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IA-QUEST - (Indoor Air Quality Emission Simulation Tool) Won, D. Y.

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IA-QUEST (Indoor Air Quality Emission Simulation Tool)

IRC-ORAL-850

Won, D.

February 13, 2008

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NRC-CNRC

*Institute for
Research in
Construction*

IA-QUEST

(Indoor Air QUality Emission Simulation Tool)

D. Won

Feb 13, 2008



National Research
Council Canada

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de recherches Canada

Canada

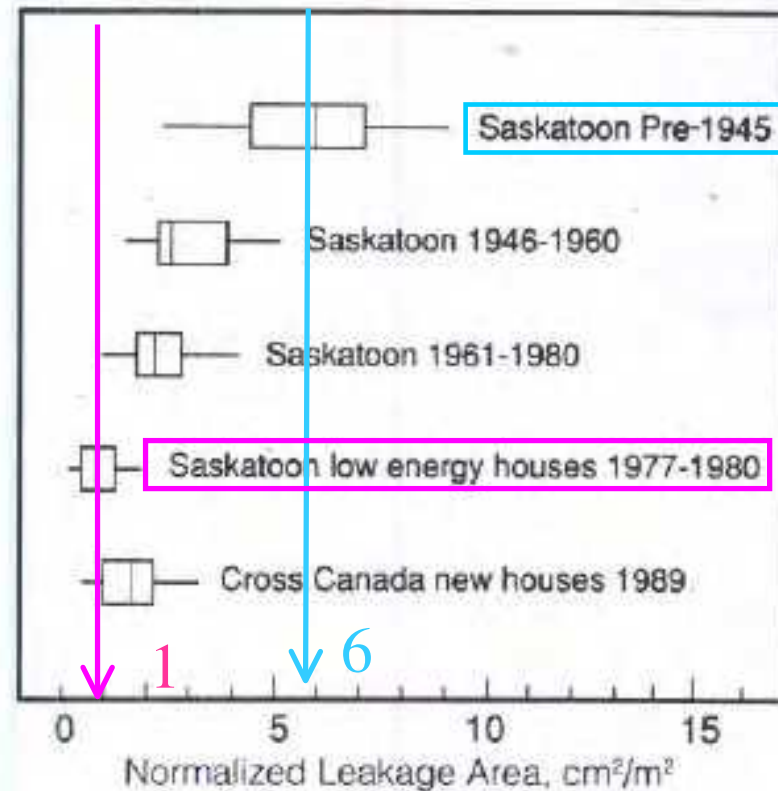
Contents

- **Background for IA-QUEST**
 - Importance of VOCs & Low-Emitting Materials
 - Material Emission Project (1996 – 2000, 2000-2004)
- **IA-QUEST**
 - Major features
 - Application scenarios

Why do we care about IAQ & VOCs?

- Volatile organic compounds (C & H)
 - Indoor >> Outdoor (US EPA)
 - 200-300 VOCs indoors
 - Health Effects: irritants, carcinogens, asthma
 - No standards for non-industrial sources

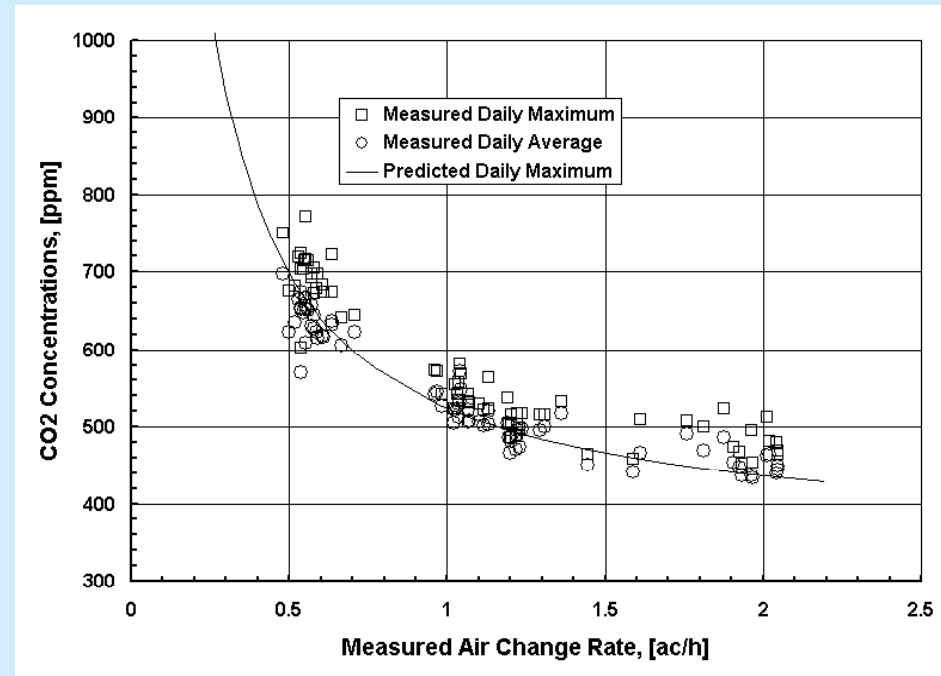
- Factors:
 - Many sources indoors
 - Tight houses



Air tightness survey results (BSI '90)

Control Options?

- Ventilation
 - Open window
 - Mechanical ventilation (\$\$)
- Air cleaning devices
 - Energy cost (\$\$)
 - Not efficient
- Source control
 - Avoidance
 - Selection of low-emitting materials



Low-emitting materials (Canada)

- **LEED** (Leadership in Energy and Environmental Design)
 - Low-emitting materials
 - Adhesives and sealants (1 point)
 - Paints and coating (1 point)
 - Carpet (1 point)
 - Composite wood & laminated adhesives (1 point)
- **Labeling Scheme**
 - EcoLogo by Environmental Choice



Low-emitting materials (USA)

- **LEED**
- **California**
 - Section 01350 specification
 - Recognized by US EPA & others
- **BIFMA Emission Standards**
(Business & Institutional Furniture Manufacturer's Ass.)
- **Industry Labeling Schemes**
 - Green Label Plus ([Carpet & Rug Institute](#))
 - Indoor Advantage Gold ([Scientific Certification Systems](#))
 - Floorscore ([Scientific Certification Systems](#))
 - GREENGUARD Children & Schools Certification Program ([GREENGUARD Environmental Institute](#))
 - GreenSeal, etc.

Problem Statement

- **Product labeling is Voluntary**
 - Very limited products are labeled.
- **Lack of Consistency in Product Labeling**
 - Focused on a sector or a national market
 - Specific tests
 - Testing procedures (4 vs 3 & 28 days)
 - Chemicals (TVOC, formaldehyde, ~80 VOCs, ~170 VOCs)
 - Reporting Units
(Emission factor - $\text{mg/m}^2/\text{h}$, Indoor concentration - mg/m^3)

Objectives of Material Emissions Projects (1996-)

- **Baseline data on material emissions with a standardized method**
- **Estimation of impacts on indoor air quality by building materials**
- **Material selections and ventilation strategies**

Consortium Members

Government partners

- Canada Mortgage and Housing Corporation
- Natural Resources Canada
- Public Works and Government Services Canada
- Health Canada
- Panel of Energy Research & Development

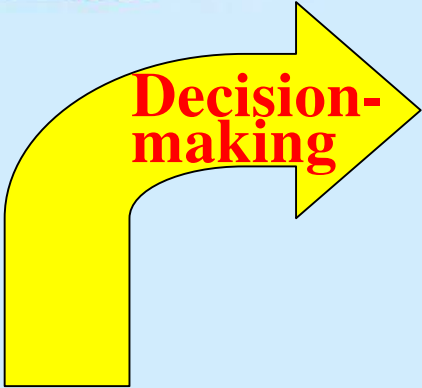
Industry partners

- Canadian Wood Council
- Chemical Manufacturers Association (USA)
- Gypsum Association (USA)
- USG Corporation (USA)

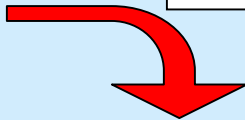
International partners

- Building Center of Japan

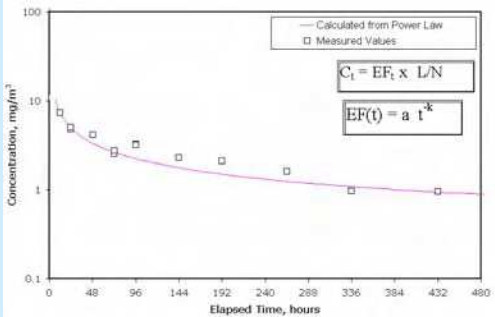
ME project



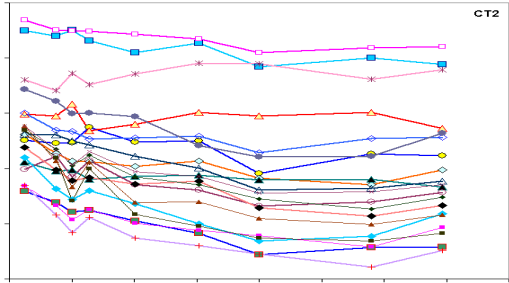
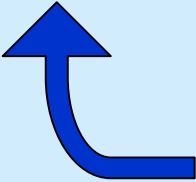
**Building
material
Specimens
(69)**



