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Innovative approaches to the reuse of asphalt pavements

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Why more focus on reuse of reclaimed asphalt (RAP)?

- Sustainability
- Climate changes
- Economy

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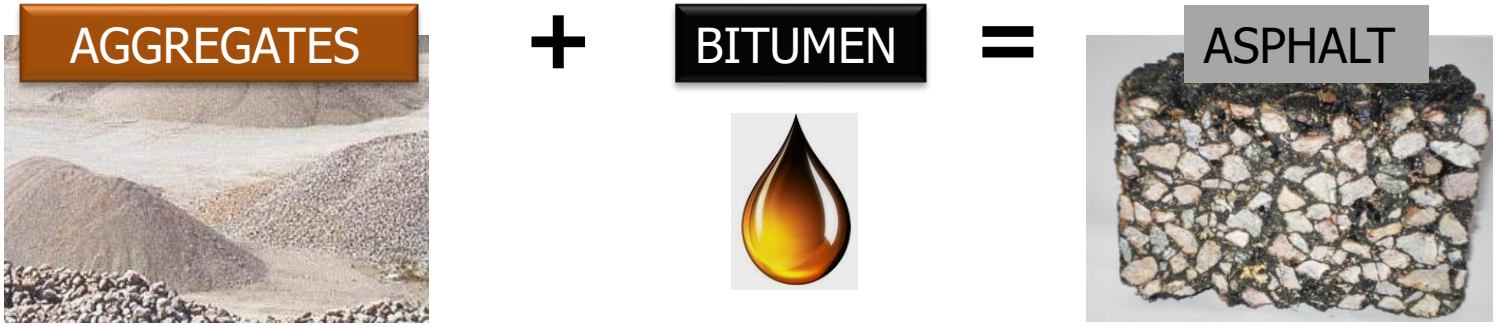
Asphalt: 100% recyclable



- Old hardened bitumen 'refreshed' with new soft bitumen/rejuvenator
- Aggregates in RAP similar to aggregates in new
- Thus: Reuse RAP in new hot-mix asphalt – Higher value than to reuse as gravel or land fill (where the binder is not reused)
- **RAP is a valuable resource – not waste!**

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EU approval of RAP?

- Product standards for asphalt (EN 13108-series):
  RAP is fully approved as constituent material

CE ✓

- EU waste directive:
  - Strive to avoid waste and deposit.
  - Recycle rather than reuse or deposit
  - Use at highest level of value chain! (here: asphalt wearing course)
  - Everyone – Road owners, consultants, producers/contractors are all responsible to allow more recycling/reuse

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Danish RAP experience and practice

(project start 2015)

- Good experience with RAP in asphalt base courses since 1980'es – Practical approach DK: No specified limitations, as long as the finished product fulfils same requirements as virgin asphalt

- Dense graded AC wearing courses: ≤ 30% RAP*

- SMA and opengraded AC: ≤ 15% RAP*

- ABB binder course for heavy traffic: 0% RAP

**) however seldomly accepted by DRD and road owners*

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THE POTENTIAL

ASPHALT PRODUCTION	2014	2015	2016
Total production, tons	3.720.000	3.720.000	3.820.000
RAP in % of total	19%	18%	20%
Base courses, tons	1.960.000	1.820.000	1.920.000
RAP in % of base courses	29%	29%	30%
Wearing courses, tons	1.760.000	1.900.000	1.900.000
RAP in % of wearing courses, t	8%	8%	10%

Clear potential for more recycling in asphalt wearing courses!

Especially SMA, but also ABB binder courses

'Circular Asphalt production in Denmark'

- R&D project carried out 2015 – 2018
- Supported by Danish Environmental Protection Agency
- Project budget: 800.000 Euro.
- Project partners from across the road sector:
  - YIT Denmark A/S (Asphalt contractor)
  - Danish Road Directorate
  - KL (Union of Danish municipalities)
  - Danish Asphalt Industry
  - Danish Technological Institute (project management)

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Project Goals

- More sustainable asphalt production: Higher content of reclaimed asphalt in the asphalt production.
- Environmental benefit: Reduced CO_2-emission – less global warming
- Socio-economic benefit: Reduced import of aggregates and bitumen
- Quality: Same quality and durability as virgin asphalt is a must!
- Implementation: DRD specifications to be revised accordingly

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OLD ASPHALT FOR RECYCLING

- Previous: Mixed RAP in large stockpiles (old base- and wearing courses)
- Wearing courses need RAP from old wearing courses (crushed rock)
- Special challenge for high-stability SMA and ABB.

