



# IEA 4E SSL ANNEX – 3<sup>RD</sup> TERM, TASK 1 UPDATE

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2022-11-29 – IEA 4E SSL Annex Experts' Meeting, Zoom



# 3rd Term Work Plan – Task 1

## Objectives:

To study the health impacts on people of solid-state lighting, considering issues that concern both large fractions and small sensitive groups of the population.

Provide interpretation and guidance to policy-makers on setting appropriate requirements on health-related metrics for all forms of solid-state lighting.

# Task 1 Team Members

## Canada (NRC-CNRC Ottawa) :

### Jennifer Veitch, Ashley Nixon

Jennifer Veitch is known internationally for her work on the human aspects of lighting.

Ashley Nixon has a PhD from the University of Ottawa. She was recently hired by NRC. She currently works around the interplay between sleep/circadian rhythms, well-being, and light

## Australia (Australian Radiation Protection and Nuclear Safety Agency) :

### Sarah Loughran, Lin Shen, Rohan Mate

Sarah Loughran is the Director of Radiation Research and Advice. She has contributed to ICNIRP guidelines on electromagnetic fields.

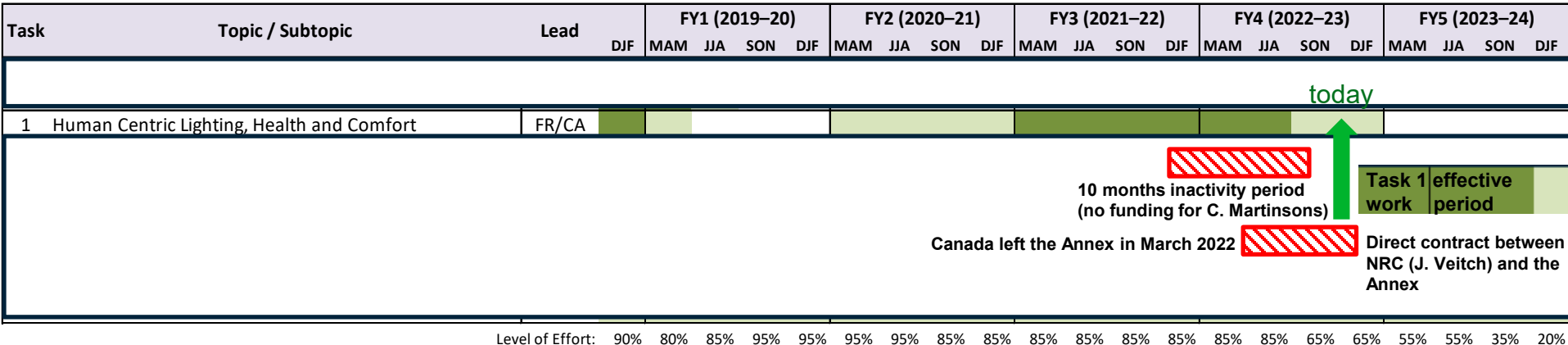
Lin Shen is a research Fellow at the Sleep and Circadian Medicine Laboratory at Monash University. Her current work includes examining light exposure, biomathematical modelling and personalised interventions for improving performance and wellbeing in shift workers across multiple industries

## France (Centre Scientifique et Technique du Bâtiment) :

### Christophe Martinsons

Christophe Martinsons is a lighting researcher studying the assessment and design of the lighted environment in buildings and cities to improve people's well-being and health.

# “Official” planned schedule



Key:

- More intense period of work by Task Leader and Experts
- Less intense level of effort, preparation or completion of work, mainly by Task Leader

DJF December, January, February  
MAM March, April, May  
JJA June, July, August  
SON September, October, November

# New work plan

## 2019

Refine list of review topics, Develop review criteria; Assign topics to leaders.

Done, revised plan shown here.

## Jan 2020 to Dec 2021

Literature search, develop databases; Review key papers, inter-compare reviewing results; Refine criteria; Continuous coordination with CIE & ISO committees; continue reviewing & developing recommendations.

Done for some sections, not for others.