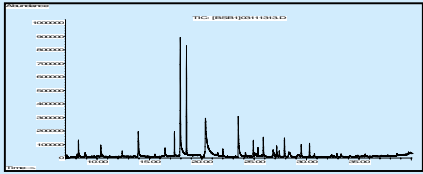
Emissions Tests



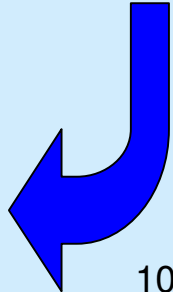
Modelling



Data Analysis



**Chemical Analysis
(90 VOCs)**



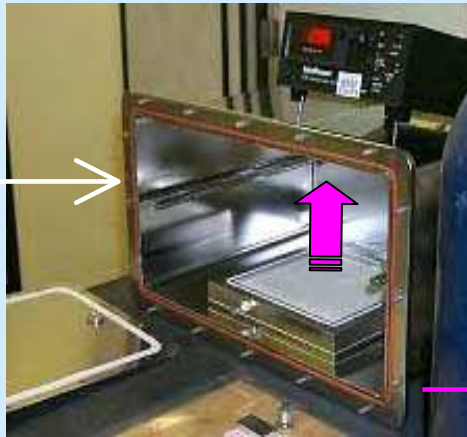
Test Methods: 50-L chamber test

Chamber testing

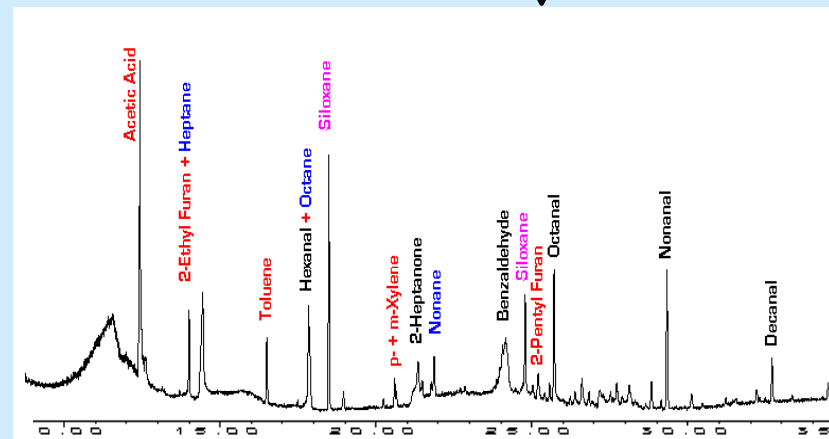
Sampling

Chemical Analysis

Clean air

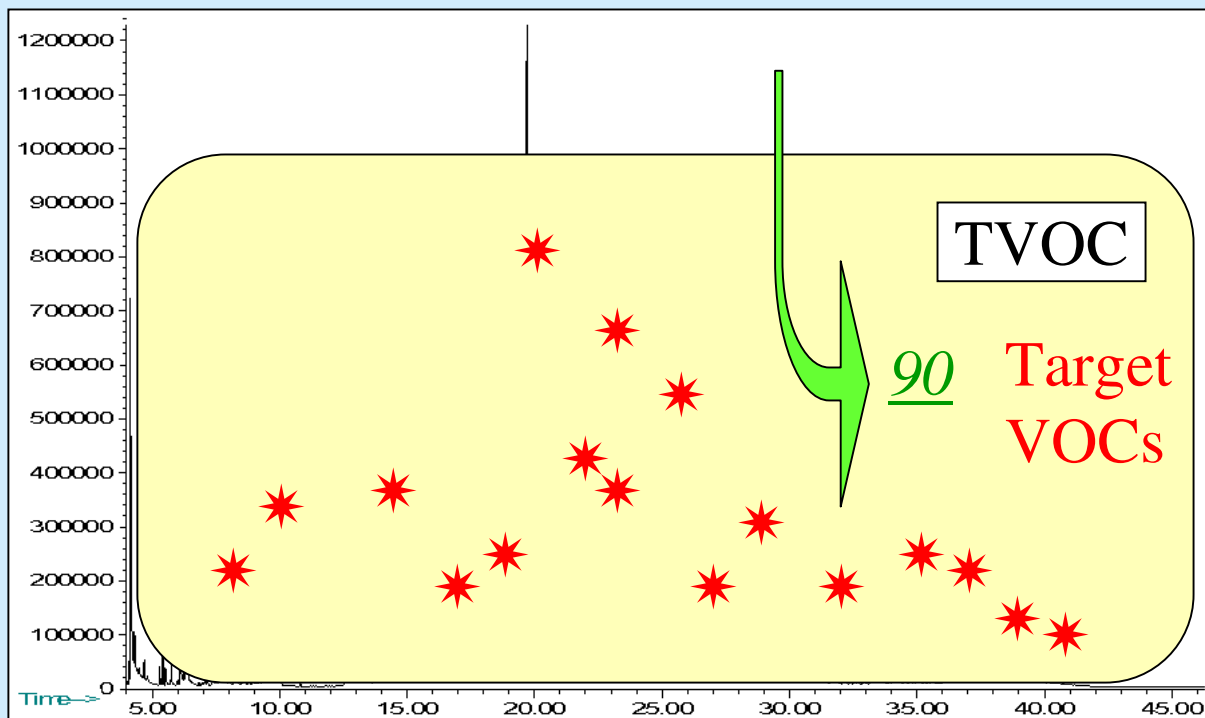


Exhaust



Target VOCs

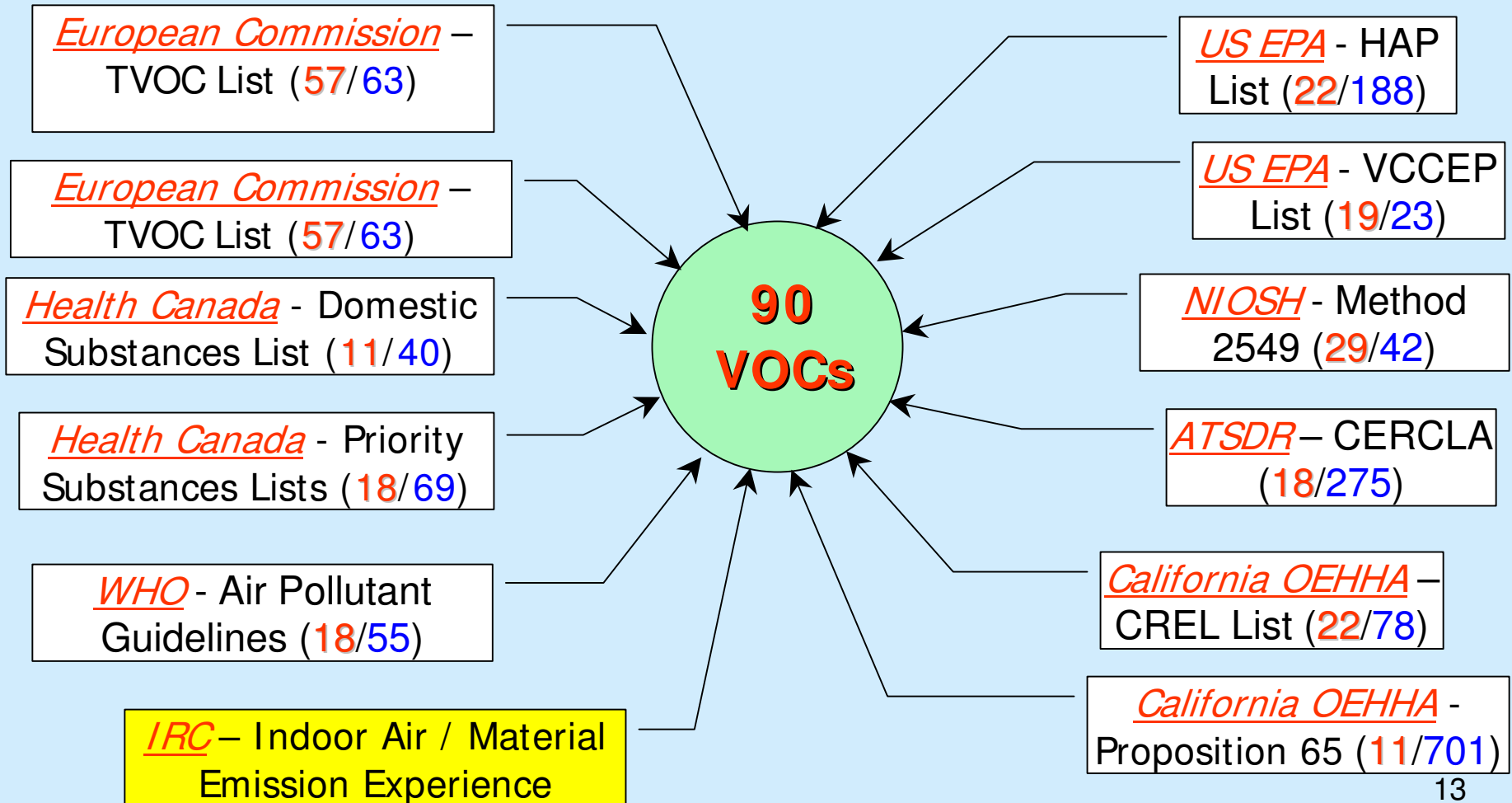
CMEIAQ-II Advisory Committee:
HC, CMHC, NRCan, PWGSC, Univ.