Base courses

Local gravel

Crushed rock

Wearing courses

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RAP 'HARVESTING' (MILLING)

- Mill off and store wearing course RAP separately - Do not mix with base
- Keep wearing course RAP from large milling jobs seperately (smaller quantities in a 'mixed wearing course' RAP stockpile)
- Special, fine milling (extra milling 'teeth') will cause too much fines

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STORAGE AND PRODUCTION

- Store RAP at asphalt plants according to DEPA regulations (simple)
- Keep water content low: Store dry under roof and save energy/CO_2
- Asphalt plant modification may be needed
- Compensate for hardened RAP binder by use of soft bitumen (or rejuvenator) according to CEN-standards

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LABORATORY TESTING

- Very comprehensive laboratory test program carried out.
- Tests based on SMA and ABB– both based on crushed rock aggregates
- 20-30% RAP from wearing courses added (quantity dep. on grading)
- 2 types RAP (SMA-RAP and mixed AC-RAP) + Reference 0% RAP.
- Tests including Material stiffness, Rutting resistance, Durability (Fatigue test),Water sensitivity (ITSR, Modified Lottman), binder properties, binder rheology (DSR), FTIR etc.

Conclusion: Same values with/without 20-30% RAP from old wearing courses

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FULL SCALE DEMONSTRATION ON NEW MOTORWAY SECTION (2 KM TEST STRETCH)

ABB 16 with 0% and 25% RAP, SMA 11 with 0% and 30% RAP

- Same laboratory test values, including durability/fatigue test etc.
- Same visual appearance, texture, workability, level of compaction, evenness, skid resistance, CPX noise level etc.

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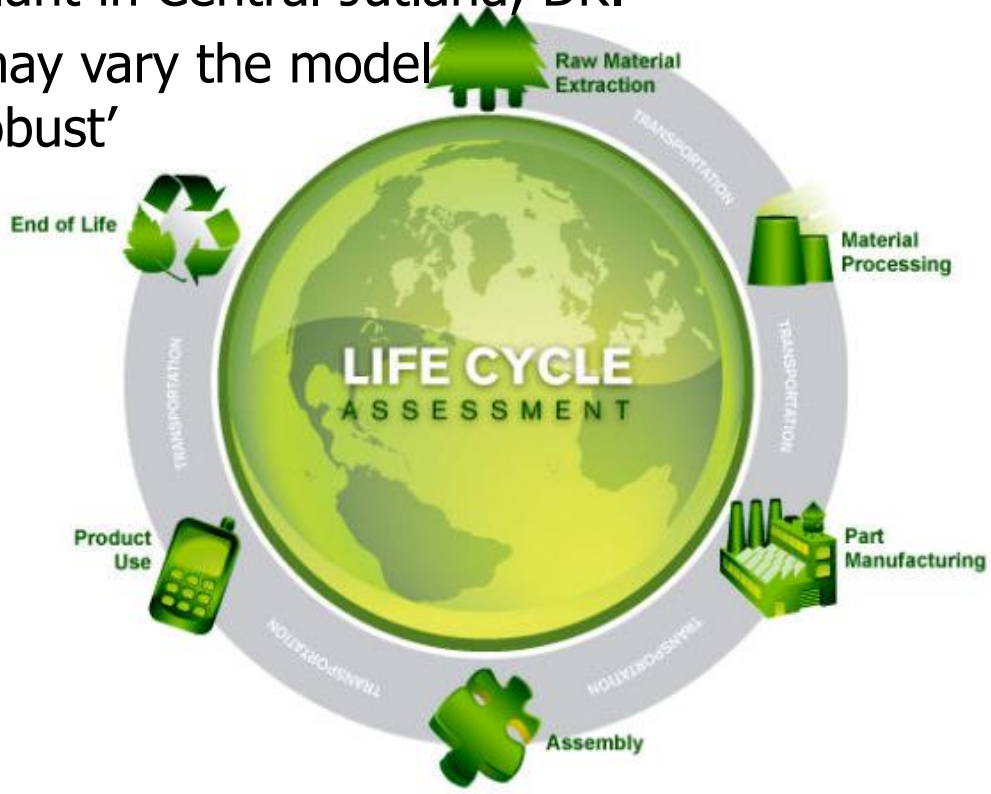
LCA (Life Cycle Assessment)

- Comprehensive LCA calculations performed
- LCA 'Cradle-to-gate' used as finished pavement documented to be the same with/without up to 30% RAP from wearing courses
- Calculations based on approved models and data (GaBi, ReCiPe)
- Basis for model is an asphalt plant in Central Jutland, DK.
- Although transport distances may vary the model is evaluated to be very 'robust'