## Jan 2022 to Dec 2022

Inactivity period due to French agency ADEME's late commitment and Canada leaving the Annex

Contracting in progress between NRC and the SSL Annex

**Jan 2023 to Sep 2023** Literature search, reading & analyzing papers and reports, writing (to be detailed by the team)

**Oct 2023 to Dec 2023** Internal review of report by annex members and management committee, rounds of corrections

**Dec 2023- Jan 2024** Publication of report



# Update the 2014 Health Report

**Health: broadly defined according to WHO (1948) definition: *Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.* (World Health Organization (WHO) 1948)**

Do:

- Identify the psychological and physiological processes that light can affect, based on scientific evidence,
- Focus on areas where regulation or consumer advice might help to prevent adverse effects – identify how to identify products that work for people, or ways to apply them that will be beneficial (or avoid harm)
- Identify areas where metrics and test methods don't exist yet; but

Don't:

- Specify the lighting design choices that deliver the desired conditions. This is a review of the evidence not a guide to how to do lighting correctly.



# Revised Report scope

- **Literature search will encompass light effects on health regardless of source (to capture relevant papers).**
- **Conclusions will focus on products: lamps & luminaires (both consumer and commercial) for general interior lighting; street lighting; with the caveat that these are products designed to emit white light.**
  - Focus on emissions (from products), but with commentary on exposures (products in use)
- **Out of scope: automotive, light sources that are not lighting products (e.g., battery powered: toys, portable lamps) and displays**
- **In general, the conclusions will address products in the Task 1 performance tiers,**
  - When used as intended in everyday applications;
  - Highlighting risks that could emerge if used incorrectly by consumers (where engineering controls don't apply);
  - Providing guidance relevant to sensitive populations;
  - Excluding exposures during manufacturing or installation.

# Updated plan

Glare	If possible, include subsection on identifying sensitive people & the conditions that cause problems for them	Christophe
Photobiological safety	Reduced length – no need to describe or derive action spectrum or risk categories (as was previously done) – being concise. If possible, include subsection on identifying sensitive people & the conditions that cause problems for them	Christophe
Temporal light modulation	If possible, include subsection on identifying sensitive people & the conditions that cause problems for them <i>LiFi / visible light communication?</i>	Jennifer <b>and/or Christophe</b>
“Non-visual” effects	<b>PROPOSITION of NEW ITEM: review of metrics related to the non-visual effects of light exposure in humans</b> <u>Part 1</u> : circadian regulation; sleep; related medical (cancer, hormone...); physiological (cardiovascular, digestive, etc.) <u>Part 2</u> : mood; cognitive (vigilance, attention, etc.); well-being If possible, include subsections on identifying sensitive people & the conditions that cause problems or that benefit them; Evaluate some product claims	New item: <b>Christophe</b>  Part 1: Sarah with Lin  Part 2: Jennifer with Ashley
Ecological effects of exterior lighting	Section based on published reviews and meta-analyses.	Sarah and Rohan started the literature search <b>Christophe is no longer dealing with this theme because of limited funds provided by ADEME.</b>  <b>Georges Zisis offered to provide an in-kind contribution in this area.</b>



**Draw the individual issues together to help to identify what a “good” product might be and identify how they might combine**

# Literature Search Strategy

## Common general strategy with specific outcome terms for each section

### Part 1 – Lighting terms (IV)

Title & abstract: ("Light" OR lighting OR LED OR LEDs OR "solid state lighting" OR "light emitting diode" OR "fluorescent \*\*" OR "incandescent \*\*" OR "optical radiation" OR lamp OR luminaire)

AND

Title & Abstract: Section specific light terms – See TLM for example

### Part 2 – Population/ Sample terms

AND

Title & Abstract: TBD

### Part 3 – DV terms (by section)

AND

Title & Abstract: TBD

### Part 4 – What we don't want to include

AND NOT

Title & Abstract: "colour preference" OR "color preference"

### Filters

#### Scopus

Year (2012 – 2021)

Language (French & English)

Document type (Article, conference proceeding, review)

(no option to select human/animal studies as a filter)