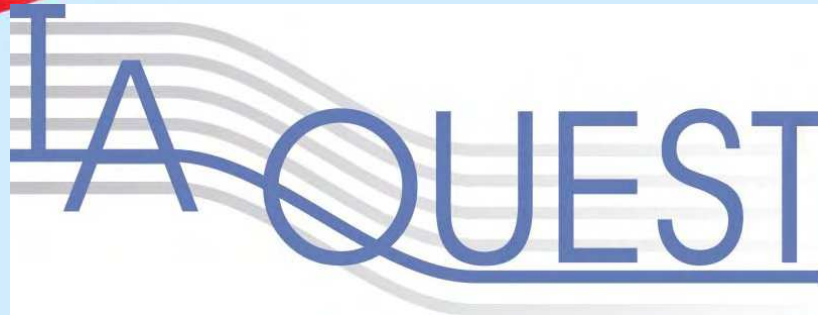
*Health-Relevant
IAQ
Analysis*

VOC Emission Profile – Building Material

Target VOCs: References



Software: IA-QUEST



IA-QUEST



Database

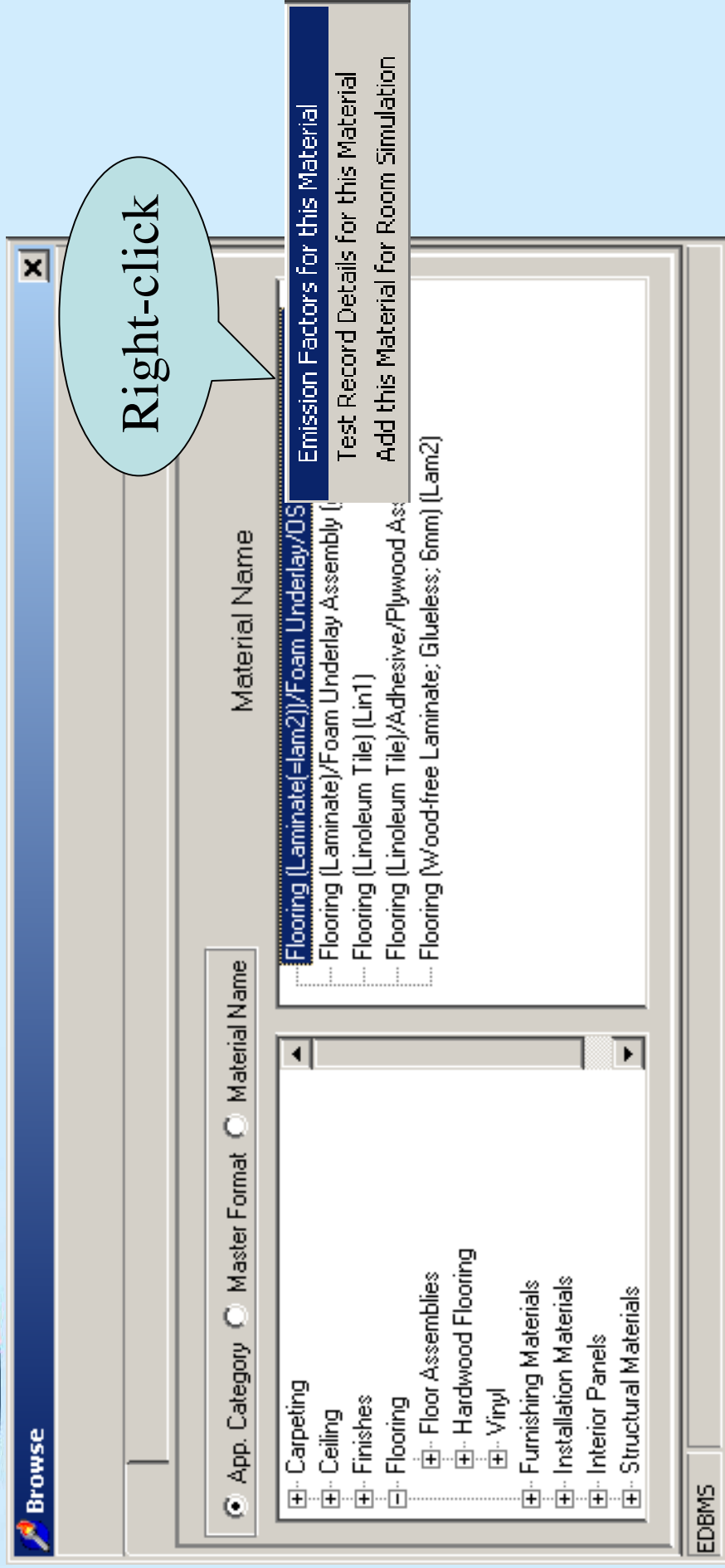
- Emission Data for
 - 90+ VOCs
 - 69 Materials
- Test record
 - Specimens
 - Conditions



Simulation Tool

- single zone model
- prediction of VOC concentrations
- tool for evaluating impact of:
 - material selection choices
 - ventilation schedules and rates

Information (1): Emission Factor



Information (1): Emission Factor (measured)

Emission factors: Flooring (Laminate(=lam2))/Foam Underlay/OSB Assembly (Lam3)

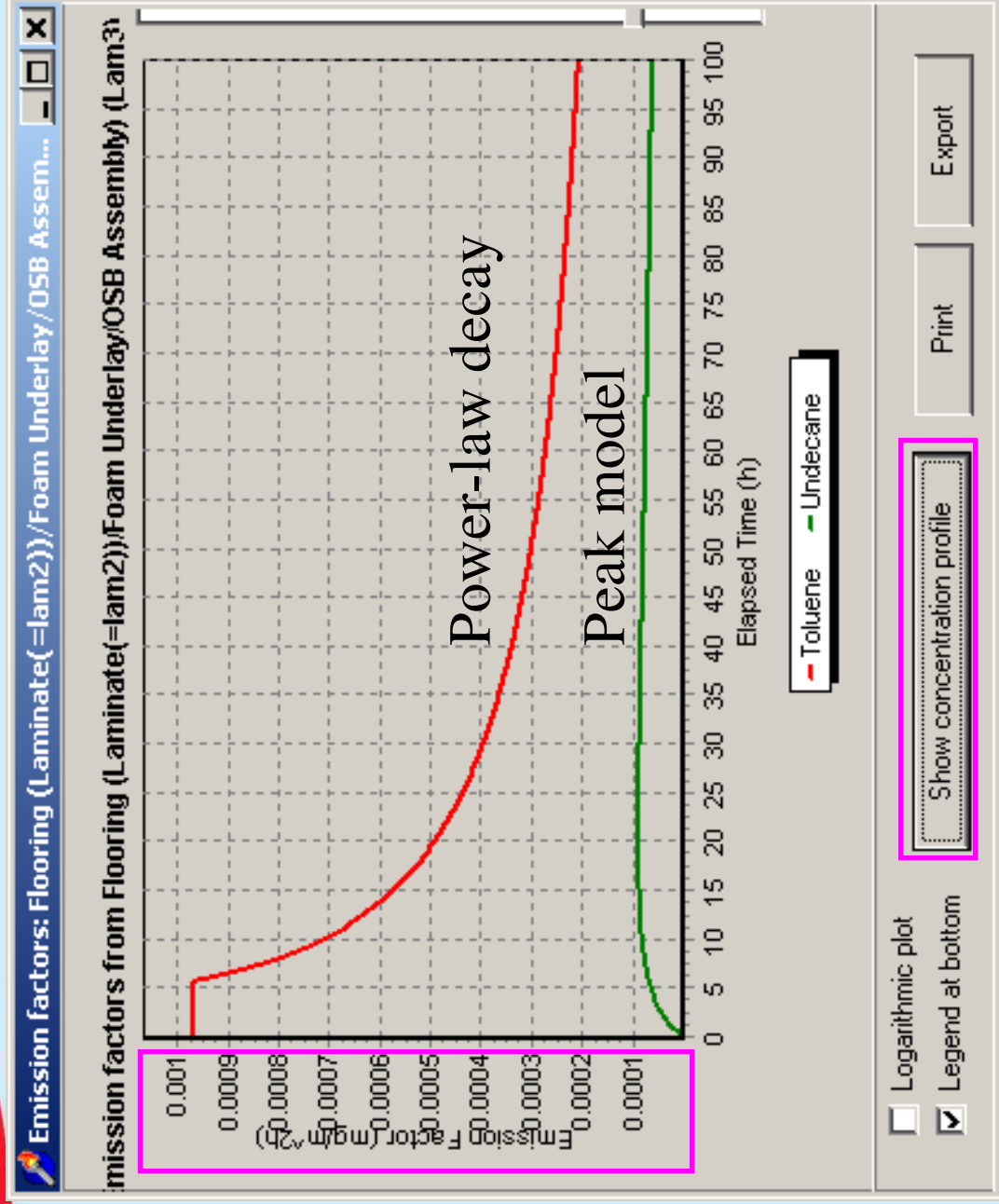
Emission factors for Flooring (Laminate(=lam2))/Foam Underlay/OSB Assembly (Lam3)