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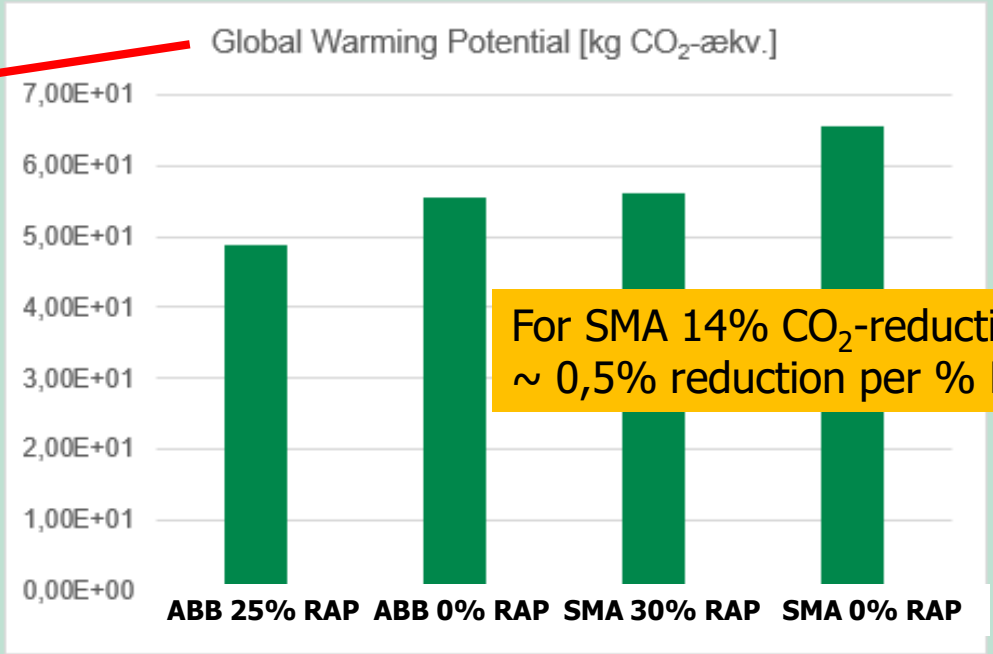
LCA result

Environmental impact from production af ABB with 0% and 25% RAP and SMA with 0% and 30% RAP (as motorway demonstration)

TABEL 15.1.4. Samlede LCA resultater

Parameter	Unit	AAB med GB	AAB uden GB	SMA med GB	SMA uden GB
GWP	[kg CO_2-eq.]	4,87E+01	5,56E+01	5,62E+01	6,55E+01
ODP	[kg CFC11-eq.]	2,68E-08	2,84E-10	2,69E-08	4,22E-10
AP	[kg SO_2-eq.]	1,53E-01	1,78E-01	1,84E-01	2,23E-01
EP	[kg $(PO_4)^{3-}$-eq.]	2,28E-02	2,58E-02	2,96E-02	3,50E-02
POCP	[kg ethene-eq.]	8,59E-03	1,40E-02	1,16E-02	1,88E-02
ADPE	[kg Sb-eq.]	8,08E-06	1,01E-05	3,31E-05	3,51E-05
ADPF	[MJ]	2,08E+03	2,59E+03	2,44E+03	3,07E+03
PERT	[MJ]	6,01E+01	7,04E+01	1,88E+02	1,98E+02
PENRT	[MJ]	2,11E+03	2,64E+03	2,49E+03	3,13E+03
FW	[m^3]	1,02E-01	1,25E-01	1,30E-01	1,57E-01
HWD	[kg]	4,68E-06	4,19E-06	6,51E-06	5,88E-06
NHWD	[kg]	4,70E+00	6,40E+00	1,63E+00	3,87E+00
RWD	[kg]	1,53E-02	1,93E-02	2,08E-02	2,53E-02

Som det fremgår af tabellen udviser asfalttyperne med genbrug, som forventet, (
miljøprofil (ca. 5-60 % lavere værdi) for alle kategorier, på nær "Nedbrydning af (
(ODP) og mængden af "Bortskaffet farligt affald" (HWD).



For SMA 14% CO_2-reduction
~ 0,5% reduction per % RAP

Calculated effects on a long row of different environmental aspects such as bio-diversity, ozone depletion, global warming (CO2), etc.

Effect even larger if environmental impact from RAP 'harvesting' (milling) is not included!