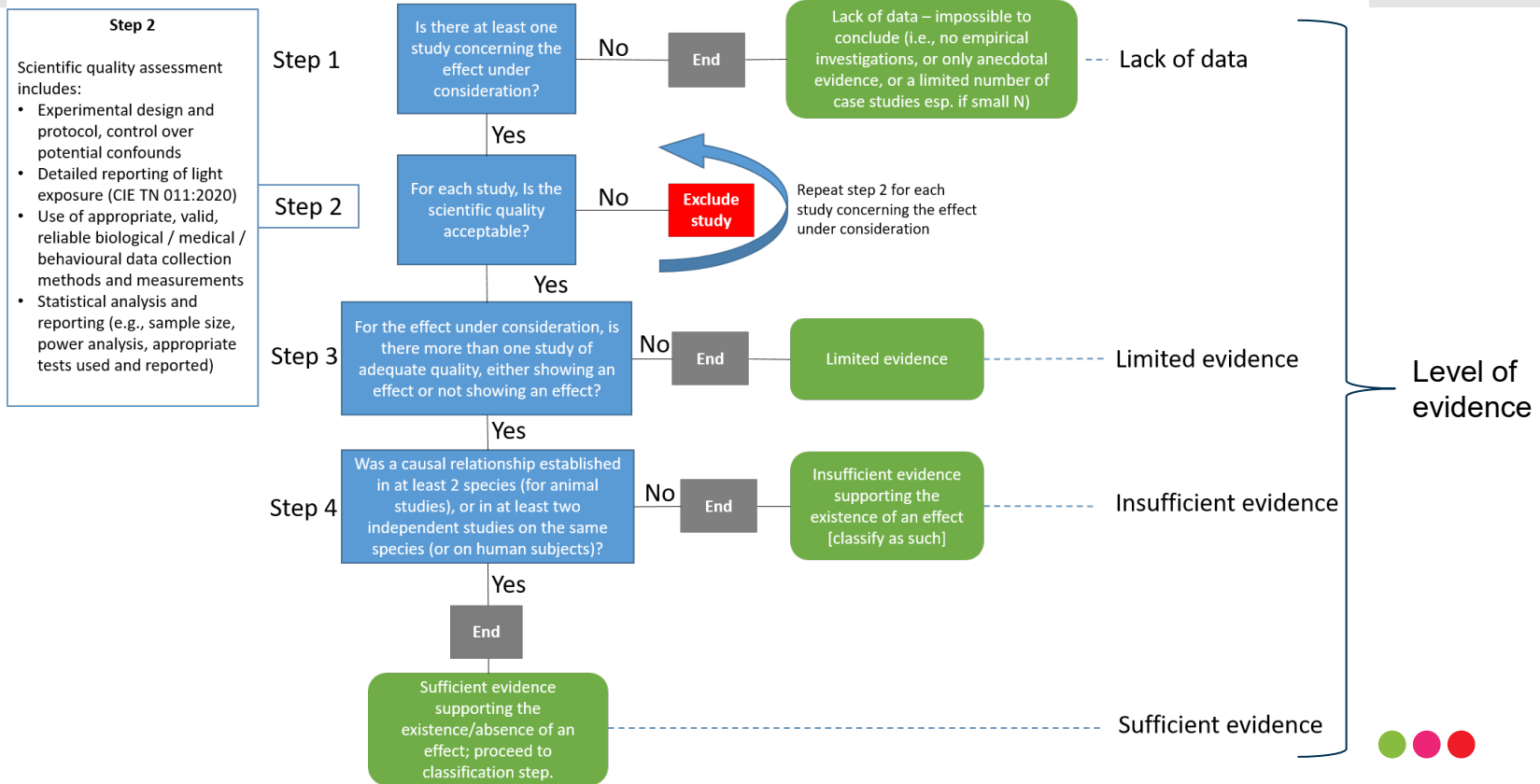
#### Pubmed

Publication date (2012 – 2021)

Language (French & English)



# Inclusion Flow Chart



# Effect categorization : Humans only

Procedure applicable to outcomes measured on humans: glare, headaches, visual performance, asthenopia, fatigue, mood, etc.