Select Contaminants Show Emission Plots Save To File

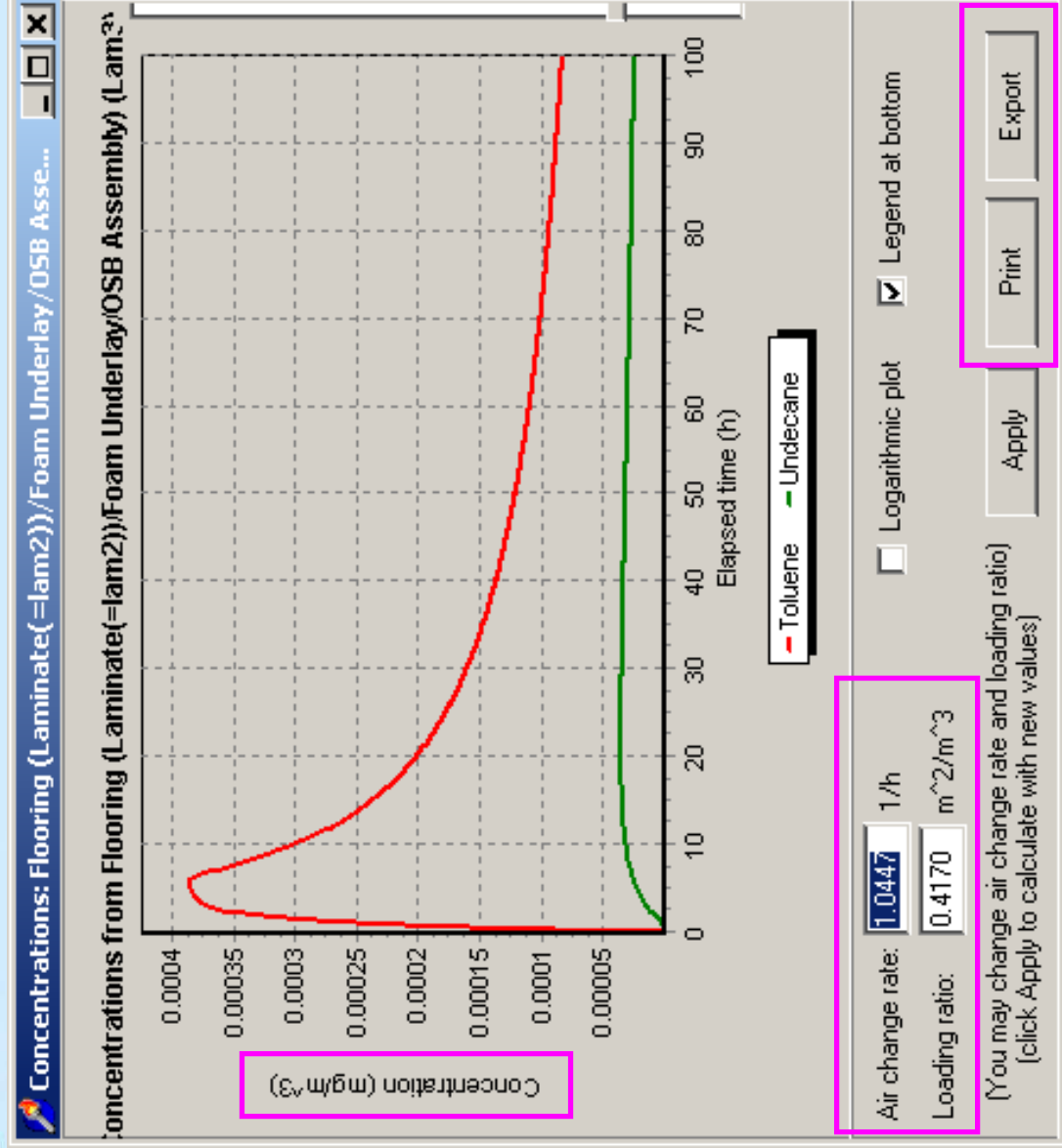
Contaminant	Nominal Emission Factor (mg/m ² h)	Maximum Emission Factor (mg/m ² h)
1,2,3-Trimethylbenzene	9.54628E-6	2.14992E-5
1,2,4-Trimethylbenzene	4.20388E-5	5.01788E-5
1,2-Dimethylbenzene	0.000122508	0.000122508
1,3,5-Trimethylbenzene	1.83593E-5	1.83593E-5
1,3-Dimethylbenzene	0.000283734	0.000283734
1,4-Dichlorobenzene	8.16255E-5	0.000371919
1,4-Dimethylbenzene	0.000102267	0.000102972
1-Heptene	0.06772	0.06772
1-Hexanol	0.00132292	0.00132292
1-Hexene	0.00628888	0.00628888
1-Octene	0.00312231	0.00312231
1-Pentene	0.00214307	0.00214307

Notes:

Information (1): Emission Factor (modeled)



Information (1): Concentration (modeled)



Information (2): Test Record

Emission Test Record Details: Acoustical Ceiling Tile (Cellulose) (ACT3)

Emission Data for Test : ACT3

Print

Contaminant	Nominal Emission Factor (mg/m ² h)	Maximum Emission Factor (mg/m ² h)
1,2,3-Trimethylbenzene	5.39095E-5	0.000379731
1,2,4-Trimethylbenzene	9.24125E-5	0.000779959
1,2-Dimethylbenzene	2.52401E-5	0.000247815
1,3,5-Trimethylbenzene	4.65021E-5	0.000238733

Test date: 3/8/1998 Test laboratory: Indoor Environment Research Program, IRC/NRC

Product: Acoustical Ceiling Tile (Cellulose) (ACT3)

Product notes: Residential, 12x12", cellulose

Test conditions:

Temperature = 23 °C; Humidity = 50 %; Velocity = .05 m/s;

Turbulence intensity = 1 %; Air change rate = 1 ACH; Loading ratio = 0.72899 m²/m³

Test notes: Source: Local retail outlet

Product sample:

Shape/Dimension: 0.212 x 0.212

Surface area = .05 m² Thickness = mm Initial mass = g

Information (3): Compounds

Contaminant Properties and Health Effects
CAS #: 108-88-3

Type:

Sub-type: Aromatic Hydrocarbons

Physical Properties:

Molecular weight (g/mol): 92.141

Boiling point (°C): 110.78

Vapor pressure @23°C (mmHg): 25.641

Health Effect Data:

Odor detection threshold (mg/m³): .644

Permissible exposure level, OSHA (mg/m³): 750

Occupational exposure limit, USA (mg/m³): 188.535

Occupational exposure limit, Denmark (mg/m³): 131.975

Mucous membrane irritation threshold (mg/m³): 487.29

Non-cancer chronic reference exposure level, California (mg/m³): .3

Alternate Names

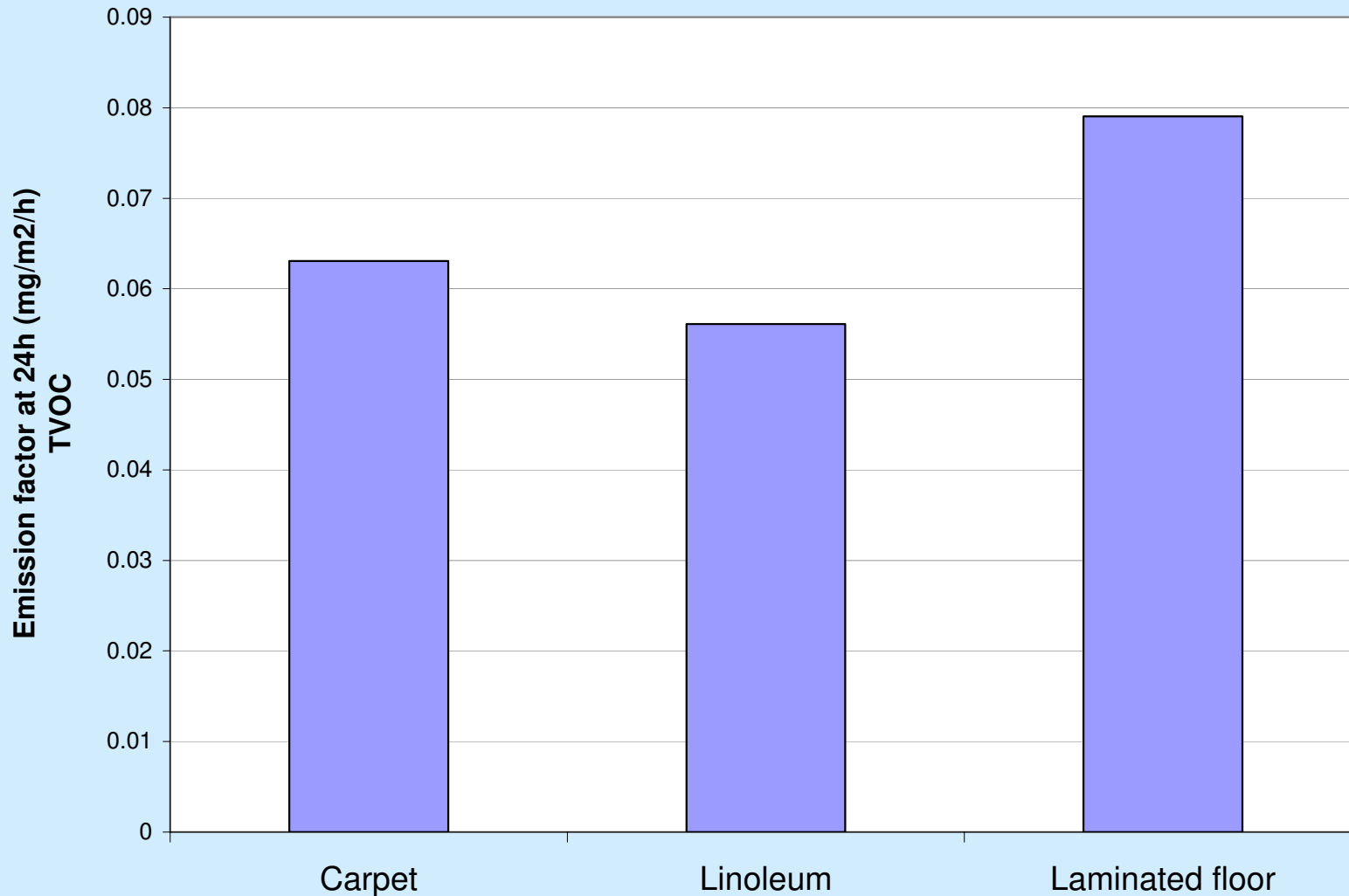
antisal 1a

Methacide

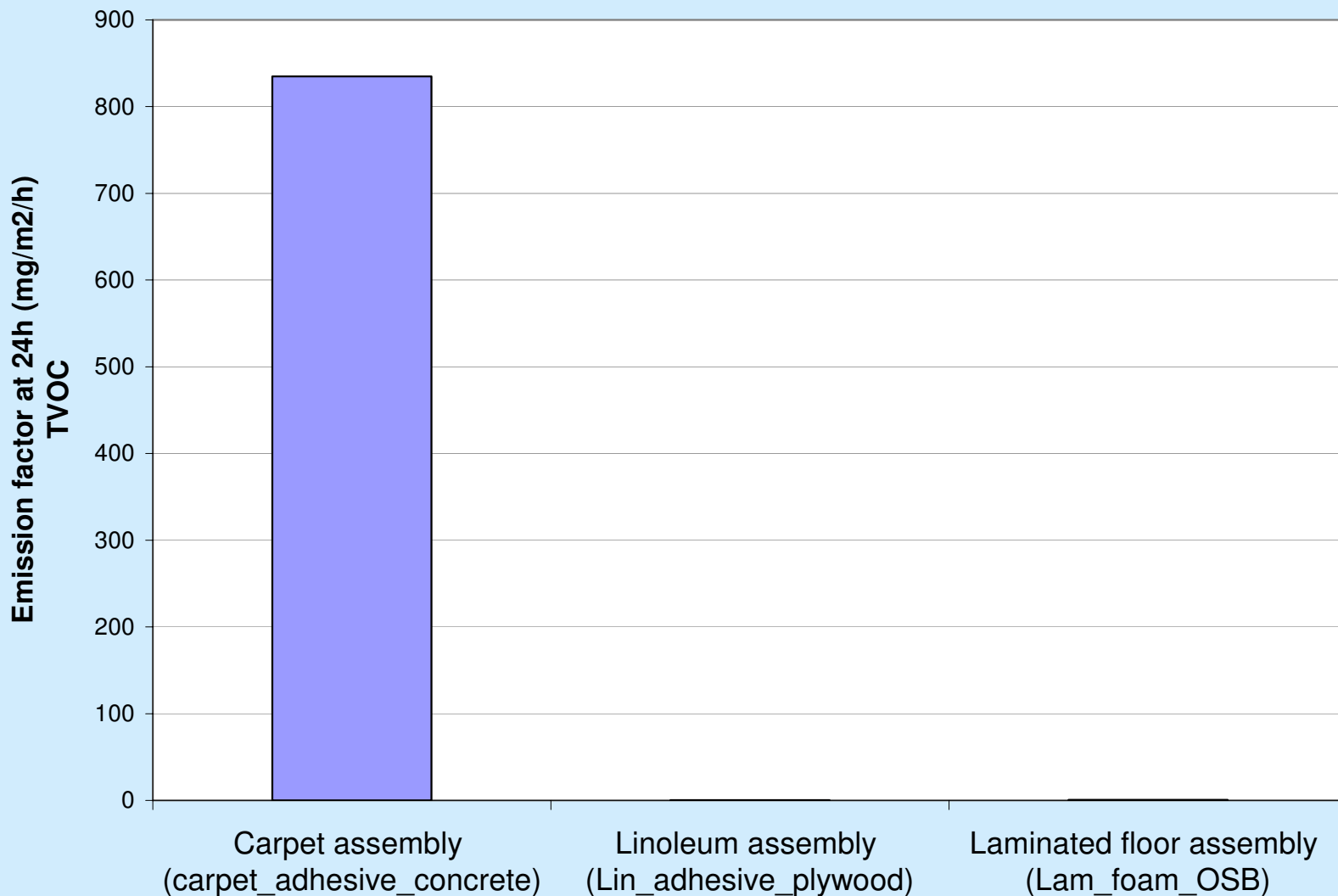
methyl-Benzene

Methylbenzol

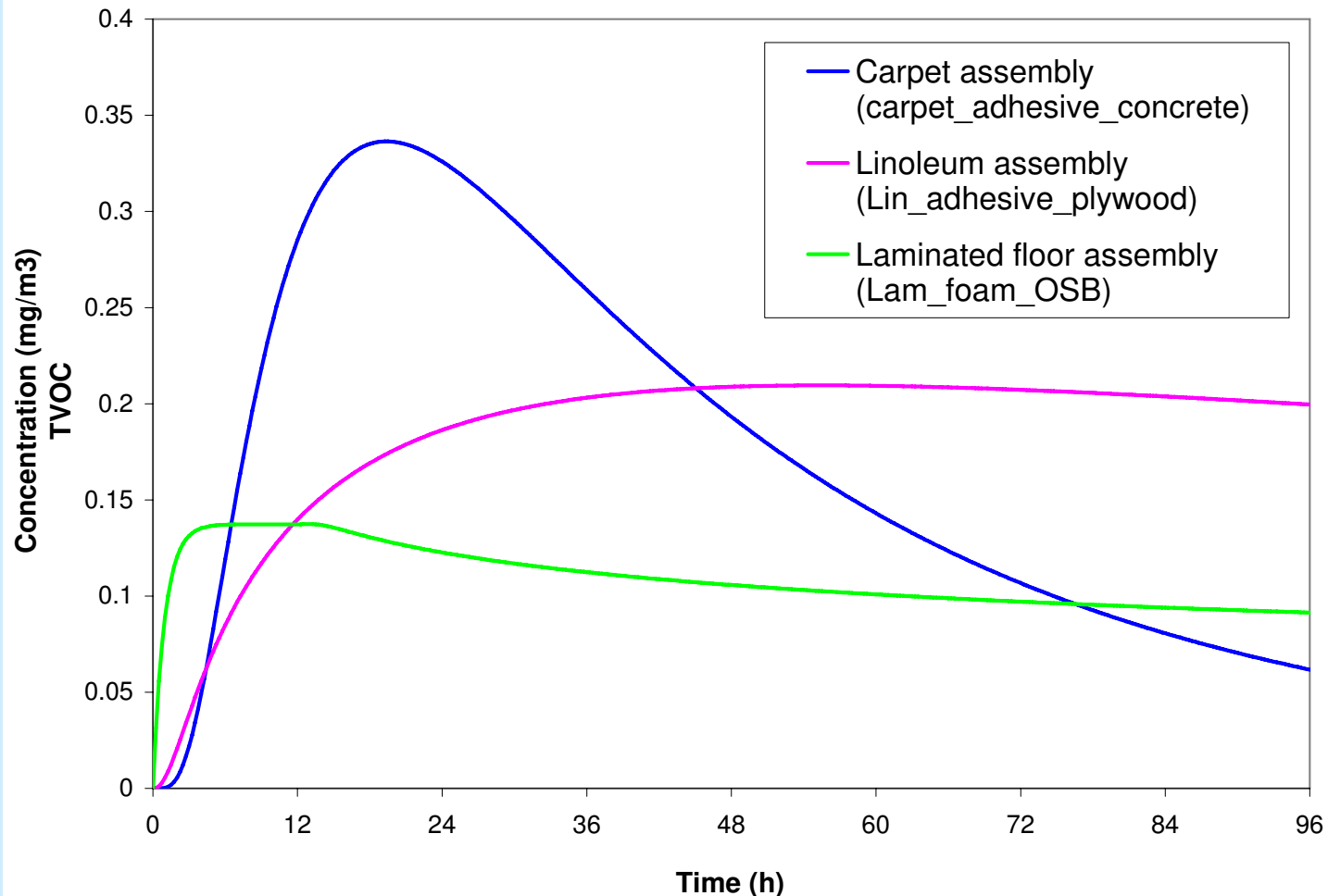
Application #1: Product Comparison (within floor category)



Application #1: Product & application (within floor assemblies)



Application #1: Product Comparison (IAQ - modeled)



Application #2: Product Selection (Labeling Requirement)

- Scenario:
 - Find a carpet product
 - CRI's Green Label
 - Max Emission Factor: 0.5 mg/m²/h for TVOC, etc.

- IA-QUEST function
 - Use “Query”

Application #2: Labeling Requirement (Query)

Query

Query Definition

Parameters:

- Chamber type
- Contaminant CAS no.
- Contaminant Name
- Dry or Wet
- Material Name
- Max emission factor (mg/m²h)**
- Nominal emission factor (mg/m²h)
- Test ID

Enter numerical value: 0.5

Criteria overview:

- Contaminant Name LIKE TVOC%
- Material Name LIKE Carpet%
- Max emission factor (mg/m²h) <= 0.5**

Material List

EDBMS Query result: 4 records found in the database.

Application #2: Labeling Requirement (Query)

The screenshot shows a software window titled "Query" with a standard Windows-style title bar (minimize, maximize, close buttons). The window is divided into several sections:

- Query Definition:**
 - Parameters:** A list of fields with "Select" and "Set As Default" buttons. The "Max emission factor (mg/m²h)" field is highlighted in blue.
 - Enter numerical value:** A text box containing "0.5" and a dropdown menu set to "OR".
 - Criteria overview:** A text box containing the query criteria: "... Contaminant Name LIKE TVOC%", "Material Name LIKE Carpet%", and "... Max emission factor (mg/m²h) <= 0.5".
- Material List:** A list of search results enclosed in a pink border. The items are:
 - Carpet [Commercial; 20oz Polypropylene; Woven PP back; Flame-re-
 - Carpet [Commercial; 28oz Olefin; Woven Synthetic; Latex laminate]
 - Carpet [Commercial; Nylon; Latex backing] (from renovation site) [Cr
 - Carpet [Residential; 45 oz Nylon; Latex backing] [CRP2]
- Green Label:** A light blue speech bubble with the text "Green Label" is positioned over the search results.
- Buttons:** A row of buttons includes "Add", "Remove", "Clear", "Open", "Save", and "Find". The "Find" button is highlighted with a pink border.
- Footer:** A status bar at the bottom left shows "EDBMS" and a status bar at the bottom right shows "Query result: 2 records found in the database."

Application #3: IAQ Meet the Guideline Value?