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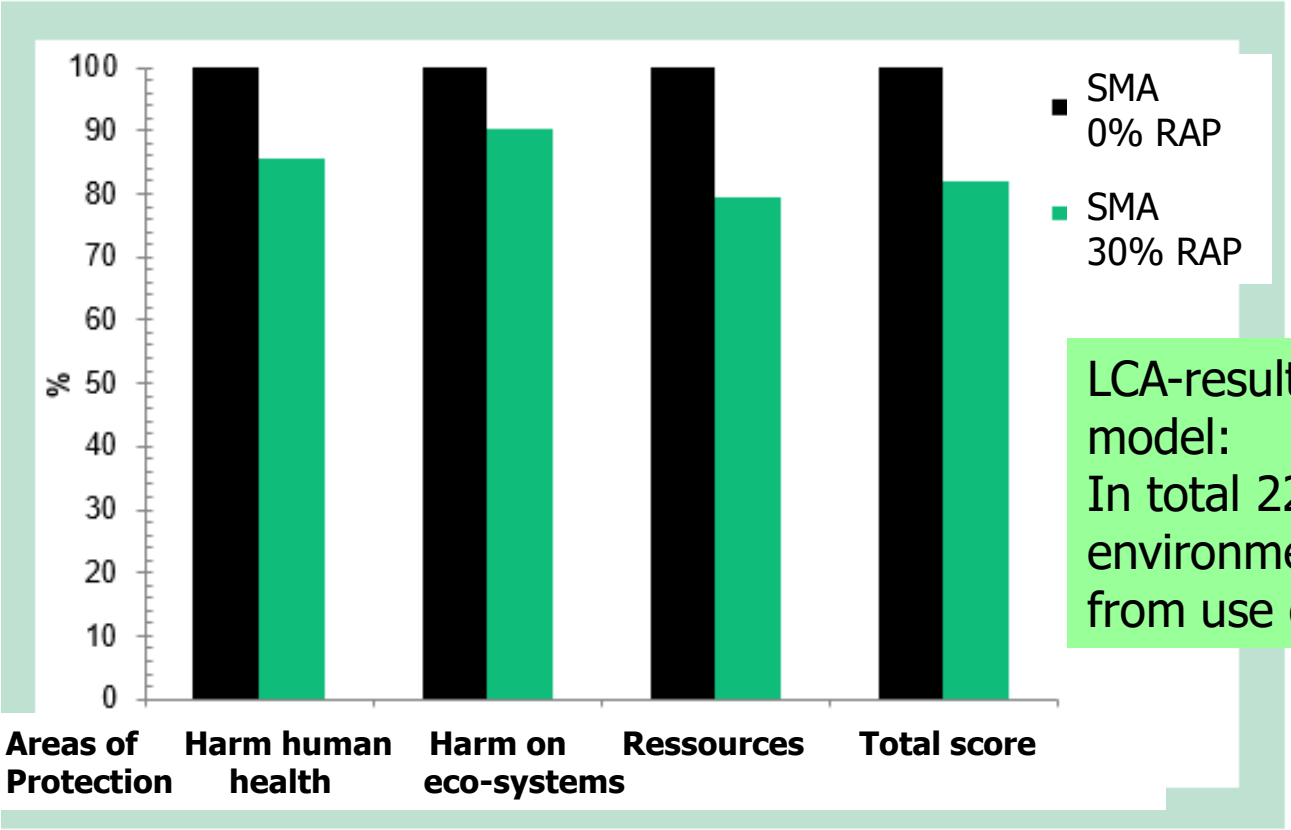
LCA – alternative single-score model, SMA



LCA-result, single-score model:
In total 22% reduced environmental impact from use of 30% RAP

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Socio-economic benefit of RAP

- LCC-calculations (life-cycle-cost) included
- Saved import of constituent materials contra local milling/transport works and plant modification costs
- Modelling difficult. Resource and production costs etc. are competition-sensitive information. Simple calculation showed 12% savings.
- Socio-economic benefit on national trade balance from import savings

Conclusion

- ✓ Large potential for increased use of RAP in wearing and binder causes.
- ✓ SMA and ABB: Add up to 30% RAP from wearing courses. Also valid for traditional AC-wearing courses
- ✓ Same functional properties and same expected durability
- ✓ 30% RAP in SMA/ABB: 14-22% reduction of CO_2 emissions!
- ✓ Socio-economic benefit: Reduced import of bitumen/rock aggregates
- ✓ In line with governmental strategy, environmental legislation etc.
- ✓ Everyone has a responsibility to strive for higher sustainability

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IMPLEMENTATION

Project result already implemented in Danish Road Directorate's 2019 asphalt works specifications (30% RAP allowed).

New system for future road work contracts expected.
System with bonus/penalty for environmental savings (CO_2 emissions)?

SEE RECLAIMED ASPHALT AS A VALUABLE RESOURCE
- NOT AS WASTE!

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THANK YOU! – QUESTIONS?

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