		Method of investigation on humans (adapted from Boyce 2021)			
		<u>Observation:</u> isolated case reports, anecdotal evidence, very small number of subjects	<u>Basic epidemiology:</u> Descriptive studies, ecological studies	<u>Advanced epidemiology:</u> case-control studies (retrospective), cohort/longitudinal studies (prospective)	<u>Interventional studies:</u> Field trials.
Level of evidence on humans	Sufficient evidence supporting the existence of an effect	Observation and basic epidemiology cannot provide evidence (causal proofs), only hints or correlations.	Probable effect	Proven effect	
	Limited evidence supporting the existence of an effect		Possible effect	Probable effect	
	Insufficient evidence supporting the existence of an effect	The available data do not allow us to conclude whether the effect exists or not.			
	Lack of data	Observation and basic epidemiology cannot provide the evidence of "no effect"	Effect not supported by data		
No effect indicated by the available data					

# Effect categorization: Animal + humans

Procedure applicable to outcomes measured on animal models and humans: retinal damage, sleep disruption, etc.

		Level of evidence on <u>animal models, in-vivo, ex-vivo or in-vitro studies</u>				
		Sufficient evidence supporting the existence of an effect	Limited evidence supporting the existence of an effect	Insufficient evidence supporting the existence of an effect	Lack of data	No effect indicated by the available data
Level of evidence on <u>humans</u> (assessed from advanced epidemiological studies, or interventional studies, or controlled clinical/laboratory studies)	Sufficient evidence supporting the existence of an effect	Proven effect		Probable effect		
	Limited evidence supporting the existence of an effect	Probable effect	Possible effect			
	Insufficient evidence supporting the existence of an effect	Possible effect	The available data do not allow us to conclude whether the effect exists or not			
	Lack of data					
	No effect indicated by the available data					Effect not supported by data

# Level of Certainty for Classification

For each effect under consideration	
CLASSIFICATION	LEVEL OF CERTAINTY
Impossible to conclude	
Possible effect	
Probable effect	
Proven effect or Effect not supported by data	

# Search equation for Photobiological Safety (PBS) – December 2021

## Part 1 – Lighting terms (IV)

Title & abstract: [light\\*](#) OR [LED](#) OR [\(light?emitting AND diode?\)](#) OR [\(solid state lighting\)](#) OR [\(fluorescent light\\*\)](#) OR [\(incandescent light\\*\)](#) OR [\(optical radiation\)](#) OR [lamp](#) OR [luminaire](#)

AND

Title & Abstract: [\(\(photobiological OR eye OR ocular OR visual\) AND safety\)](#) OR [\(blue?light hazard\)](#) OR [phototoxicity](#)

## Part 2 – Population/ Sample terms

AND

Title & Abstract:

**Sensitive populations (better not include them in search strategy)**

**Pre-existing conditions:**

Retinal disease

RPE disease

Macular disorder

Age related macular degeneration (AMD, ARMD)

dystrophy of the photoreceptors, cone dystrophy, rod dystrophy

Aphakic, pseudophakic

lens implant

**Age:**

Children, Infant, adolescent, Elderly

**Part 3 – DV terms (by section)**

AND

Title & Abstract :

[\(vision loss\)](#) OR [photochemical](#) OR [retinopathy](#) OR [photobleaching](#) OR [\(thermal damage\)](#) OR [cataract](#) OR [photokeratitis](#) OR [glaucoma](#) OR [retina](#) OR [cornea](#) OR [\(crystalline lens\)](#) OR [\(retinal pigmented epithelium\)](#) OR [RPE](#) OR [\(oxidative stress\)](#) OR [inflammation](#) OR [\(reactive oxygen\)](#) OR [lipofuscin](#) OR [A2E](#) OR [\(free radicals\)](#) OR [\(cellular death\)](#) OR [\(macular disorder\)](#) OR [\(age related macular degeneration\)](#) OR [AMD](#) OR [ARMD](#) OR [\(cone dystrophy\)](#) OR [\(rod dystrophy\)](#)

## Part 4 – What we don't want to include terms

AND NOT

Title & Abstract: [decontamination](#) OR [biofilm](#) OR [laser](#)