- Scenario:
 - Carpet in a room (27 m³, 10 m², 0.5 ACH)
 - Can we meet the guideline for the first 10 days?
 - TVOC: ~0.4 mg/m³ (Japan)
 - Formaldehyde: ~0.015 mg/m³ (California)

- IAQUEST function
 - Use the “Simulation” capability

Simulation: Ventilation Data

Room Simulation - Case: Example2-crp7a

File Cases Materials User Help

Load New Store StoreAs Browse Query Close

Room Setup Calculation

Description Ventilation Materials

Room Volume (m³): 27

Note: This ventilation schedule will be repeated as necessary when the simulation period is longer than the ventilation schedule.

Preset Ventilation Rates (optional):

Minimum:	Normal:	Maximum:
ach: .5	.5	.5
m ³ /h: 13.5	13.5	13.5

Note: these optional presets are variables that can be used to assign values by name in the ventilation schedule (see documentation).

Ventilation Schedule:

Weekly Schedule

Edit Schedule Print Import

Ventilation Rate (m³/h)

Elapsed Time (h)

Ventilation schedule length (h) = 2448 Number of Materials = 1 No. of contaminants (selected) = 29 (1)

Simulation: Ventilation (measured & complex)

Room Simulation - Case: CCHI-Ref-05B5d-ACH324f-10

File Cases Materials User Help

Room Setup

Description

Room Volume (m³):

Note: This ventilation schedule will be repeated as necessary when the simulation period is longer than the ventilation schedule.

Preset Ventilation Rates (optional):

Minimum:	<input type="text" value=".12"/>	Normal:	<input type="text" value=".23"/>	Maximum:	<input type="text" value="50"/>
m ³ /h:	<input type="text" value="95.32"/>		<input type="text" value="182.69"/>		<input type="text" value="39715"/>

Note: these optional presets are variables that can be used to assign values by name in the ventilation schedule (see documentation).

Ventilation Schedule:

Ventilation Rate (m³/h)

Elapsed Time (h)

Ventilation schedule length (h) = 20016 Number of Materials = 14 No. of contaminants (selected) = 64 (64)

Simulation: Ventilation (weekly)

Room Simulation - Case: Example2 File Cases Materials User Help

Room Volume (m³):

Note: This ventilation schedule will be repeated as necessary when the simulation period is longer than the ventilation schedule.

Preset Ventilation Rates (optional):

Minimum: m³/h
 Normal: m³/h
 Maximum:

Note: these optional presets are variables that can be used to assign values by name in the ventilation schedule (see documentation).

Ventilation Schedule:

Ventilation schedule length (h) = 168 Number of Materials = 1 No. of contaminants (selected) = 37 (1)

Simulation: Materials

Room Simulation - Case: Example2-crp7a

File Cases Materials User Help

Load New Store StoreAs Browse Query Close

Room Setup Calculation

Description Ventilation **Materials**

Product Name	Unit	Amount	In Time (h)	Out Time (h)	SimMaterialNote
Carpet (=Crp7)/Adhesive/Concrete Assembly (Crp7a)	m ²	10	0	999999	

Browse

App. Category
 Master Format
 Material Name

- Carpeting
 - Commercial, Synthetic
 - Commercial, Nylon/Latex backing
 - Residential, Nylon/Latex backing
 - Undercushion
- Ceiling
- Finishes
- Flooring
- Furnishing Materials
- Installation Materials
- Interior Panels
- Structural Materials

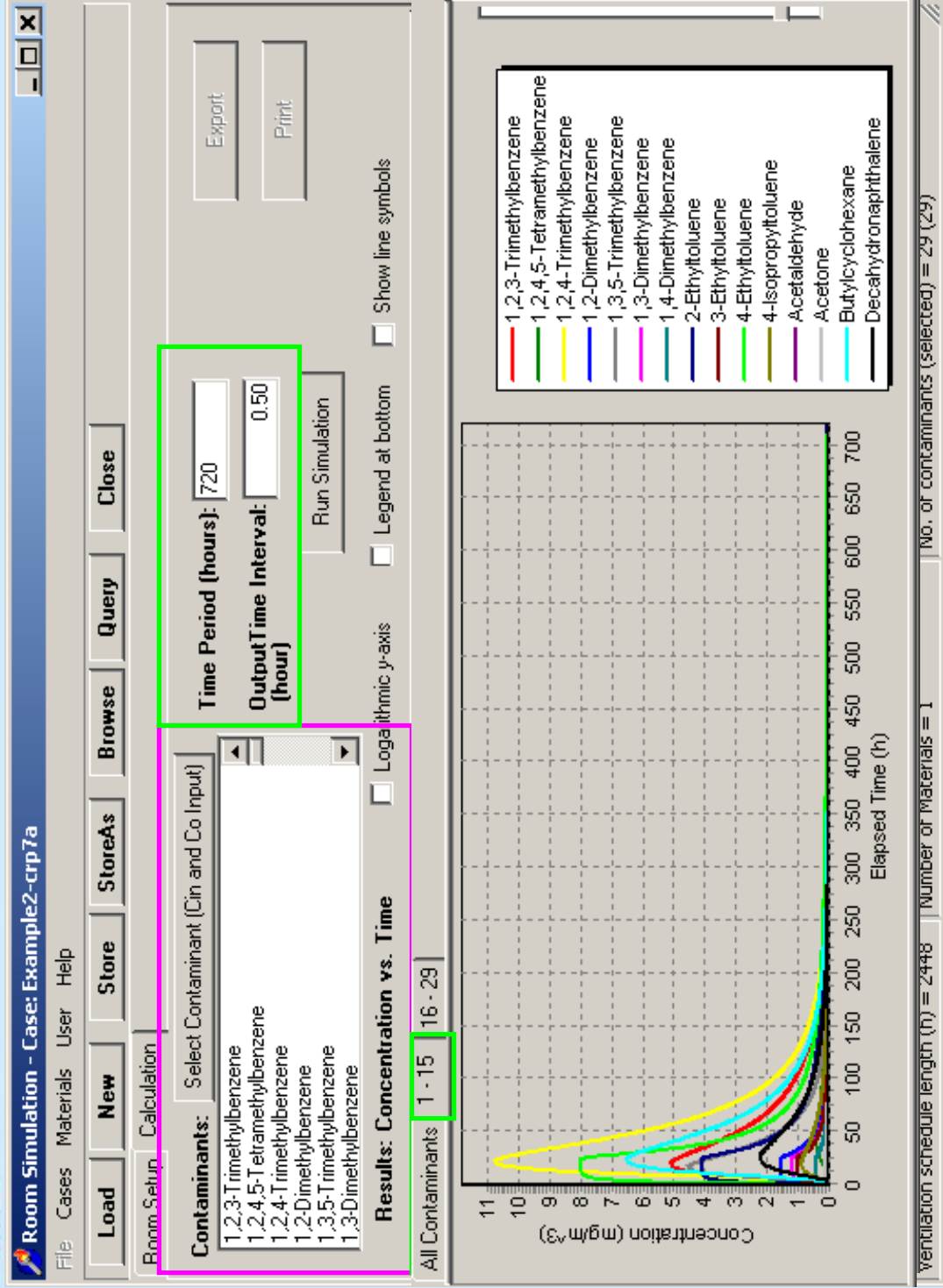
Material Name

- Carpet (=Crp7)/Adhesive/Concrete Asse
- Carpet (Commercial, 20oz Nylon) (CRP6)
- Carpet (Commercial, 20oz Polypropylene;
- Carpet (Commercial, 28oz Olefin; w/oven
- Carpet (Commercial, Nylon; Latex backing) (from renovation site) (Crp.

Emission Factors for this Material
Test Record Details for this Material
Add this Material for Room Simulation

EDBMS Ventilation schedule length (h) = 2440 Number of materials = 1 No. of contaminants (selected) = 29 (1)

Simulation: Calculation Results



Simulation: Calculation Results

Room Simulation - Case: Example2-crp7a

File Cases Materials User Help

Load New Store StoreAs Browse Query Close

Room Setup Calculation

Contaminants: Select Contaminant (Cin and Co Input) Time Period (hours): 720 Export

1,2,3-Trimethylbenzene
 1,2,4,5-Tetramethylbenzene
 1,2,4-Trimethylbenzene
 1,2-Dimethylbenzene
 1,3,5-Trimethylbenzene
 1,3-Dimethylbenzene

Results: Concentration

Concentration (mg/m³)

Select Contaminant (and input for initial and supply air concentrations)

Contaminant	Select	C_0*	C_in**
Dodecane	<input type="checkbox"/>	0	0
Ethylbenzene	<input type="checkbox"/>	0	0
Ethylcyclohexane	<input type="checkbox"/>	0	0
Formaldehyde	<input checked="" type="checkbox"/>	0	0
Isopropylbenzene	<input type="checkbox"/>	0	0
Naphthalene	<input type="checkbox"/>	0	0
Nonane	<input type="checkbox"/>	0	0

