption, higher level of road usage.

c) **Lower burden on the economy**

By shifting part of the traffic load (commuter traffic) from private automobiles to public passenger transport the following becomes possible:
- a more economical use of economic resources in short supply such as land, capital, energy and work
- saving of capital investment costs in road construction
- saving in operational costs of private transportation
  (police, traffic lights, garages and workshops etc.)
- reduction in maintenance costs of private transportation
  (repair of roadways)
- reduction in costs due to traffic jams (loss of time and car operational costs)
- reduction in reliance on oil imports.

d) **Importance to social and income policies**

By offering reasonably priced public passenger transport systems:
- the compulsion to use the considerably more expensive (to purchase as well as to operate) automobile is negated in many cases. Considerable savings are the result. The money thus saved is at the disposal of the private household for other necessities and therefore influ-
ences other sectors of the economy favourably.
- other groups of the population at an economic dis-
  advantage (as III.3a) have the same chance to get to
  educational, health and recreational facilities as
  car drivers.
- larger sections of the population have the same pur-
  chasing opportunity (shopping etc).
- opportunities of social contact within a region are
  improved.

e) Influence on the sector of urban development, space
  allocation and regional development

A good means of public passenger transport makes it
possible to:
- improve the living and recreational quality of cities
  and therefore to reduce the emigration of people outwards
  from the city.
- re-instate the central importance of city centers as
  market and trading places.
- reduce the volume of car traffic and to create controlled
  traffic zones (for example pedestrian zones).
- use the land opened up more intensively as a result of
  higher building density.
- promote settlement development along the public passenger
  transport corridors and control the planless settlement
  of a region.
- open up public service facilities better and thus promote
  more intensive use by a higher proportion of the popu-
  lation (swimming pools, libraries, sports grounds etc.)
- create efficient service and commercial organs as the
  radius of influence and circle of users will be increased.
Especially the construction of underground systems of
public passenger transport creates the opportunity to:

- change and improve the urban road network (for example by
  removing through traffic from residential areas).
- improve the utilities network (long distance heating etc.)
- improve already existing set ups
- realise goals of urban construction (pedestrian zones, bicycle paths, parks etc.)

IV. Analysis of energy economics of transportation systems

1. Energy balance of the Federal Republic of Germany

Of all the energy consumed in the year 1976, about 19% was used in the "traffic" sector. Of this share, street traffic was responsible for 86% or in other words 17% of the total energy consumed; other transport systems, rail, air traffic and inland shipping together only used 2%.

2. Comparison of the traction energy of the transportation systems

A comparison of the different transport systems is problematic, as each system operates under different basic conditions. In the Federal Republic of Germany, the energy consumed by car, bus and subway systems has been determined in the city of Hamburg.

The energy used was based on the transportation efficiency (person kilometer), as the transportation efficiency shows the manufactured quantity actually used. Fig. 1 shows the specific usage of traction energy based on one person kilometer:

The following fringe conditions apply:

bicyclist: 50 kilojoule/person/km on level ground at a speed of about 12 km/hour

pedestrian: 150 kilojoule/person/km on level ground and a speed of 4 km/hour.

subway passenger: 500 kilojoule/person/km with
travelling speeds of 30 km/hour and 15% of actual capacity used

bus passenger: 890 kilojoule/person/km with travelling speeds of 21.5 km/hour

car driver: 2800 kilojoule/person/km with travelling speeds of about 26 km/hour, occupation of car: 1.5 persons.

This shows that car drivers need considerably more energy for one kilometer than all other systems. This becomes even *more evident, when the weight of the vehicle is compared with the weight of the average number of passengers carried (picture 2). Travelling by car, the tenfold weight of the payload has to be moved in addition.

3. Total energy used by transport systems

Aside from the traction costs, the individual transportation systems consume a considerable amount of additional energy, which can only be touched on here.

The following factors should be taken into consideration for an over-all balance:

a) energy used during production of the vehicles
b) energy used during production of the roadways
c) energy used to maintain vehicles
d) energy used to maintain roadways
e) energy used for operation (lights etc.)
f) energy used for infrastructure (refineries, operational networks, gas stations, garages etc.)

If one takes all these factors into consideration, the consumption balance becomes even worse as far as the car user is concerned.

4. Availability of energy

To evaluate the individual transportation systems one
has to take into consideration the availability of energy. Pedestrians and bicyclists get their required energy from practically all domestically produced food stuffs.

Electrically driven transportation systems such as subways, railways, light rail rapid transit and O-buses can revert to the primary energy sources coal, water, gas, atomic power and oil depending on which is offered most economically. The omnibus and the car will still be dependent on mineral oil as their source of energy for a long time to come and are, therefore, very liable to disruption.

V. Areas of operation of the transportation systems

If one assumes, that in daily commuter transit a travelling time of longer than 45 minutes from living to working area is not acceptable, a certain application for each transportation system is the result as can be seen in Fig. 3.

In the following the same fringe conditions apply given medium travelling speeds as under IV.2.

pedestrian: from door to door 3 km

bicyclist: from door to door 9 km

bus user: 5 mins. each walking to and from bus stops and 35 mins. travelling time 12 km

subway user: 5 mins. each walking to and from stops and 35 mins. travelling time 16 km

car user: door to door 20 km
Area opened up by each of these transportation systems:

- pedestrian: 28 km²
- bicyclist: 255 km²
- bus user: 450 km²
- subway user: 800 km²
- car user: 1250 km²

VI. Summary

In short, the following can be determined:

- The energy offer has had and will in the future continue to have a considerable influence on urban development.

- The car has created considerable problems in our cities which are in urgent need of solution.

- Future urban planning has to give much more serious consideration to alternatives to the automobile.

These are:

a) pedestrian zones
b) bicycle paths
c) public passenger transport systems

- The energy consumption of the car user lies far above that of the user of other systems of transportation.

- Dependence on "oil" and the high economic costs will also in future present severe problems to individual countries.

- The general public, politicians, the government, industry, the city planners are called upon to do their part to turn our cities again into what they once were, the intellectual, cultural and economic center of a region, in which people can feel at home.
ENERGY CONSUMPTION OF TRANSPORTATION SYSTEMS

Kilo-Joule / Pers. Km

- Bicycle: 50
- Pedestrian: 150
- Subway: 500
- Bus: 900
- Car: 2800

Picture 1
Ratio between vehicle weight and weight of passengers carried on an average.

- Car: 10.62
- Bus: 4.35
- Bicycle: 4.05
- Pedestrian: 0.2

Transportation System

Vehicle Weight (kg)

Carried Weight (kg)
### Area of Application of the Transportation System

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<th>Mode</th>
<th>Distance (KM)</th>
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<tr>
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<td>Subway</td>
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### Area Opened Up

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*Picture 3*