# Search equation for Photobiological Safety (PBS)



Scopus

Search Sources Lists SciVal ↗



232 document results

TITLE-ABS-KEY((lighting OR leds OR (light?emitting AND diode?) OR (optical AND radiation) OR luminaire) AND (((photobiological OR eye OR ocular OR visual) AND safety) OR (blue?light AND hazard) OR phototoxicity) AND ((vision AND loss) OR (photochemical) OR retinopathy OR photobleaching OR (thermal AND damage) OR cataract OR photokeratitis OR glaucoma OR retina OR cornea OR (crystalline AND lens) OR (retinal AND pigmented AND epithelium) OR rpe OR (oxidative AND stress) OR inflammation OR (reactive AND oxygen) OR lipofuscin OR a2e OR (free AND radicals) OR (cellular AND death) OR (macular AND disorder) OR (age AND related AND macular AND degeneration) OR amd OR armd OR (cone AND dystrophy) OR (rod AND dystrophy)) AND NOT (decontamination OR biofilm)) AND NOT (TITLE (laser\*)) AND (LIMIT-TO(PUBYEAR, 2021) OR LIMIT-TO(PUBYEAR, 2020) OR LIMIT-TO(PUBYEAR, 2019) OR LIMIT-TO(PUBYEAR, 2018) OR LIMIT-TO(PUBYEAR, 2017) OR LIMIT-TO(PUBYEAR, 2016) OR LIMIT-TO(PUBYEAR, 2015) OR LIMIT-TO(PUBYEAR, 2014) OR LIMIT-TO(PUBYEAR, 2013) OR LIMIT-TO(PUBYEAR, 2012)) AND (LIMIT-TO(LANGUAGE, "English") OR LIMIT-TO(LANGUAGE, "French"))

[View less ^](#)






# Results of search equation

## Photobiological Safety (PBS)

Database	SCOPUS
	Updated 11 Oct 2021
Search date	
Time period covered by search	2011 to Sep. 2021
Identified from databases	232
Excluded (not relevant)	174
Identified from other sources	5
Relevant	63



### Excluded papers:

- Biology, medical and ophthalmology papers on retinal pathologies **unrelated to exposure to LEDs**.
- Articles on **blue light filters** and **intraocular (IOL) implants** with blue light filters.
- **Exposures not reflecting general lighting**: automotive headlights, medical treatments using light (photobiomodulation for instance), displays, screens, billboards, smartphones.
- **Luminaire design**, optical design, electrical engineering aimed to improve PBS.
- **Metrology**, measurement techniques of PBS.

# Topics of included papers

## Photobiological Safety (PBS)

Thematic categories	Number of references
Biology, medical and ophthalmology papers on ocular phototoxicity from blue light, LEDs, lamps or luminaires. In-vivo and ex-vivo animal studies (rat, mice, etc.) : 19 papers In-vitro studies (light interactions with retinal cells) : 7 papers	26
Considerations and critics of animal models used in phototoxicity experiments	2
Considerations about exposure limit values	2
Emission or exposure data of LED lamps and luminaires	12
Review papers	16
Collective health appraisal reports	3 reports 2 papers

# Search equation for glare

## Part 1 – Lighting terms (IV)

Title & abstract: light\* OR LED OR (light?emitting AND diode?) OR (solid?state lighting) OR “fluorescent light\*” OR “incandescent light\*” OR “optical radiation” OR lamp OR luminaire

AND

Title & Abstract: glare

## Part 2 – Population/ Sample terms

AND

Title & Abstract:

**Sensitive populations (better not include them in search strategy)**

**Pre-existing conditions:**

**Age:** Children, Infant, adolescent, Elderly

## Part 3 – DV terms (by section)

AND

(disability OR discomfort) OR scotoma OR {after-image} OR {post-image} OR dazzle OR {dry?eye} OR accommodation OR migraine OR headache OR paroxysmal)

Title & Abstract :

## Part 4 – What we don’t want to include terms

AND NOT

Title & Abstract: photovoltaic OR glazing OR window OR fa?ade OR shading OR laser