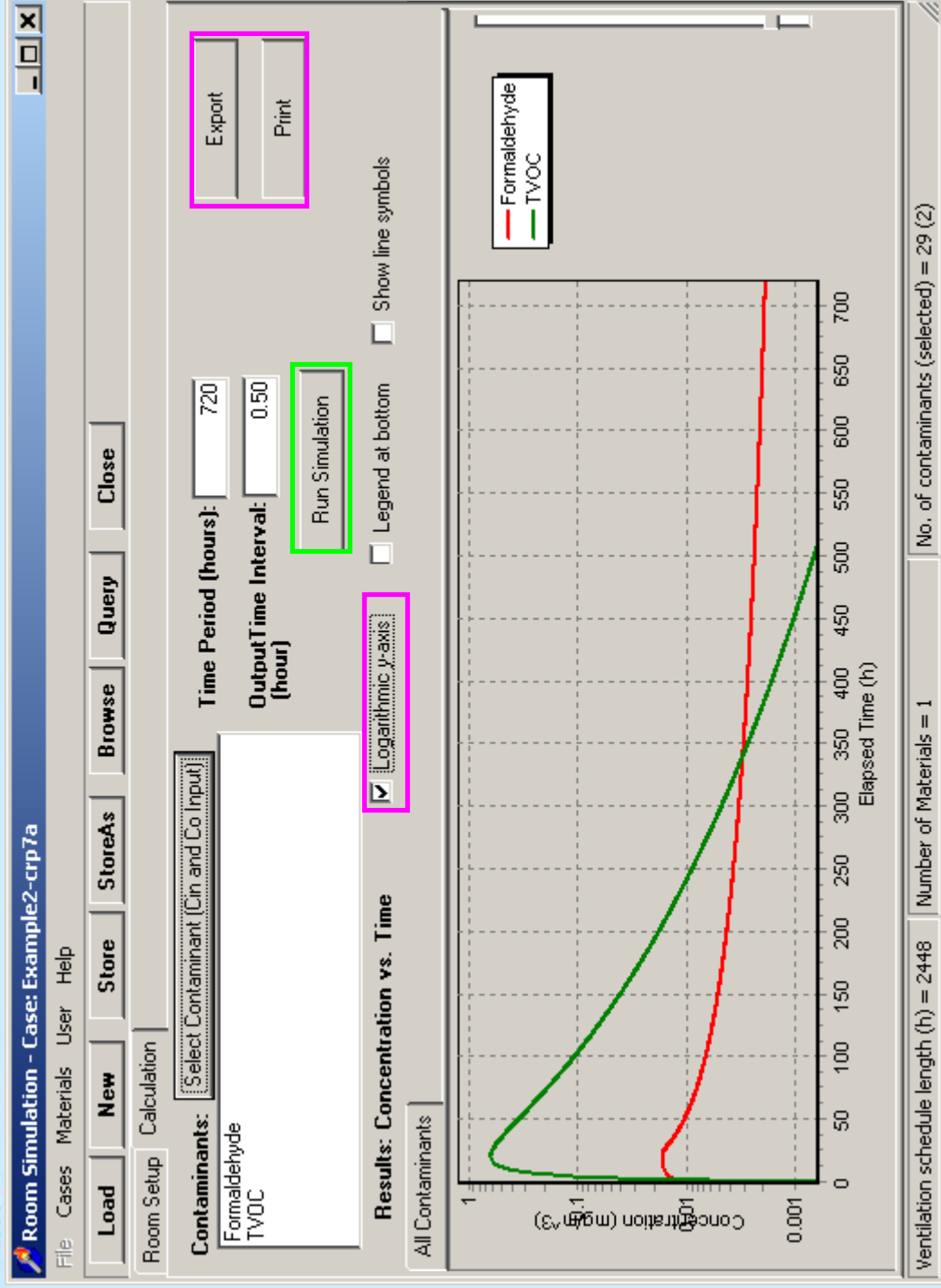
Note:
 [+] means selected for simulation
 [] means not selected for simulation
 C_0*: Initial Concentration (mg/m³)
 C_in**: Concentration in Supply Air (mg/m³)

Cancel OK

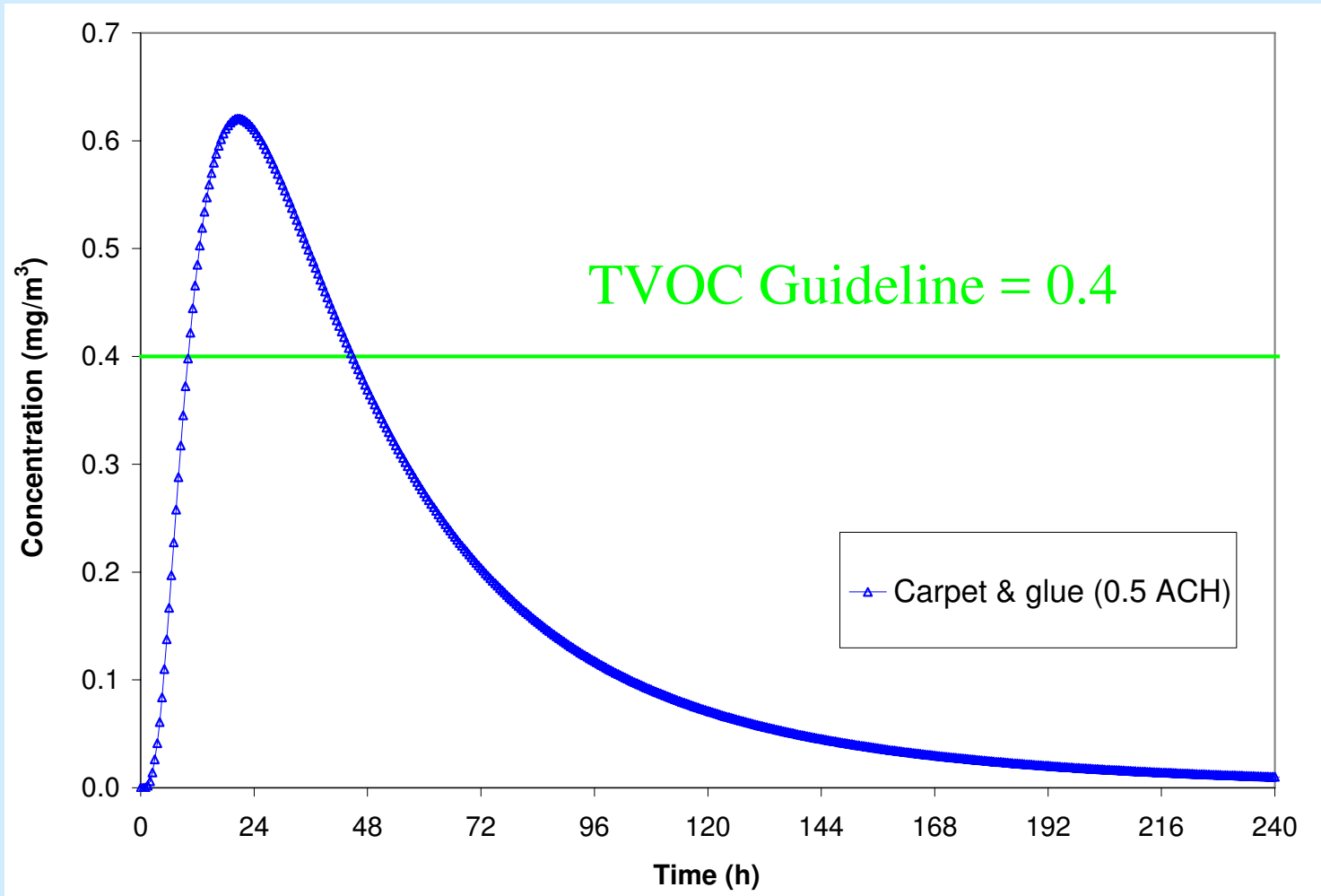
Select All
 Deselect All

Ventilation schedule length (h) = 2448 Number of Materials = 1 No. of contaminants (selected) = 29 (29)

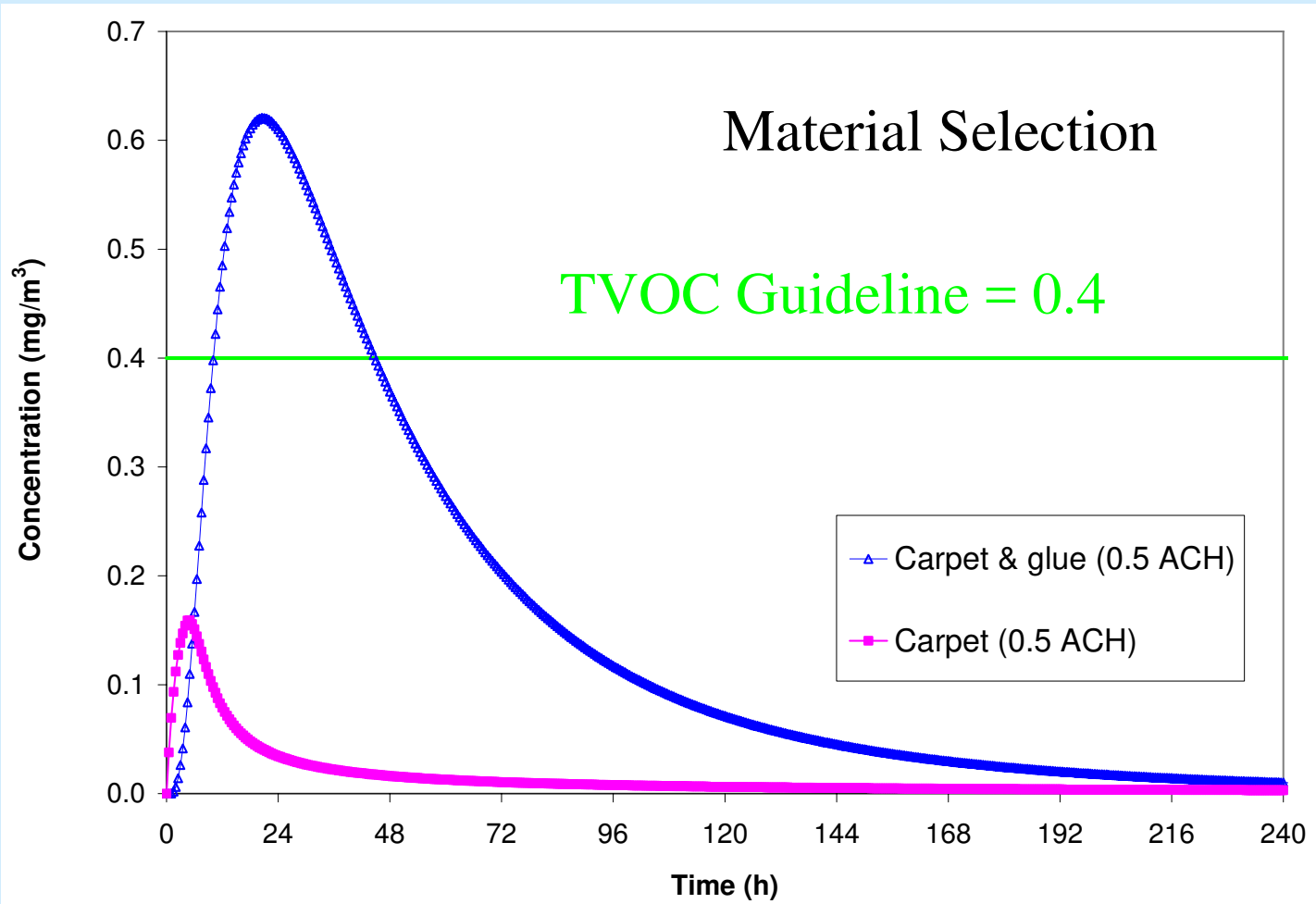
Simulation: Calculation Results



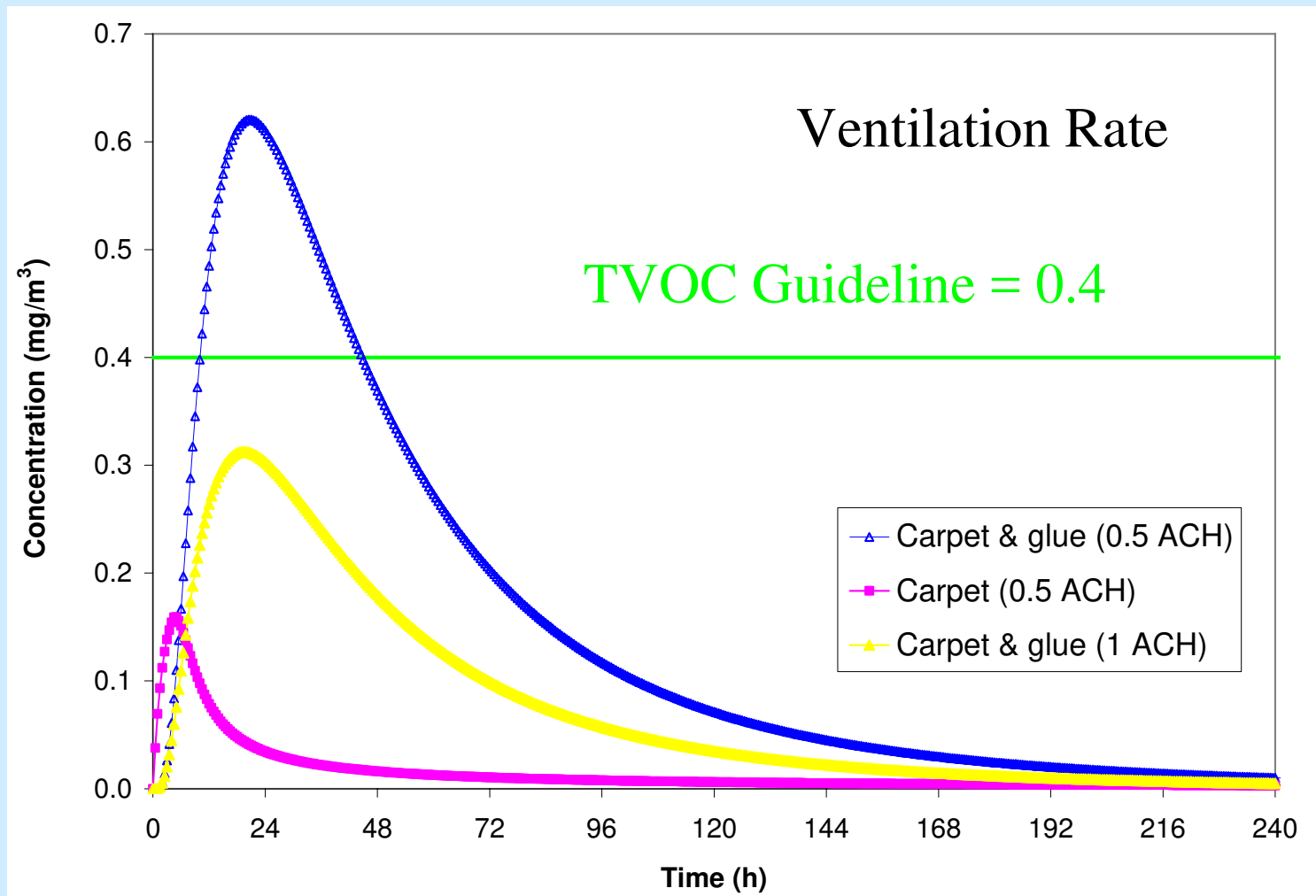
Application #3: IAQ Guideline Values (carpet & glue)



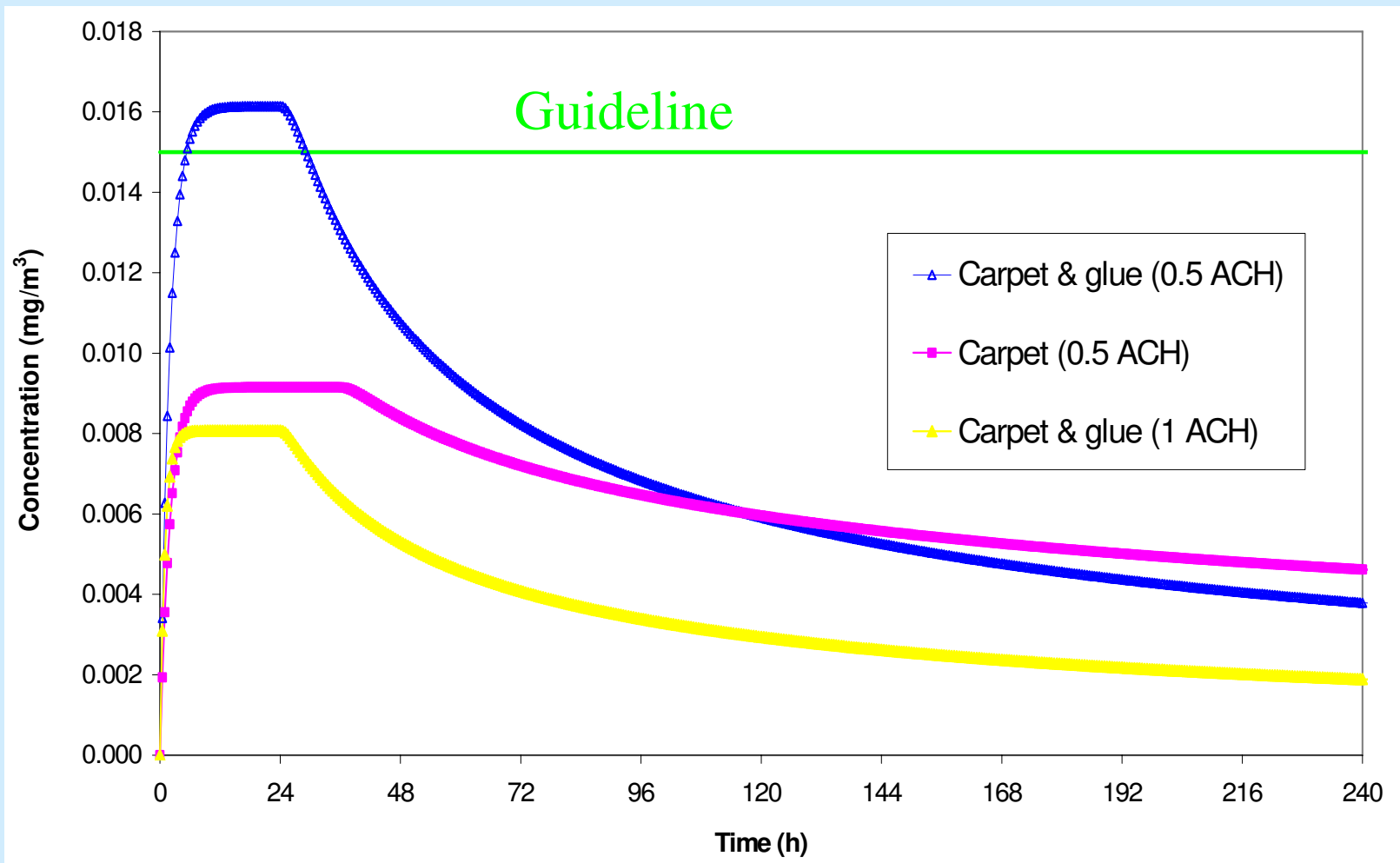
Application #3: IAQ Guideline Values (No glue)



Application #3: IAQ Guideline Values (0.5 → 1 ACH)



Application #3: IAQ Guideline Values (Formaldehyde)



Limitations:

- Comprehensive, but Limited Database
 - 69 materials? (genetic description)
 - 90 VOCs? (semi-VOCs: plasticizers & flame retardants?)
 - Formaldehyde data (not measured for all)

 - Remedies: collaborations with testing companies

Summary



- **1st tool to manage VOCs indoors**
- **69 bldg materials**
- **90 target compounds, developed by federal partners**
- **Database for emission factors**
- **Simulation of indoor air quality (concentrations)**
 - Building materials
 - Ventilation rates
 - Chemicals
- **2nd version is planned (inputs are appreciated!)**