# Search equation for Glare



Scopus

Search Sources Lists SciVal ↗



## 192 document results

TITLE-ABS-KEY(( {light source} OR lighting OR led OR leds OR {solid state lighting} OR {light emitting diode} OR fluorescent OR incandescent OR {optical radiation} OR lamp OR luminaire) AND glare AND (disability OR discomfort OR scotoma OR {after-image} OR {post-image} OR dazzle OR {dry-eye} OR accommodation OR migraine OR headache OR paroxysmal) AND NOT (laser OR photovoltaic OR glazing OR window OR facade OR shading)) AND (LIMIT-TO(PUBYEAR, 2021) OR LIMIT-TO(PUBYEAR, 2020) OR LIMIT-TO(PUBYEAR, 2019) OR LIMIT-TO(PUBYEAR, 2018) OR LIMIT-TO(PUBYEAR, 2017) OR LIMIT-TO(PUBYEAR, 2016) OR LIMIT-TO(PUBYEAR, 2015) OR LIMIT-TO(PUBYEAR, 2014) OR LIMIT-TO(PUBYEAR, 2013) OR LIMIT-TO(PUBYEAR, 2012)) AND (LIMIT-TO(LANGUAGE, "English") OR LIMIT-TO(LANGUAGE, "French"))

[View less ^](#)

# Results of search equation: Glare

Database	SCOPUS
	Updated 11 Oct 2021
Search date	
Time period covered by search	2011 to Sep. 2021
Identified from databases	192
Excluded (not relevant)	138
Identified from other sources	
Relevant	54

Excluded papers:

- Glare of **image sensors**
- Glare from **daylight**
- **Glare tests** used in optometry
- **Glare filters** / colored glasses / photochromic glasses
- **Luminaire design**, optical design to minimize glare
- **Visual ergonomics**, rating of luminous environments (not about products)
- Glare from **other sources of light**: medical procedures using light, automotive headlights, traffic signals, billboards, computer vision syndrome, etc.
- **Metrology**, measurement methods of glare
- Computation of **glare metrics**, generic models

# Topics of included papers

## Glare

Thematic categories	Number of references
Health effects of glare (muscular troubles, eye symptoms, migraine)	3
Spectral and color sensitivity	8
Non-uniform sources, multiple sources, moving sources, small sources	10
Discomfort glare with indoor lighting SSL products	4
Discomfort glare with outdoor lighting SSL products	7
Age factor in disability and discomfort glare	4
Glare and timing considerations	4
Physiological response to glare: pupil size, eye opening, eye movements, bio-signals	9
Review papers	5
Collective health appraisal reports	7

# Systematic review management

Covidence will be used to review, share and manage all the scientific papers.

The access is provided by NRC

Removes article duplicates

Keeps track of reasons for excluding

Keeps track of the review progress by team member & study stage (title abstract vs full-text review)

Generates a PRISMA flow diagram

The screenshot shows the Covidence Review Summary interface. At the top, there is a dark blue header with the Covidence logo and the text "Review Summary". To the right of the header are three buttons: "Settings", "PRISMA", and "Export". Below the header is a section for "Import references" with a link for "0 total duplicates removed" and an "Import" button. The main content area is divided into three horizontal sections: "Title and abstract screening", "Full text review", and "Extraction". The "Title and abstract screening" section is currently active and shows a progress bar for "TEAM PROGRESS" with a green bar indicating 22% completion. Below the progress bar are four categories: "DONE" (22), "ONE VOTE" (86), "CONFLICTS" (1), and "NO VOTES" (0). To the right of the progress bar, there is a section for "CHRISTOPHE, YOU CAN STILL" with two columns: "RESOLVE" (1) and "SCREEN" (86). Below these columns are buttons for "Resolve conflicts" and "Continue". At the bottom of this section, there is a small bar chart and the text "You've screened 1 study so far". The "Full text review" section shows "1 excluded" and "4 studies to screen". The "Extraction" section shows "0 extracted" and "3 studies to extract".

# New work plan

## 2019

Refine list of review topics, Develop review criteria; Assign topics to leaders.

Done, revised plan shown here.

## Jan 2020 to Dec 2021

Literature search, develop databases; Review key papers, inter-compare reviewing results; Refine criteria; Continuous coordination with CIE & ISO committees; continue reviewing & developing recommendations.

In process.

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